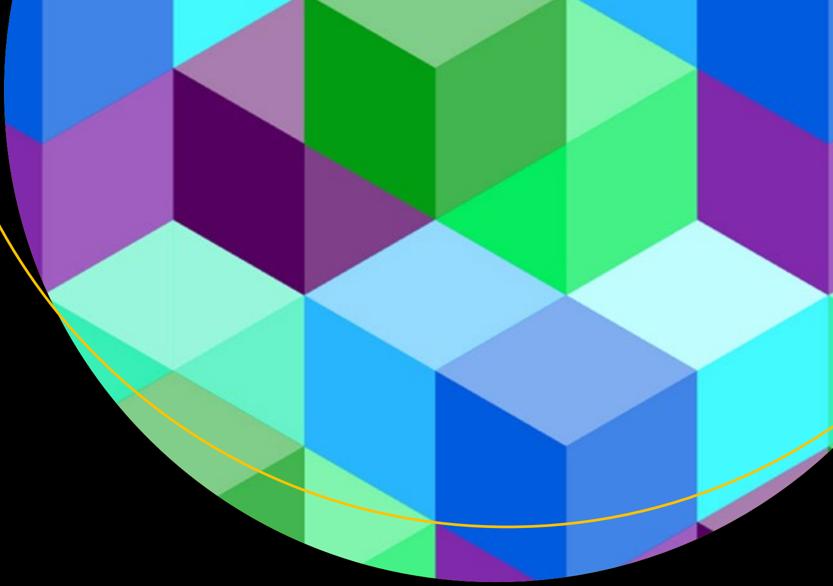

Pro Angular

Learn to harness the power of modern web browsers from within your application's code

Second Edition

Adam Freeman

Apress®

Pro Angular

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Printed on acid-free paper

Dedicated to my lovely wife, Jacqui Griffyth. And to Peanut,
who can also be lovely when she tries.

Contents at a Glance

Contents

About the Author

Adam Freeman is an experienced IT professional who has held senior positions in a range of companies, most recently serving as chief technology officer and chief operating officer of a global bank. Now retired, he spends his time writing and long-distance running.

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CHAPTER 1

Getting Ready

Angular taps into some of the best aspects of server-side development and uses them to enhance HTML in the browser, creating a foundation that makes building rich applications simpler and easier. Angular applications are built around a design pattern called *Model-View-Controller* (MVC), which places an emphasis on creating applications that are

- *Extendable*: It is easy to figure out how even a complex Angular app works once you understand the basics—and that means you can easily enhance applications to create new and useful features for your users.
- *Maintainable*: Angular apps are easy to debug and fix, which means that long-term maintenance is simplified.
- *Testable*: Angular has good support for unit and end-to-end testing, meaning that you can find and fix defects before your users do.
- *Standardized*: Angular builds on the innate capabilities of the web browser without getting in your way, allowing you to create standards-compliant web apps that take advantage of the latest features (such as HTML5 APIs) and popular tools and frameworks.

Angular is an open source JavaScript library that is sponsored and maintained by Google. It has been used in some of the largest and most complex web apps around. In this book, I show you everything you need to know to get the benefits of Angular in your own projects.

What Do You Need to Know?

Before reading this book, you should be familiar with the basics of web development, have an understanding of how HTML and CSS work, and, ideally, have a working knowledge of JavaScript. If you are a little hazy on some of these details, I provide refreshers for the HTML, CSS, and JavaScript I use in this book in Chapters 4, 5, and 6. You won't find a comprehensive reference for HTML elements and CSS properties, though. There just isn't the space in a book about Angular to cover all of HTML. If you need a complete reference for HTML and CSS, then I suggest another of my books, *The Definitive Guide to HTML5*, also published by Apress.

What Is the Structure of This Book?

This book is split into three parts, each of which covers a set of related topics.

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Part 1: Getting Ready

Part 1 of this book provides the information you need to get ready for the rest of the book. It includes this chapter and primers/refreshers for key technologies, including HTML, CSS, and TypeScript, which is a superset of JavaScript. I also show you how to build your first Angular application and take you through the process of building a more realistic application, called SportsStore.

Part 2: Working with Angular

Part 2 of this book takes you through the building blocks provided by Angular for creating applications, working through each of them in turn. Angular includes a lot of built-in functionality, which I describe in depth, and provides endless customization options, all of which I demonstrate.

Part 3: Advanced Angular Features

Part 3 of this book explains how advanced features can be used to create more complex and scalable applications. I introduce the Reactive Extensions package, which underpins a lot of the functionality provided by Angular and is used directly by advanced features. I demonstrate how to make asynchronous HTTP requests in an Angular application, how to use URL routing to navigate around an application, and how to animate HTML elements when the state of the application changes.

Are There Lots of Examples?

There are *loads* of examples. The best way to learn Angular is by example, and I have packed as many of them as I can into this book. To maximize the number of examples in this book, I have adopted a simple convention to avoid listing the contents of files over and over again. The first time I use a file in a chapter, I'll list the complete contents, just as I have in Listing 1-1. I include the name of the file in the listing's header and the folder in which you should create it. When I make changes to the code, I show the altered statements in bold.

Listing 1-1. A Complete Example Document

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

This listing is taken from Chapter 15. Don't worry about what it does; just be aware that the first time I use a file in each chapter there will be complete listing, similar to the one shown in Listing 1-1. For the second and subsequent examples, I just show you the elements that change, to create a *partial listing*. You can spot a partial listing because it starts and ends with ellipsis (...), as shown in Listing 1-2.

Listing 1-2. A Partial Listing

```
...
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
        [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
            {{item.category}}
        </td>
        <td [pa-attr]="'bg-info'">{{item.price}}</td>
    </tr>
</table>
...
```

Listing 1-2 is a later listing from Chapter 15. You can see that just the body element, and its content, is shown and that I have highlighted a number of statements. This is how I draw your attention to the part of the example that shows the feature or technique I am describing. In a partial listing like this, only those parts shown have changed from the full listing earlier in the chapter. In some cases, I need to make changes to different parts of the same file, in which case I simply omit some elements or statements for brevity, as shown in Listing 1-3.

Listing 1-3. Omitting Statements for Brevity

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();
    form: ProductFormGroup = new ProductFormGroup();

    // ...other members omitted for brevity...

    showTable: boolean = true;
}
```

This convention lets me pack in more examples, but it does mean it can be hard to locate a specific technique. To this end, all of the chapters in which I describe Angular features in Parts 2 and 3 begin with a summary table that describes the techniques contained in the chapter and the listings that demonstrate how they are used.

Where Can You Get the Example Code?

You can download the example projects for all the chapters in this book from `www.apress.com`. The download is available without charge and includes all of the supporting resources that are required to re-create the examples without having to type them in. You don't have to download the code, but it is the easiest way of experimenting with the examples and cutting and pasting it into your own projects.

How Do You Set Up Your Development Environment?

Chapter 2 introduces Angular by creating a simple application, and, as part of that process, I tell you how to create a development environment for working with Angular.

Contacting the Author

If you have problems making the examples in this chapter work or if you find a problem in the book, then you can email me at `adam@adam-freeman.com` and I will try my best to help.

Summary

In this chapter, I outlined the content and structure of this book. The best way to learn Angular development is by example, so in the next chapter, I jump right in and show you how to set up your development environment and use it to create your first Angular application.

CHAPTER 2

Your First Angular App

The best way to get started with Angular is to dive in and create a web application. In this chapter, I show you how to set up your development environment and take you through the process of creating a basic application, starting with a static mock-up of the functionality and applying Angular features to create a dynamic web application, albeit a simple one. In Chapters 7–10, I show you how to create a more complex and realistic Angular application, but for now a simple example will suffice to demonstrate the major components of an Angular app and set the scene for the other chapters in this part of the book.

Don't worry if you don't follow everything that happens in this chapter. Angular has a steep learning curve, so the purpose of this chapter is just to introduce the basic flow of Angular development and give you a sense of how things fit together. It won't all make sense right now, but by the time you have finished reading this book, you will understand every step I take in this chapter and much more besides.

Preparing the Development Environment

There is some preparation required for Angular development. In the sections that follow, I explain how to get set up and ready to create your first project. There is wide support for Angular in popular development tools, and you can pick your favorites.

Installing Node.js and NPM

Many of the tools used for Angular development rely on Node.js—also known as Node—which was created in 2009 as a simple and efficient runtime for server-side applications written in JavaScript. Node.js is based on the JavaScript engine used in the Chrome browser and provides an API for executing JavaScript code outside of the browser environment.

Node.js has enjoyed success as an application server, but for this book it is interesting because it has provided the foundation for a new generation of cross-platform development and build tools. Some smart design decisions by the Node.js team and the cross-platform support provided by the Chrome JavaScript runtime have created an opportunity that has been seized upon by enthusiastic tool writers. In short, Node.js has become an essential tool for web application development.

It is important that you download the same version of Node.js that I use throughout this book. Although Node.js is relatively stable, there are still breaking API changes from time to time that they may stop the examples I include in the chapters from working.

The version I have used is the 6.9.1 release. You may prefer more recent releases for your own projects, but you should stick with the 6.9.1 release for the rest of this book. A complete set of 6.9.1 releases, with installers for Windows and Mac OS and binary packages for other platforms, is available at `https://nodejs.org/dist/v6.9.1`.

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When you install Node.js, make sure you select the installer option to add the Node.js executables to the path. When installation is complete, run the following command:

```
node -v
```

If the installation has gone as it should, then you will see the following version number displayed:

```
V6.9.1
```

Updating NPM

The success of Node.js has been helped by the Node Package Manager (NPM), which provides easy access to an enormous catalog of development packages, including Angular. NPM takes care of downloading packages and managing the dependencies between them. The extent to which NPM eases the process of keeping a project up-to-date is hard to overstate. You will see NPM in action shortly, but part of the initial process is updating the version of NPM that was installed with Node.js, which is done by running the following command (you may need to perform this step with root or administrator privileges):

```
npm install -g npm@3.10.9
```

Installing an Editor

Angular development can be done with any programmer's editor, from which there is an endless number to choose from. Some editors have enhanced support for working with Angular, including highlighting key terms and good tool integration. If you don't already have a preferred editor for web application development, then Table 2-1 describes some popular options for you to consider. I don't rely on any specific editor for this book, and you should use whichever editor you are comfortable working with.

Table 2-1. *Popular Angular-Enabled Editors*

Name	Description
Sublime Text	Sublime Text is a commercial cross-platform editor that has packages to support most programming languages, frameworks, and platforms. See `www.sublimetext.com` for details.
Atom	Atom is a free, open source, cross-platform editor that has a particular emphasis on customization and extensibility. See `atom.io` for details.
Brackets	Brackets is a free open source editor developed by Adobe. See `brackets.io` for details.
WebStorm	WebStorm is a paid-for cross-platform editor that integrates many tools so that you don't have to use the command line during development. See `www.jetbrains.com/webstorm` for details.
Visual Studio Code	Visual Studio Code is a free, open source, cross-platform editor from Microsoft, with an emphasis on extensibility. See `code.visualstudio.com` for details.

When choosing an editor, one of the most important considerations is the ability to filter the content of the project so that you can focus on a subset of the files. There can be a lot of files in an Angular project and many of the files have similar names, so being able to find and edit the right file is essential. Editors make this focus possible in different ways, either by presenting a list of the files that are open for editing or by providing the ability to exclude files with specific extensions.

Installing a Browser

The final choice to make is the browser that you will use to check your work during development. All the current-generation browsers have good developer support and work well with Angular. I have used Google Chrome throughout this book, and this is the browser I recommend you use as well.

Creating and Preparing the Project

Once you have Node.js, NPM, an editor, and a browser, you have enough of a foundation to start the development process. The first step is to create the folder structure for the project. The example for this chapter is a to-do application. Select the location that you will use for the examples in this book and create a `todo` folder, which is where all the files for the project will be stored. Now create a `todo/app` folder; this is where the Angular parts of the application will be stored.

Creating the Package File

NPM uses a file called `package.json` to get a list of the software packages that are required for a project. I created a file called `package.json` in the `todo` folder and set the contents so they match Listing 2-1.

■ **Caution** By the time you read this, later versions of at least some of the packages shown in Listing 2-1 will have been released. It is important that you use the specific versions shown in the listing to get the expected results from the examples in this chapter and in the rest of the book. If you have problems with the examples in this chapter or any subsequent chapter, then try using the source code that accompanies this book that can be downloaded from `apress.com`. If you are really stuck, then e-mail me at `adam@adam-freeman.com`, and I will try to help you.

Listing 2-1. The Contents of the package.json File in the todo Folder

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/forms": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.3",
    "typings": "1.4.0",
    "concurrently": "3.1.0"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "typings": "typings"
  }
}
```

The `package.json` file lists the packages required to get started with Angular development and some commands to use them. I describe each configuration entry in Chapter 11, but for now, it is enough to understand what each section of the `package.json` file is for, as described in Table 2-2.

Table 2-2. *The package.json Sections*

Name	Description
`dependencies`	This is a list of NPM packages that the web application relies on to run. Each package is specified with a version number. The `dependencies` section in the listing contains the core Angular packages, libraries that Angular depends on, polyfill libraries that add modern features for old browsers, and the Bootstrap CSS library that I use to style HTML content in this book.
`devDependencies`	This is a list of NPM packages that are relied on for development but that are not required by the application once it has been deployed. This section contains packages that will compile TypeScript files, provide a development HTTP server, and allow multiple commands to be run at the same time using NPM.
`scripts`	This is a list of scripts that can be run from the command line. The `scripts` section in the listing starts the TypeScript compiler and the development HTTP server.

Installing the NPM Packages

To process the `package.json` file to download and install the packages that it specifies, run the following command inside the `todo` folder:

```
npm install
```

You will see some warnings as NPM grumbles about the packages it processes, but there should be no errors reported. Once the installation process has completed, you will be left with a `todo/node_modules` directory that contains all the packages specified in the `package.json` file, along with their dependencies. There will be a lot of packages in the `node_modules` folder because the tendency in NPM development is to build on existing functionality that other packages contain, which is good development practice but does mean the initial download and installation can take a while.

Configuring the TypeScript Compiler

Angular applications are written in TypeScript, which is a superset of JavaScript. Working with TypeScript provides some useful advantages, which I describe in Chapter 6, but requires that TypeScript files are processed to generate backward-compatible JavaScript that can be used by browsers.

■ **Note** Don't worry about the requirement to use TypeScript for the moment. As I explain in Chapter 6, it simplifies working with Angular and, with just a few exceptions, you can write Angular applications using the JavaScript skills you already have.

The TypeScript compiler requires a configuration file to control the kind of JavaScript files that it generates. I created a file called `tsconfig.json` in the `todo` folder and added the configuration statements shown in Listing 2-2.

Listing 2-2. The Contents of the tsconfig.json File in the todo Folder

```
{
  "compilerOptions": {
    "target": "es5",
    "module": "commonjs",
    "moduleResolution": "node",
    "emitDecoratorMetadata": true,
    "experimentalDecorators": true
  },
  "exclude": [ "node_modules" ]
}
```

I explain what each configuration setting does in Chapter 11, but for now, it is enough to just create the file.

Installing the TypeScript Type Information

The TypeScript compiler relies on descriptions of the standard JavaScript APIs, known as type definitions, for the enhancements that TypeScript provides to the JavaScript language specification. I don't use these features in this chapter, but the descriptions are still required to prevent the compiler reporting errors.

Run the following commands in the todo folder:

```
npm run typings -- install dt~core-js --save -global
npm run typings -- install dt~node --save --global
```

Once the commands have completed, the todo folder will contain typings/globals/core-js and typings/global/node folders that contain the type definitions and a typings.json file that contains details of the type information that was downloaded, as shown in Listing 2-3. You may see different version numbers in your typings.json file.

Listing 2-3. The Contents of the typings.json File in the todo Folder

```
{
  "globalDependencies": {
    "core-js": "registry:dt/core-js#0.0.0+20160914114559",
    "node": "registry:dt/node#6.0.0+20161110151007"
  }
}
```

Creating the HTML File

I am going to start with an HTML placeholder that contains static content, which I will later enhance using Angular. I created an HTML file called index.html in the todo folder and added the markup shown in Listing 2-4.

Listing 2-4. The Contents of the index.html File in the todo Folder

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
</head>
<body>
    <h1>Content will go here</h1>
</body>
</html>
```

This is a basic HTML document with a link element that tells the browser to load the Bootstrap CSS stylesheet from the package installed in the node_modules folder, which was installed by NPM in the previous chapter.

Starting the Server

The project tools and basic structure are in place, so it is time to test that everything is working. Run the following command from the todo folder:

```
npm start
```

This command tells npm to run the start script, which starts the TypeScript compiler and the light-weight development HTTP server that I installed using the package.json file. After a few seconds, a new browser window will start, and you will see the placeholder content from Listing 2-4, as shown in Figure 2-1.

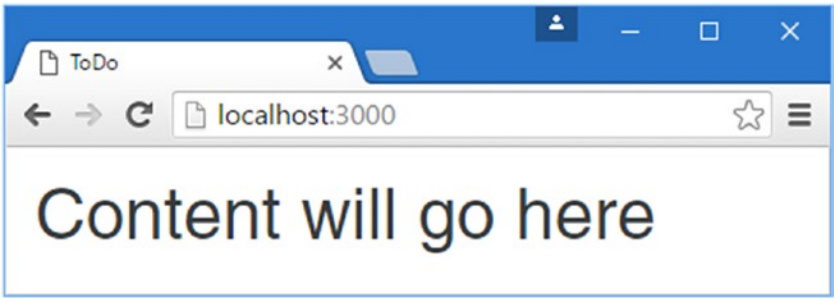


Figure 2-1. *The placeholder HTML content*

Replacing the HTML Content

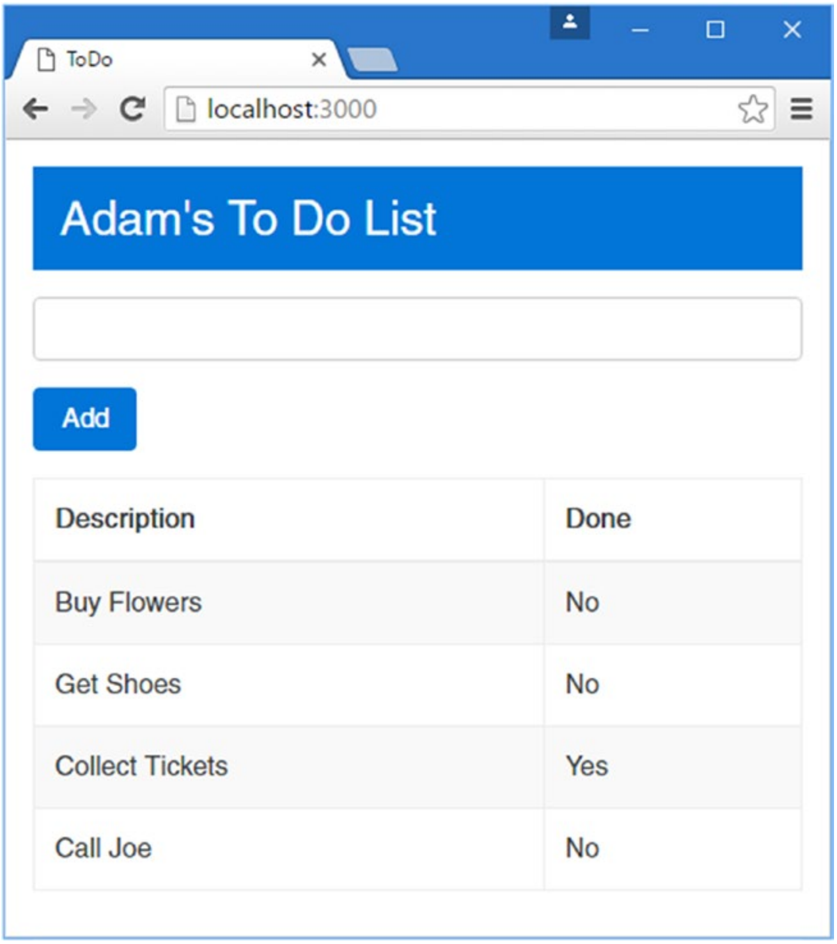
The final test of the development environment is to change the content in the index.html file, as shown in Listing 2-5.

Listing 2-5. Changing the Contents of the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
</head>
<body class="m-a-1">

    <h3 class="bg-primary p-a-1">Adam's To Do List</h3>

    <div class="m-t-1 m-b-1">
        <input class="form-control" />
        <button class="btn btn-primary m-t-1">Add</button>
    </div>
    <table class="table table-striped table-bordered">
        <thead>
            <tr>
                <th>Description</th>
                <th>Done</th>
            </tr>
        </thead>
        <tbody>
            <tr><td>Buy Flowers</td><td>No</td></tr>
            <tr><td>Get Shoes</td><td>No</td></tr>
            <tr><td>Collect Tickets</td><td>Yes</td></tr>
            <tr><td>Call Joe</td><td>No</td></tr>
        </tbody>
    </table>
</body>
</html>
```

The `lite-server` package, which is the development HTTP server I am using, adds a fragment of JavaScript to the HTML content it delivers to the browser. The JavaScript opens a connection back to the server and waits for a signal to reload the page, which is sent when the server detects a change in any of the files in the `todo` directory. As soon as you save the `index.html` file, `lite-server` will detect the change and send the signal, and the browser will reload, reflecting the new content as shown in Figure 2-2.

■ **Tip** When you are making changes to a series of files, there may be times when the browser won't be able to load and execute the example application, especially in later chapters where the examples are more complex. For the most part, the development HTTP server will trigger a reload in the browser and everything will be fine, but if it gets stuck, just click the browser's reload button or navigate to `http://localhost:3000` to get going again.



Adam's To Do List

Add

Description	Done
Buy Flowers	No
Get Shoes	No
Collect Tickets	Yes
Call Joe	No

Figure 2-2. *Editing the contents of the HTML file*

The HTML elements in the `index.html` file show how the simple Angular application I create in this chapter will look. The key elements are a banner with the user's name, an `input` element and an Add button that add a new to-do item to the list, and a table that contains all the to-do items and indicates whether they have been completed.

Throughout this book, I use the excellent Bootstrap CSS framework to style HTML content. Bootstrap is applied by assigning elements to classes, like this:

```
...
<h3 class="bg-primary p-a-1">Adam's To Do List</h3>
...
```

This `h3` element has been assigned to two classes. The `bg-primary` class sets the background color of the element to the primary color of the current Bootstrap theme. I am using the default theme, for which the primary color is dark blue and there are other themed colors available, including `bg-secondary`, `bg-info`, and `bg-danger`. The `p-a-1` class adds a fixed amount of padding to all edges of the element, ensuring that the text has some space around it.

In the next section, I'll remove the HTML from the file, cut it up into smaller pieces, and use it to create a simple Angular application.

USING THE BOOTSTRAP PRE-RELEASE

Throughout this book, I use a pre-release version of the Bootstrap CSS framework. As I write this, the Bootstrap team is in the process of developing Bootstrap version 4 and has made several early releases. These releases have been labeled as "alpha," but the quality is high and they are stable enough for use in the examples in this book.

Given the choice of writing this book using the soon-to-be-obsolete Bootstrap 3 and a pre-release version of Bootstrap 4, I decided to use the new version even though some of the class names that are used to style HTML elements are likely to change before the final release. This means you must use the same version of Bootstrap to get the expected results from the examples, just like the rest of the packages listed in the `package.json` file in Listing 2-1.

Adding Angular to the Project

The static HTML in the `index.html` file acts as a placeholder for the basic application. The user should be able to see the list of to-do items, check off items that are complete, and create new items. In the sections that follow, I add Angular to the project and use some of its basic features to bring the to-do application to life. To keep the application simple, I assume that there is only one user and that I don't have to worry about preserving the state of the data in the application, which means that changes to the to-do list will be lost if the browser window is closed or reloaded. (Later examples, including the SportsStore application developed in Chapters 7–10, demonstrate persistent data storage.)

Preparing the HTML File

The first step toward adding Angular to the application is to prepare the `index.html` file, as shown in Listing 2-6. The new `script` elements add the JavaScript files for the Angular framework, and the third-party JavaScript libraries and polyfill that provide compatibility for older browsers. These files are all from the NPM packages added to the `package.json` file in Listing 2-1 and must be added in the order shown.

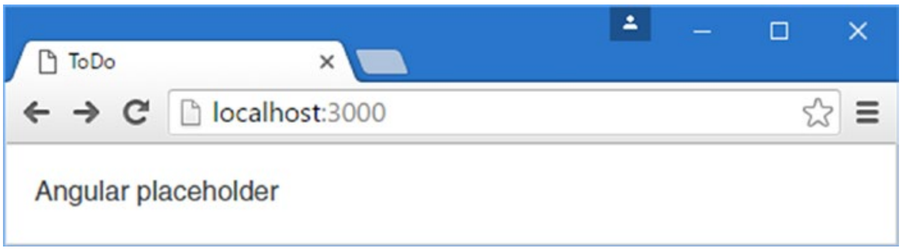
Listing 2-6. Preparing for Angular in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
</head>
```

```
<body class="m-a-1">
    <todo-app>Angular placeholder</todo-app>
</body>
</html>
```

The `script` elements add the JavaScript files that Angular applications rely on. There are no entries for Angular functionality or the application features yet; I'll add them at the end of the process.

The second change in Listing 2-6 is to replace the content of the `body` element and replace it with a `todo-app` element. There is no `todo-app` element in the HTML specification and the browser will ignore it when parsing the HTML file, but this element will be the entry point into the world of Angular and will be replaced with my application content. When you save the `index.html` file, the browser will reload the file and show the placeholder message, as shown in Figure 2-3.



Angular placeholder

Figure 2-3. *Preparing the HTML file*

Creating a Data Model

When I created the static mock-up of the application, the data was distributed across all the HTML elements. The user's name is contained in the header, like this:

```
...
<h3 class="bg-primary p-a-1">Adam's To Do List</h3>
...
```

and the details of the to-do items are contained within `td` elements in the table, like this:

```
...
<tr><td>Buy Flowers</td><td>No</td></tr>
...
```

The next task is to pull all the data together to create a data model. Separating the data from the way it is presented to the user is one of the key ideas in the MVC pattern, as I explain in Chapter 3.

■ **Tip** I am simplifying here. The model can also contain the logic required to create, load, store, and modify data objects. In an Angular app, this logic is often at the server and is accessed by a web service. See Chapter 3 for further details and Chapter 24 for examples.

Angular applications are typically written in TypeScript. I introduce TypeScript in Chapter 6 and explain how it works and why it is useful. TypeScript is a superscript of JavaScript, but one of its main advantages is that it lets you write code using the latest JavaScript language specification with features that are not yet supported in all of the browsers that can run Angular applications. One of the packages added to the project in the previous section was the TypeScript compiler, which I set up to generate browser-friendly JavaScript files automatically when a change to a TypeScript file is detected. To create a data model for the application, I added a file called `model.ts` to the `todo/app` folder (TypeScript files have the `.ts` extension) and added the code shown in Listing 2-7.

Listing 2-7. The Contents of the model.ts File in the todo/app Folder

```
var model = {
    user: "Adam",
    items: [{ action: "Buy Flowers", done: false },
    { action: "Get Shoes", done: false },
    { action: "Collect Tickets", done: true },
    { action: "Call Joe", done: false }]
};
```

One of the most important features of TypeScript is that you can just write “normal” JavaScript code as though you were targeting the browser directly. In the listing, I used the JavaScript object literal syntax to assign a value to a global variable called `model`. The data model object has a `user` property that provides the name of the application’s user and an `items` property, which is set to an array of objects with `action` and `done` properties, each of which represents a task in the to-do list.

When you save the changes to the file, the TypeScript compiler will detect the change and generate a file called `model.js`, with the following contents:

```
var model = {
    user: "Adam",
    items: [{ action: "Buy Flowers", done: false },
        { action: "Get Shoes", done: false },
        { action: "Collect Tickets", done: true },
        { action: "Call Joe", done: false }]
};
```

This is the most important aspect of using TypeScript: you don’t have to use the features it provides, and you can write entire Angular applications using just the JavaScript features that are supported by all browsers, like the code in Listing 2-7.

But part of the value of TypeScript is that it converts code that uses the latest JavaScript language features into code that will run anywhere, even in browsers that don’t support those features. Listing 2-8 shows the data model rewritten to use JavaScript features that were added in the ECMAScript 6 standard (known as ES6).

Listing 2-8. Using ES6 Features in the model.ts File

```
export class Model {
    user;
    items;

    constructor() {
        this.user = "Adam";
        this.items = [new TodoItem("Buy Flowers", false),
                      new TodoItem("Get Shoes", false),
                      new TodoItem("Collect Tickets", false),
                      new TodoItem("Call Joe", false)]
    }
}

export class TodoItem {
    action;
    done;

    constructor(action, done) {
        this.action = action;
        this.done = done;
    }
}
```

This is still standard JavaScript code, but the `class` keyword was introduced in a later version of the language than most web application developers are familiar with because it is not supported by older browsers. The `class` keyword is used to define types that can be instantiated with the `new` keyword to create objects that have well-defined data and behavior.

Many of the features added in recent versions of the JavaScript language are syntactic sugar to help programmers avoid some of the most common JavaScript pitfalls, such as the unusual type system. The `class` keyword doesn't change the way that JavaScript handles types; it just makes it more familiar and easier to use for programmers experienced in other languages, such as C# or Java. I like the JavaScript type system, which is dynamic and expressive, but I find working with classes more predictable and less error-prone, and they simplify working with Angular, which has been designed around the latest JavaScript features.

■ **Tip** Don't worry if you are not familiar with the features that have been added in recent versions of the JavaScript specification. Chapters 5 and 6 provide a primer for writing JavaScript using the features that make Angular easier to work with, and Chapter 6 also describes some useful TypeScript-specific features.

The `export` keyword relates to JavaScript modules. When using modules, each TypeScript or JavaScript file is considered to be a self-contained unit of functionality, and the `export` keyword is used to identity data or types that you want to use elsewhere in the application. JavaScript modules are used to manage the dependencies that arise between files in a project and avoid having to manually manage a complex set of `script` elements in the HTML file. See Chapter 7 for details of how modules work.

The TypeScript compiler processes the code in Listing 2-8 to generate JavaScript code that uses only the subset of features that are widely supported by browsers. Even though I used the `class` and `export` keywords, the `model.js` file generated by the TypeScript compiler produced JavaScript code that will work in browsers that don't implement that feature, like this:

```
"use strict";
var Model = (function () {
    function Model() {
        this.user = "Adam";
        this.items = [new TodoItem("Buy Flowers", false),
            new TodoItem("Get Shoes", false),
            new TodoItem("Collect Tickets", false),
            new TodoItem("Call Joe", false)];
    }
    return Model;
}());
exports.Model = Model;
var TodoItem = (function () {
    function TodoItem(action, done) {
        this.action = action;
        this.done = done;
    }
    return TodoItem;
}());
exports.TodoItem = TodoItem;
```

I won't keep showing you the code that the TypeScript compiler produces. The important point to remember is that the compilation process translates new JavaScript features that are not widely supported by browsers into standard features that are supported.

Creating a Template

I need a way to display the data values in the model to the user. In Angular, this is done using a *template*, which is a fragment of HTML that contains instructions that are performed by Angular.

I created an HTML file called `app.component.html` in the `todo/app` folder and added the markup shown in Listing 2-9. The name of the file follows the standard Angular naming conventions, which I explain later.

Listing 2-9. The Contents of the app.component.html File in the todo/app Folder

```
<h3 class="bg-primary p-a-1">{{getName()}}'s To Do List</h3>
```

I'll add more elements to this file shortly, but a single `h3` element is enough to get started. Including a data value in a template is done using double braces—`{{` and `}}`—and Angular evaluates whatever you put between the double braces to get the value to display.

The `{{` and `}}` characters are an example of a *data binding*, which means that they create a relationship between the template and a data value. Data bindings are an important Angular feature, and you will see more examples of them in this chapter as I add features to the example application and as I describe them in detail in Part 2. In this case, the data binding tells Angular to invoke a function called `getName` and use the result as the contents of the `h3` element. The `getName` function doesn't exist anywhere in the application at the moment, but I'll create it in the next section.

Creating a Component

An Angular *component* is responsible for managing a template and providing it with the data and logic it needs. If that seems like a broad statement, it is because components are the parts of an Angular application that do most of the heavy lifting. As a consequence, they can be used for all sorts of tasks.

At the moment, I have a data model that contains a `user` property with the name to display, and I have a template that displays the name by invoking a `getName` property. What I need is a component to act as the bridge between them. I added a JavaScript file called `app.component.ts` to the `todo/app` folder and added the code shown in Listing 2-10.

Listing 2-10. The Contents of the app.component.ts File in the todo/app Folder

```
import { Component } from "@angular/core";
import { Model } from "./model";

@Component({
    selector: "todo-app",
    templateUrl: "app/app.component.html"
})
export class AppComponent {
    model = new Model();

    getName() {
        return this.model.user;
    }
}
```

This is still JavaScript, but it relies on features that you may not have encountered before but that underpin Angular development. The code in the listing can be broken into three main sections, as described in the following sections.

Understanding the Imports

The `import` keyword is the counterpart to the `export` keyword that I used in Listing 2-8 and is used to declare a dependency on the contents of a JavaScript module. The `import` keyword is used twice in Listing 2-10, as shown here:

```
...
import { Component } from "@angular/core";
import { Model } from "./model";
...
```

The first `import` statement is used in the listing to load the `@angular/core` module, which contains the key Angular functionality, including support for components. When working with modules, the `import` statement specifies the types that are imported between curly braces. In this case, the `import` statement is used to load the `Component` type from the module. The `@angular/core` module contains many classes that have been packaged together so that the browser can load them all in a single JavaScript file.

The second `import` statement is used to load the `Model` class from a file in the project. The target for this kind of import starts with `./`, which indicates that the module is defined relative to the current file.

Notice that neither `import` statement includes a file extension. This is because the relationship between the target of an import statement and the file that is loaded by the browser is managed by a *module loader*, which I configure in the "Putting the Application Together" section.

Understanding the Decorator

The oddest-looking part of the code in the listing is this:

```
...
@Component({
    selector: "todo-app",
    templateUrl: "app/app.component.html"
})
...
```

This is an example of a *decorator*, which provides metadata about a class. This is the `@Component` decorator, and, as its name suggests, it tells Angular that this is a component. The decorator provides configuration information through its properties, which in the case of `@Component` includes properties called `selector` and `templateUrl`.

The `selector` property specifies a CSS selector that matches the HTML element to which the component will be applied: in this case, I have specified the `todo-app` element, which I added to the `index.html` file in Listing 2-6. When an Angular application starts, Angular scans the HTML in the current document and looks for elements that correspond to components. It will find the `todo-app` element and know that it should be placed under the control of this component.

The `templateUrl` property is used to tell Angular how to find the component's template, which is the `app.component.html` file in the `app` folder for this component. In Part 2, I describe the other properties that can be used with the `@Component` decorator and the other decorators that Angular supports.

Understanding the Class

The final part of the listing defines a class that Angular can instantiate to create the component.

```
...
export class AppComponent {
    model = new Model();

    getName() {
        return this.model.user;
    }
}
...
```

These statements define a class called `AppComponent` that has a `model` property and a `getName` function, which provide the functionality required to support the data binding in the template from Listing 2-9.

When a new instance of the `AppComponent` class is created, the model property will be set to a new instance of the `Model` class defined in Listing 2-8. The `getName` function returns the value of the user `property` defined by the `Model` object.

Putting the Application Together

I have the three key pieces of functionality required to build a simple Angular application: a model, a template, and a component. Now I need to bring them together to create the application.

The first step is to create an Angular module. Through an unfortunate naming choice, there are two types of module used in Angular development. A *JavaScript module* is a file that contains JavaScript functionality that is used through the `import` keyword. The other type of module is an *Angular module*, which is used to describe an application or a group of related features. Every application has a root module, which provides Angular with the information that it needs to start the application. I created a file called `app.module.ts`, which is the conventional file name for the root module, in the `todo/app` folder and added the code shown in Listing 2-11.

Listing 2-11. The Contents of the app.module.ts File in the todo/app Folder

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { AppComponent } from "./app.component";
```

```
@NgModule({
    imports: [BrowserModule, FormsModule],
    declarations: [AppComponent],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

The purpose of the Angular module is to provide configuration information through the properties defined by the `@NgModule` decorator. I explain how modules work in detail in Chapter 21, but for the moment, it is enough to know that the decorator's `imports` property tells Angular that the application depends on features required to run an application in the browser and that the `declarations` and `bootstrap` properties tell Angular about the components in the application and which one should be used to start the application (there is only one component in this simple example application, which is why it is the only value for both properties).

Angular applications also need a bootstrap file, which contains the code required to start the application and load the Angular module. To create the bootstrap file, I added a file called `main.ts` to the `todo/app` folder with the code shown in Listing 2-12.

Listing 2-12. The Contents of the main.ts File in the todo/app Folder

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { AppModule } from './app.module';

platformBrowserDynamic().bootstrapModule(AppModule);
```

Although this book focuses on applications that run in a web browser, Angular is intended to work in a range of environments. The code statements in the bootstrap file select the platform that will be used and load the root module, which is the entry point into the application.

■ **Tip** Calling the `platformBrowserDynamic().bootstrapModule` method is for browser-based applications, which is what I focus on in this book. If you are working on different platforms, such as the Ionic mobile development framework, then you will have to use a different bootstrap method specific to the platform you are working with. The developers of each platform that supports Angular provide details of their platform-specific bootstrap method.

The final step is to update the HTML file so that the browser will load the application and the modules that contain the Angular framework functionality, as shown in Listing 2-13.

Listing 2-13. Completing the HTML Document in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script>
        var paths = {
            "rxjs/*": "node_modules/rxjs/bundles/Rx.min.js",
            "@angular/*": "node_modules/@angular/*"
        }
        var packages = { "app": {} };
        var angularModules = ["common", "compiler", "core", "forms",
            "platform-browser", "platform-browser-dynamic"];
        angularModules.forEach(function (pkg) {
            packages["@angular/" + pkg] = {
                main: "/bundles/" + pkg + ".umd.min.js"
            };
        });
        System.config({ paths: paths, packages: packages });
        System.import("app/main").catch(function(err){ console.error(err); });
    </script>
</head>
<body class="m-a-1">
    <todo-app>Angular placeholder</todo-app>
</body>
</html>
```

When working with JavaScript modules, you don't add `script` elements for all the files that are required by the application. Instead, a *module loader* is provided with the application's bootstrap file and with details of how to load the modules that are specified by the `import` statements in the code. The module loader ensures that all the required modules are loaded and processed before the JavaScript code they contain is executed. The `script` element in the listing configures the module loader that I use in this book—called SystemJS—so that it knows how to find the JavaScript modules that contain the Angular functionality and the custom files in the project. I explain how the module loader is configured in Chapter 11, but for now, it is enough to know that the Angular framework and the example application code will be loaded when the browser processes the HTML file.

Running the Application

As soon as you save the changes to the `index.html` file, the browser should reload the page, and your first Angular application will spring to life, as shown in Figure 2-4.

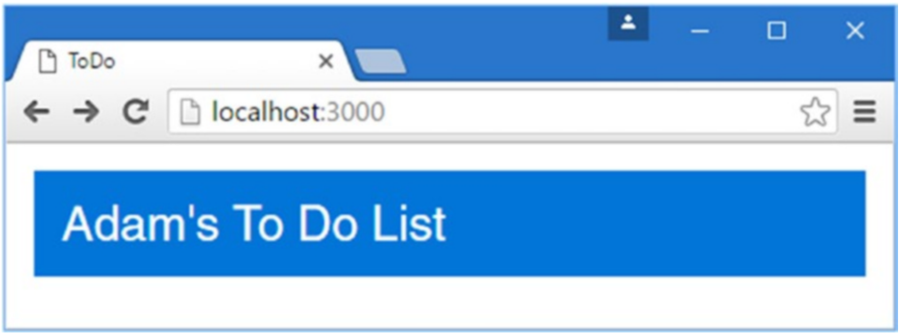


***Figure 2-4.** Running the example application*

The browser executed the code in the bootstrap file, which fired up Angular, which in turn processed the HTML document and discovered the todo-app element. The selector property used to define the component matches the todo-app element, which allowed Angular to remove the placeholder content and replace it with the component's template, which was loaded automatically from the app.component.html file. The template was parsed; the {{ and }} data binding was discovered, and the expression it contains was evaluated, calling the getName and displaying the result.

It may not be that impressive, but it is a good start, and it provides a foundation on which to add more features.

■ **Tip** In any Angular project, there is a period where you have to define the main parts of the application and plumb them together. During this period, it can feel like you are doing a lot of work for little return. This period of initial investment *will* ultimately pay off, I promise. You will see a larger example of this in Chapter 7 when I start to build a more complex and realistic Angular application; there is a lot of initial setup and configuration required, but then the features start to quickly snap into place.

Adding Features to the Example Application

Now that the basic structure of the application is in place, I can add the remaining features that I mocked up with static HTML at the start of the chapter. In the sections that follow, I add the table containing the list of to-do items and the input element and button for creating new items.

Adding the To-Do Table

Angular templates can do more than just display simple data values. I describe the full range of template features in Part 2, but for the example application, I am going to use the feature that allows a set of HTML elements to be added to the DOM for each object in an array. The array in this case is the set of to-do items in the data model. To begin, Listing 2-14 adds a method to the component that provides the template with the array of to-do items.

Listing 2-14. Adding a Method in the app.component.ts File

```
import { Component } from "@angular/core";
import { Model } from "./model";

@Component({
    selector: "todo-app",
    templateUrl: "app/app.component.html"
})
export class AppComponent {
    model = new Model();

    getName() {
        return this.model.user;
    }

    getTodoItems() {
        return this.model.items;
    }
}
```

The getTodoItems method returns the value of the items property from the Model object. Listing 2-15 updates the component's template to take advantage of the new method.

Listing 2-15. Displaying the To-Do Items in the app.component.html File

```
<h3 class="bg-primary p-a-1">{{getName()}}'s To Do List</h3>

<table class="table table-striped table-bordered">
    <thead>
        <tr><th></th><th>Description</th><th>Done</th></tr>
    </thead>
    <tbody>
        <tr *ngFor="let item of getTodoItems(); let i = index">
            <td>{{ i + 1 }}</td>
            <td>{{ item.action }}</td>
            <td [ngSwitch]="item.done">
                <span *ngSwitchCase="true">Yes</span>
                <span *ngSwitchDefault>No</span>
            </td>
        </tr>
    </tbody>
</table>
```

The additions to the template rely on several different Angular features. The first is the *ngFor expression, which is used to repeat a region of content for each item in an array. This is an example of a directive, which I describe in Chapters 12–16 (directives are a big part of Angular development). The *ngFor expression is applied to an an attribute of an element, like this:

```
...
<tr *ngFor="let item of getTodoItems(); let i = index">
...
```

This expression tells Angular to treat the tr element to which it has been applied as a template that should be repeated for every object returned by the component's getTodoItems method. The let item part of the expression specifies that each object should be assigned to a variable called item, so that it can be referred to within the template.

The ngFor expression also keeps track of the index of the current object in the array that is being processed, and this is assigned to a second variable called i:

```
...
<tr *ngFor="let item of getTodoItems(); let i = index">
...
```

The result is that the tr element and its contents will be duplicated and inserted into the HTML document for each object returned by the getTodoItems method; for each iteration, the current to-do object can be accessed through the variable called item, and the position of the object in the array can be accessed through the variable called i.

■ **Tip** It is important to remember the * character when using *ngFor. I explain what it means in Chapter 16.

Within the tr template, there are two data bindings, which can be recognized by the {{ and }} characters, as follows:

```
...
<td>{{ i + 1 }}</td>
<td>{{ item.action }}</td>
...
```

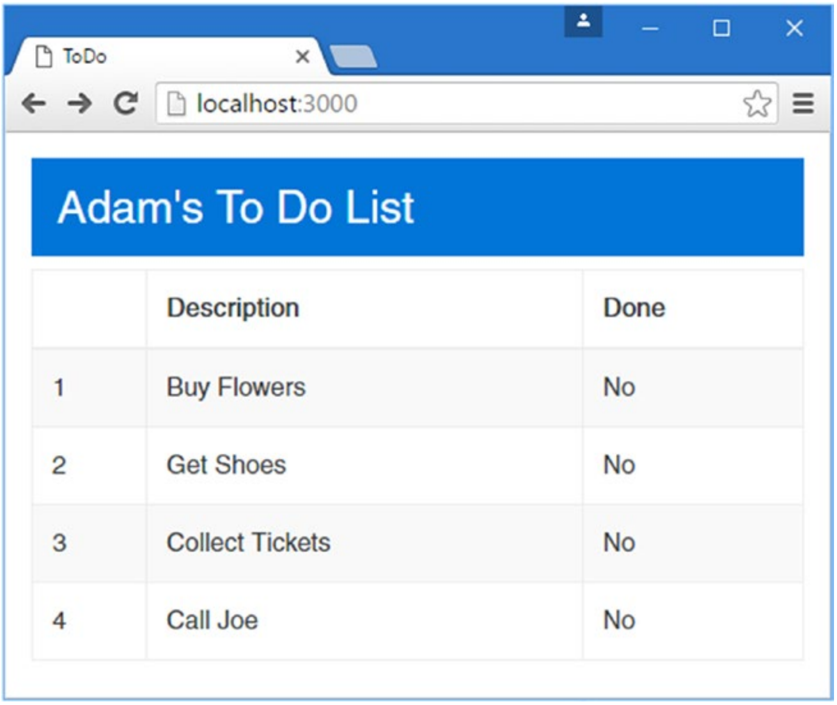
These bindings refer to the variables that are created by the *ngFor expression. Bindings are not just used to refer to property and method names; they can also be used to perform simple operations. You can see an example of this in the first binding, where I sum the i variable and 1.

■ **Tip** For simple transformations, you can embed your JavaScript expressions directly in bindings like this, but for more complex operations, Angular has a feature called *pipes*, which I describe in Chapter 18.

The remaining template expressions in the tr template demonstrate how content can be generated selectively.

```
...
<td [ngSwitch]="item.done">
    <span *ngSwitchCase="true">Yes</span>
    <span *ngSwitchDefault>No</span>
</td>
...
```

The [ngSwitch] expression is a conditional statement that is used to insert different sets of elements into the document based on a specified value, which is the item.done property in this case. Nested within the td element are two span elements that have been annotated with *ngSwitchCase and *ngSwitchDefault and that are equivalent to the case and default keywords of a regular JavaScript switch block. I describe ngSwitch in detail in Chapter 13 (and what the square brackets mean in Chapter 12), but the result is that the first span element is added to the document when the value of the item.done property is true and the second span element is added to the document when item.done is false. The result is that the true/false value of the item.done property is transformed into span elements containing either Yes or No. When you save the changes to the template, the browser will reload, and the table of to-do items will be displayed, as shown in Figure 2-5.



Adam's To Do List

	Description	Done
1	Buy Flowers	No
2	Get Shoes	No
3	Collect Tickets	No
4	Call Joe	No

Figure 2-5. *Displaying the table of to-do items*

If you use the browser's F12 developer tools, you will be able to see the HTML content that the template has generated. (You can't do this looking at the page source, which just shows the HTML sent by the server and not the changes made by Angular using the DOM API.)

You can see how each to-do object in the model has produced a row in the table that is populated with the `local` item and `i` variables and how the switch expression shows `Yes` or `No` to indicate whether the task has been completed.

```
...
<tr>
    <td>2</td>
    <td>Get Shoes</td>
    <td><span>No</span></td>
</tr>
<tr>
    <td>3</td>
    <td>Collect Tickets</td>
    <td><span>Yes</span></td>
</tr>
...
```

Creating a Two-Way Data Binding

At the moment, the template contains only *one-way data bindings*, which means they are used to display a data value but do nothing to change it. Angular also supports *two-way data bindings*, which can be used to display a data value and update it, too. Two-way bindings are used with HTML form elements, and Listing 2-16 adds a checkbox `input` element to the template that will let users mark a to-do item as complete.

Listing 2-16. Adding a Two-Way Binding in the app.component.html File

```
<h3 class="bg-primary p-a-1">{{getName()}}'s To Do List</h3>

<table class="table table-striped table-bordered">
    <thead>
        <tr><th></th><th>Description</th><th>Done</th></tr>
    </thead>
    <tbody>
        <tr *ngFor="let item of getTodoItems(); let i = index">
            <td>{{i + 1}}</td>
            <td>{{item.action}}</td>
            <td><input type="checkbox" [(ngModel)]="item.done" /></td>
            <td [ngSwitch]="item.done">
                <span *ngSwitchCase="true">Yes</span>
                <span *ngSwitchDefault>No</span>
            </td>
        </tr>
    </tbody>
</table>
```

The `ngModel` template expression creates a two-way binding between a data value (the `item.done` property in this case) and a form element. When you save the changes to the template, you will see a new column that contains checkboxes appear in the table. The initial value of the checkbox is set using the `item.done` property, just like a regular one-way binding, but when the user toggles the checkbox, Angular responds by updating the specified model property.

To demonstrate how this works, I have left the column that contains the `Yes`/`No` display of the done property value generated using the `ngSwitch` expression in the template. When you toggle a checkbox, the corresponding `Yes`/`No` value changes as well, as illustrated in Figure 2-6.

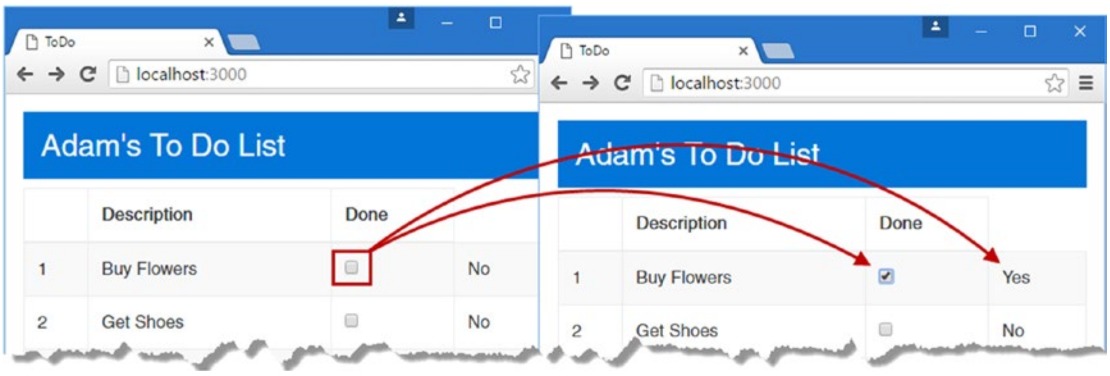


Figure 2-6. *Changing a model value using a two-way data binding*

This reveals an important Angular feature, which is that the data model is *live*. This means that data bindings—even one-way data bindings—are updated when the data model is changed. This simplifies web application development because it means you don't have to worry about ensuring that you display updates when the application state changes.

Filtering To-Do Items

The checkboxes allow the data model to be updated, and the next step is to remove to-do items once they have been marked as done. Listing 2-17 changes the component's `getTodoItems` method so that it filters out any items that have been completed.

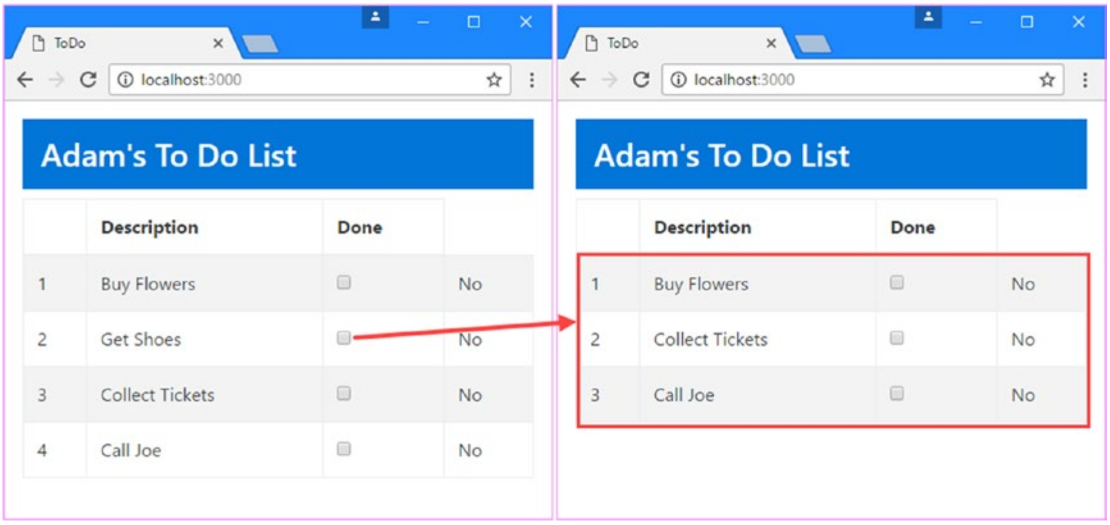
Listing 2-17. Filtering To-Do Items in the app.component.ts File

```
import { Component } from "@angular/core";
import { Model } from "./model";

@Component({
    selector: "todo-app",
    templateUrl: "app/app.component.html"
})
export class AppComponent {
    model = new Model();

    getName() {
        return this.model.user;
    }

    getTodoItems() {
        return this.model.items.filter(item => !item.done);
    }
}
```

This is an example of a lambda function, also known as a fat arrow function, which is a more concise way of expressing a standard JavaScript function. The arrow in the lambda expressions is read as "goes to" such as "`item` goes to not `item.done`." Lambda expressions are a recent addition to the JavaScript language specification, and they provide an alternative to the conventional way of using functions as arguments like this:

```
...
return this.model.items.filter(function (item) { return !item.done });
...
```

Whichever way you choose to define the expression passed to the `filter` method, the result is that only incomplete to-do items are displayed. Since the data model is live and changes are reflected in data bindings immediately, checking the checkbox for an item removes it from view, as shown in Figure 2-7.



Adam's To Do List

	Description	Done	
1	Buy Flowers	☐	No
2	Get Shoes	☐	No
3	Collect Tickets	☐	No
4	Call Joe	☐	No

Adam's To Do List

	Description	Done	
1	Buy Flowers	☐	No
2	Collect Tickets	☐	No
3	Call Joe	☐	No

Figure 2-7. *Filtering the to-do items*

Adding To-Do Items

The next step is to build on the basic functionality to allow the user to create new to-do items and store them in the data model. Listing 2-18 adds new elements to the component's template.

Listing 2-18. Adding Elements in the app.component.html File

```
<h3 class="bg-primary p-a-1">{{getName()}}'s To Do List</h3>
<div class="m-t-1 m-b-1">
    <input class="form-control" #todoText />
    <button class="btn btn-primary m-t-1" (click)="addItem(todoText.value)">
        Add
    </button>
</div>
<table class="table table-striped table-bordered">
    <thead>
        <tr><th></th><th>Description</th><th>Done</th></tr>
    </thead>
    <tbody>
        <tr *ngFor="let item of getTodoItems(); let i = index">
            <td>{{i + 1}}</td>
            <td>{{item.action}}</td>
            <td><input type="checkbox" [(ngModel)]="item.done" /></td>
            <td [ngSwitch]="item.done">
                <span *ngSwitchCase="true">Yes</span>
                <span *ngSwitchDefault>No</span>
            </td>
        </tr>
    </tbody>
</table>
```

The `input` element has an attribute whose name starts with the # character, which is used to define a variable to refer to the element in the template's data bindings. The variable is called `todoText`, and it is used by the binding that has been applied to the `button` element.

```
...
<button class="btn btn-primary m-t-1" (click)="addItem(todoText.value)">
...
```

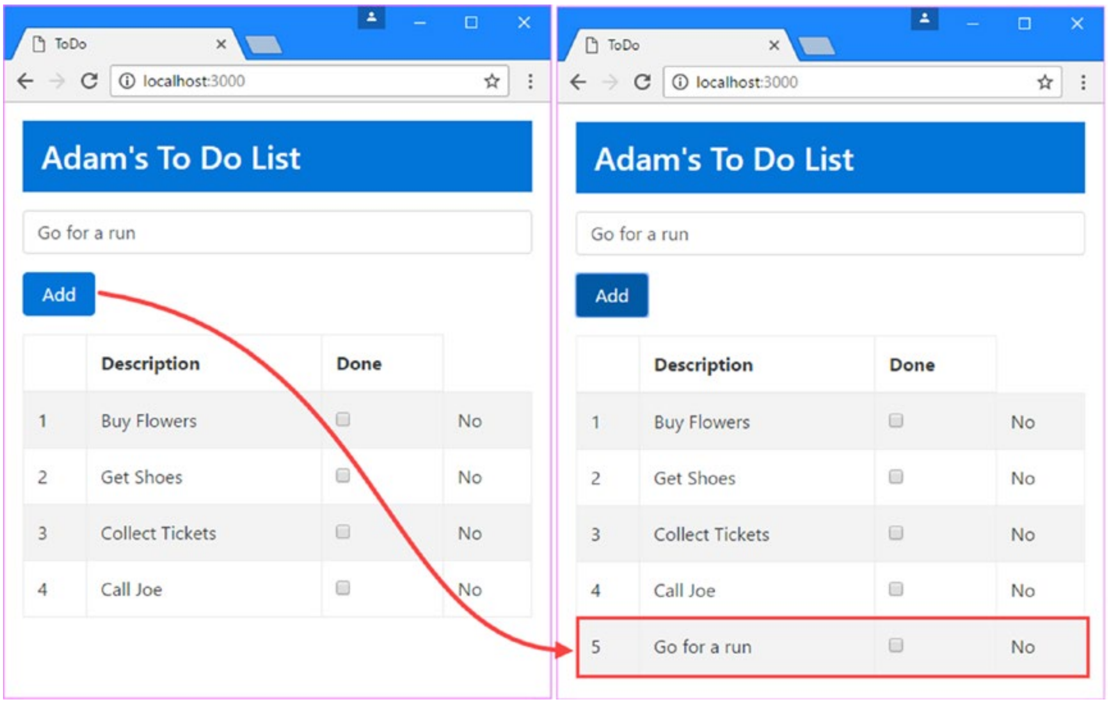
This is an example of an *event binding*, and it tells Angular to invoke a component method called `addItem`, using the `value` property of the `input` element as the method argument. Listing 2-19 implements the `addItem` method in the component.

■ **Tip** Don't worry about telling the bindings apart at the moment. I explain the different types of binding that Angular supports in Part 2 and the meaning of the different types of brackets or parentheses that each requires. They are not as complicated as they first appear, especially once you have seen how they fit into the rest of the Angular framework.

Listing 2-19. Adding a Method in the app.component.ts File

```
import { Component } from "@angular/core";
import { Model, TodoItem } from "./model";

@Component({
    selector: "todo-app",
    templateUrl: "app/app.component.html"
})
export class AppComponent {
    model = new Model();

    getName() {
        return this.model.user;
    }

    getTodoItems() {
        return this.model.items.filter(item => !item.done);
    }

    addItem(newItem) {
        if (newItem != "") {
            this.model.items.push(new TodoItem(newItem, false));
        }
    }
}
```

The `import` keyword can be used to import multiple classes from a module, and one of the `import` statements in the listing has been updated so that the `TodoItem` class can be used in the component. Within the component class, the `addItem` method receives the text sent by the event binding in the template and uses it to create a new `TodoItem` object and add it to the data model. The result of these changes is that you can create new to-do items by entering text in the `input` element and clicking the Add button, as shown in Figure 2-8.



	Description	Done	
1	Buy Flowers	☐	No
2	Get Shoes	☐	No
3	Collect Tickets	☐	No
4	Call Joe	☐	No

	Description	Done	
1	Buy Flowers	☐	No
2	Get Shoes	☐	No
3	Collect Tickets	☐	No
4	Call Joe	☐	No
5	Go for a run	☐	No

Figure 2-8. *Creating a to-do item*

Summary

In this chapter, I showed you how to create your first simple Angular app, moving from an HTML mock-up of the application to a dynamic app that lets the user create new to-do items and mark existing items as complete.

Don't worry if not everything in this chapter makes sense. What's important to understand at this stage is the general shape of an Angular application, which is built around a data model, components, and templates. If you keep these three key building blocks in mind, then you will have a context for everything that follows. In the next chapter, I put Angular in context.

CHAPTER 3

Putting Angular in Context

In this chapter, I put Angular in context within the world of web app development and set the foundation for the chapters that follow. The goal of Angular is to bring the tools and capabilities that have been available only for server-side development to the web client and, in doing so, make it easier to develop, test, and maintain rich and complex web applications.

Angular works by allowing you to *extend* HTML, which can seem like an odd idea until you get used to it. Angular applications express functionality through custom elements, and a complex application can produce an HTML document that contains a mix of standard and custom markup.

The style of development that Angular supports is derived through the use of the *Model-View-Controller* (MVC) pattern, although this is sometimes referred to as Model-View-*Whatever*, since there are countless variations on this pattern that can be adhered to when using Angular. I am going to focus on the standard MVC pattern in this book since it is the most established and widely used. In the sections that follow, I explain the characteristics of projects where Angular can deliver significant benefit (and those where better alternatives exist), describe the MVC pattern, and describe some common pitfalls.

THIS BOOK AND THE ANGULAR RELEASE SCHEDULE

Google has adopted an aggressive release schedule for Angular, starting with Angular 2.0. This means that there will be an ongoing stream of minor releases and a major release every six months. Minor releases should not break any existing features and should largely contain bug fixes. The major releases will contain substantial changes and may not offer backward compatibility. This schedule means that Angular 2.0 was released in September 2016 and will be followed by Angular 4.0 and Angular 5.0 in March and September 2017. (There will be no Angular 3.0 and Angular 2.0 will be followed directly by Anglar 4.0)

It doesn't seem fair or reasonable to ask readers to buy a new edition of this book every six months, especially since the majority of Angular features are unlikely to change even in a major release. Instead, I am going to post updates following the major releases to the GitHub repository for this book, for which there is a link on `apress.com`.

This is an experiment for me (and for Apress), and I don't yet know what form those updates may take—not least because I don't know what the major releases of Angular will contain—but the goal is to extend the life of this book by supplementing the examples it contains.

I am not making any promises about what the updates will be like, what form they will take, or how long I will produce them before folding them into a new edition of this book. Please keep an open mind and check the repository for this book when new Angular versions are released. If you have ideas about how the updates could be improved as the experiment unfolds, then email me at `adam@adam-freeman.com` and let me know.

Understanding Where Angular Excels

Angular isn't the solution to every problem, and it is important to know when you should use Angular and when you should seek an alternative.

Angular delivers the kind of functionality that used to be available only to server-side developers, but entirely in the browser. This means Angular has a lot of work to do each time an HTML document to which Angular has been applied is loaded—the HTML elements have to be compiled, the data bindings have to be evaluated, components and other building blocks need to be executed, and so on, building support for the features I described in Chapter 2 and those that I describe later in this book.

This kind of work takes time to perform, and the amount of time depends on the complexity of the HTML document, on the associated JavaScript code, and—critically—on quality of the browser and the processing capability of the device. You won't notice any delay when using the latest browsers on a capable desktop machine, but old browsers on underpowered smartphones can really slow down the initial setup of an Angular app.

The goal, therefore, is to perform this setup as infrequently as possible and deliver as much of the app as possible to the user when it is performed. This means giving careful thought to the kind of web application you build. In broad terms, there are two kinds of web application: *round-trip* and *single-page*.

Understanding Round-Trip and Single-Page Applications

For a long time, web apps were developed to follow a *round-trip* model. The browser requests an initial HTML document from the server. User interactions—such as clicking a link or submitting a form—led the browser to request and receive a completely new HTML document. In this kind of application, the browser is essentially a rending engine for HTML content, and all of the application logic and data resides on the server. The browser makes a series of stateless HTTP requests that the server handles by generating HTML documents dynamically.

A lot of current web development is still for round-trip applications, not least because they require little from the browser, which ensures the widest possible client support. But there are some serious drawbacks to round-trip applications: They make the user wait while the next HTML document is requested and loaded, they require a large server-side infrastructure to process all the requests and manage all the application state, and they require a lot of bandwidth because each HTML document has to be self-contained (leading to a lot of the same content being included in each response from the server).

Single-page applications take a different approach. An initial HTML document is sent to the browser, but user interactions lead to Ajax requests for small fragments of HTML or data inserted into the existing set of elements being displayed to the user. The initial HTML document is never reloaded or replaced, and the user can continue to interact with the existing HTML while the Ajax requests are being performed asynchronously, even if that just means seeing a "data loading" message.

Most current apps fall somewhere between the extremes, tending to use the basic round-trip model enhanced with JavaScript to reduce the number of complete page changes, although the emphasis is often on reducing the number of form errors by performing client-side validation.

Angular gives the greatest return from its initial workload as an application gets closer to the single-page model. That's not to say you can't use Angular with round-trip applications—you can, of course—but there are other technologies that are simpler and better suit discrete HTML pages, either working directly with the Document Object Model (DOM) API or using a library to simplify its use, such as jQuery. In Figure 3-1 you can see the spectrum of web application types and where Angular delivers benefit.

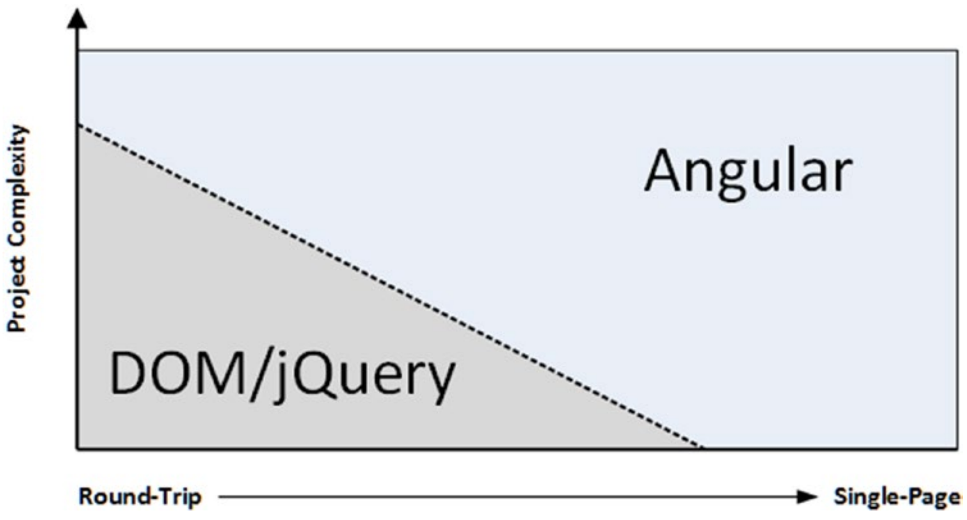


Figure 3-1. *Angular is well-suited to single-page web apps*

Angular excels in single-page applications and especially in complex round-trip applications. For simpler projects, using the DOM API directly or a library like jQuery is generally a better choice, although nothing prevents you from using Angular in all of your projects.

There is a gradual tendency for current web app projects to move toward the single-page application model, and that's the sweet spot for Angular, not just because of the initialization process but because the benefits of using the MVC pattern (which I describe later in this chapter) really start to manifest themselves in larger and more complex projects, which are the ones pushing toward the single-page model.

■ **Tip** This may seem like circular reasoning, but Angular and similar frameworks have arisen because complex web applications are difficult to write and maintain. The problems these projects face led to the development of industrial-strength tools like Angular, which then enable the next generation of complex projects. Think of it less as circular reasoning and more of a virtuous circle.

ANGULAR AND JQUERY

Angular and jQuery take different approaches to web app development. jQuery is all about explicitly manipulating the browser's Document Object Model (DOM) to create an application. The approach that Angular takes is to co-opt the browser into being the foundation for application development.

jQuery is, without any doubt, a powerful tool—and one I love to use. jQuery is robust and reliable, and you can get results pretty much immediately. I especially like the fluid API and the ease with which you can extend the core jQuery library. If you want more information about jQuery, then see my book *Pro jQuery*, which is published by Apress and provides detailed coverage of jQuery, jQuery UI, and jQuery Mobile.

But as much as I love jQuery, it isn't the right tool for every job any more than Angular is. It can be hard to write and manage large applications using jQuery, and thorough unit testing can be a challenge.

Angular also uses the DOM to present HTML content to users but takes an entirely different path to building applications, focusing more on the data in the application and associating it to HTML elements through dynamic data bindings.

The main drawback of Angular is that there is an up-front investment in development time before you start to see results—something that is common in any MVC-based development. This initial investment is worthwhile, however, for complex apps or those that are likely to require significant revision and maintenance.

So, in short, use jQuery (or use the DOM API directly) for low-complexity web apps where unit testing isn't critical and you require immediate results. Use Angular for single-page web apps, when you have time for careful design and planning and when you can easily control the HTML generated by the server.

Understanding the MVC Pattern

The term *Model-View-Controller* has been in use since the late 1970s and arose from the Smalltalk project at Xerox PARC where it was conceived as a way to organize some early GUI applications. Some of the fine detail of the original MVC pattern was tied to Smalltalk-specific concepts, such as *screens* and *tools*, but the broader ideas are still applicable to applications, and they are especially well-suited to web applications.

The MVC pattern first took hold in the server-side end of web development, through toolkits like Ruby on Rails and the ASP.NET MVC Framework. In recent years, the MVC pattern has been seen as a way to manage the growing richness and complexity of client-side web development as well, and it is in this environment that Angular has emerged.

The key to applying the MVC pattern is to implement the key premise of a *separation of concerns*, in which the data model in the application is decoupled from the business and presentation logic. In client-side web development, this means separating the data, the logic that operates on that data, and the HTML elements used to display the data. The result is a client-side application that is easier to develop, maintain, and test.

The three main building blocks are the *model*, the *controller*, and the *view*. In Figure 3-2, you can see the traditional exposition of the MVC pattern as it applies to server-side development.

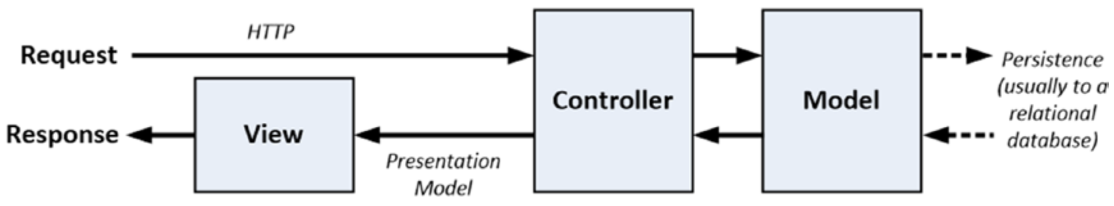


Figure 3-2. *The server-side implementation of the MVC pattern*

I took this figure from my *Pro ASP.NET Core MVC* book, which describes Microsoft's server-side implementation of the MVC pattern. You can see that the expectation is that the model is obtained from a database and that the goal of the application is to service HTTP requests from the browser. This is the basis for round-trip web apps, which I described earlier.

Of course, Angular exists in the browser, which leads to a twist on the MVC theme, as illustrated in Figure 3-3.

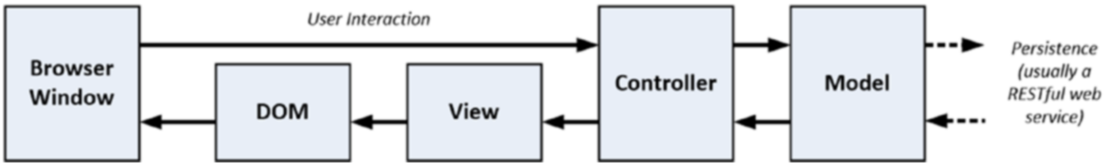


Figure 3-3. *A client-side implementation of the MVC pattern*

The client-side implementation of the MVC pattern gets its data from server-side components, usually via a RESTful web service, which I describe in Chapter 24. The goal of the controller and the view is to operate on the data in the model in order to perform DOM manipulation so as to create and manage HTML elements that the user can interact with. Those interactions are fed back to the controller, closing the loop to form an interactive application.

Angular uses slightly different terminology for its building blocks, which means that the MVC model implemented using Angular looks more like Figure 3-4.

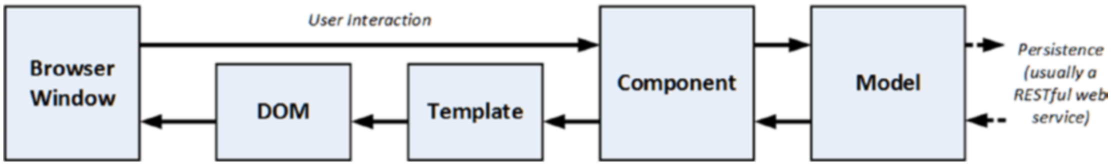


Figure 3-4. *The Angular implementation of the MVC pattern*

The figure shows the basic mapping of Angular building blocks to the MVC pattern. To support the MVC pattern, Angular provides a broad set of additional features, which I describe throughout the book.

■ **Tip** Using a client-side framework like Angular doesn't preclude using a server-side MVC framework, but you'll find that an Angular client takes on some of the complexity that would have otherwise existed at the server. This is generally a good thing because it offloads work from the server to the client, and that allows for more clients to be supported with less server capacity.

PATTERNS AND PATTERN ZEALOTS

A good pattern describes an approach to solving a problem that has worked for *other* people on *other* projects. Patterns are recipes, rather than rules, and you will need to adapt any pattern to suit your specific projects, just like a cook has to adapt a recipe to suit different ovens and ingredients.

The degree by which you depart from a pattern should be driven by need and experience. The time you have spent applying a pattern to similar projects will inform your knowledge about what does and doesn't work for you. If you are new to a pattern or you are embarking on a new kind of project, then you should stick as closely as possible to the pattern until you truly understand the benefits and pitfalls that await you. Be careful not to reform your entire development effort around a pattern, however, since wide-sweeping disruption usually causes productivity loses that undermine whatever outcome you were hoping the pattern would give.

Patterns are flexible tools and not fixed rules, but not all developers understand the difference, and some become *pattern zealots*. These are the people who spend more time talking about the pattern than applying it to projects and consider any deviation from their interpretation of the pattern to be a serious crime. My advice is to simply ignore this kind of person because any kind of engagement will just suck the life out of you, and you'll never be able to change their minds. Instead, just get on with some work and demonstrate how a flexible application of a pattern can produce good results through practical application and delivery.

With this in mind, you will see that I follow the broad concepts of the MVC pattern in the examples in this book but that I adapt the pattern to demonstrate different features and techniques. And this is how I work in my own projects—embracing the parts of patterns that provide value and setting aside those that do not.

Understanding Models

Models—the *M* in *MVC*—contain the data that users work with. There are two broad types of model: *view models,* which represent just data passed from the component to the template, and *domain models,* which contain the data in a business domain, along with the operations, transformations, and rules for creating, storing, and manipulating that data, collectively referred to as the *model logic*.

■ **Tip** Many developers new to the MVC pattern get confused with the idea of including logic in the data model, believing that the goal of the MVC pattern is to separate data from logic. This is a misapprehension: The goal of the MVC framework is to divide up an application into three functional areas, each of which may contain both logic *and* data. The goal isn't to eliminate logic from the model. Rather, it is to ensure that the model contains logic only for creating and managing the model data.

You can't read a definition of the MVC pattern without tripping over the word *business*, which is unfortunate because a lot of web development goes far beyond the line-of-business applications that led to this kind of terminology. Business applications are still a big chunk of the development world, however, and if you are writing, say, a sales accounting system, then your business domain would encompass the process related to sales accounting and your domain model would contain the accounts data and the logic by which accounts are created, stored, and managed. If you are creating a cat video web site, then you still have a business domain; it is just that it might not fit within the structure of a corporation. Your domain model would contain the cat videos and the logic that will create, store, and manipulate those videos.

Many Angular models will effectively push the logic to the server side and invoke it via a RESTful web service because there is little support for data persistence within the browser and it is simply easier to get the data you require over Ajax. I explain how Angular can be used with RESTful web services in Chapter 24.

■ **Tip** There *are* client-side persistence APIs defined as part of the HTML5 standard effort. The quality of these standards is currently mixed, and the implementations vary in quality. The main problem, however, is that most users still rely on browsers that don't implement the new APIs, and this is especially true in corporate environments, where older versions of Internet Explorer are still widely used because of problems migrating line-of-business applications to standard versions of HTML. If you are interested in client-side persistence, then the best place to start is the IndexedDB specification, which can be found at `https://www.w3.org/TR/IndexedDB`.

For each element in the MVC pattern, I'll describe what should and should not be included. The model in an application built using the MVC pattern *should*

- Contain the domain data
- Contain the logic for creating, managing, and modifying the domain data (even if that means executing remote logic via web services)
- Provide a clean API that exposes the model data and operations on it

The model *should not*

- Expose details of how the model data is obtained or managed (in other words, details of the data storage mechanism or the remote web service should not be exposed to controllers and views)
- Contain logic that transforms the model based on user interaction (because this is the component's job)
- Contain logic for displaying data to the user (this is the template's job)

The benefits of ensuring that the model is isolated from the controller and views are that you can test your logic more easily (I describe Angular unit testing in Chapter 29) and that enhancing and maintaining the overall application is simpler and easier.

The best domain models contain the logic for getting and storing data persistently and the logic for create, read, update, and delete operations (known collectively as CRUD) or separate models for querying and modifying data, known as the Command and Query Responsibility Segregation (CQRS) pattern.

This can mean the model contains the logic directly, but more often the model will contain the logic for calling RESTful web services to invoke server-side database operations (which I demonstrate in Chapter 8 when I build a realistic Angular application and which I describe in detail in Chapter 24).

ANGULAR VS ANGULARJS

Angular—also known as Angular 2—is the second major release of the framework originally known as AngularJS. The original AngularJS has been widely popular but was awkward to use and required developers to deal with some arcane and oddly implemented features that made web application development more complex than it needed to be.

Angular, which is the topic of this book, is a complete rewrite that is easier to learn, is easier to work with, and is much more consistent. It is still a complex framework, as the size of this book shows, but creating web applications with Angular is a more pleasant experience than with AngularJS.

The differences between AngularJS and Angular are so profound that I have not included any migration details in this book. If you have an AngularJS application that you want to upgrade to Angular, then you can use the upgrade adapter, which allows code from both versions of the framework to coexist in the same application. See `https://angular.io/docs/ts/latest/guide/upgrade.html` for details. This can ease the transition, although AngularJS and Angular are so different that my advice is to make a clean start and switch to Angular for a ground-up rewrite. This isn't always possible, of course, especially for complex applications, but the process of migrating while also managing coexistence is a difficult one to master and can lead to problems that are hard to track down and correct.

Understanding Controllers/Components

Controllers, which are known as components in Angular, are the connective tissue in an Angular web app, acting as conduits between the data model and views. Components add business domain logic required to present some aspect of the model and perform operations on it. A component that follows the MVC pattern *should*

- Contain the logic required to set up the initial state of the template
- Contain the logic/behaviors required by the template to present data from the model
- Contain the logic/behaviors required to update the model based on user interaction

A component *should not*

- Contain logic that manipulates the DOM (that is the job of the template)
- Contain logic that manages the persistence of data (that is the job of the model)

Understanding View Data

The domain model isn't the only data in an Angular application. Components can create *view data* (also known as *view model data* or *view models*) to simplify templates and their interactions with the component.

Understanding Views/Templates

Views, which are known as templates in Angular, are defined using HTML elements that are enhanced by data bindings. It is the data bindings that make Angular so flexible, and they transform HTML elements into the foundation for dynamic web applications. I explain the different types of data bindings that Angular provides in detail in Part 2. Templates *should*

- Contain the logic and markup required to present data to the user

Templates *should not*

- Contain complex logic (this is better placed in a component or one of the other Angular building blocks, such as directives, services, or pipes)
- Contain logic that creates, stores, or manipulates the domain model

Templates *can* contain logic, but it should be simple and used sparingly. Putting anything but the simplest method calls or expressions in a template makes the overall application harder to test and maintain.

Understanding RESTful Services

The logic for domain models in Angular apps is often split between the client and the server. The server contains the persistent store, typically a database, and contains the logic for managing it. In the case of a SQL database, for example, the required logic would include opening connections to the database server, executing SQL queries, and processing the results so they can be sent to the client.

You don't want the client-side code accessing the data store directly—doing so would create a tight coupling between the client and the data store that would complicate unit testing and make it difficult to change the data store without also making changes to the client code as well.

By using the server to mediate access to the data store, you prevent tight coupling. The logic on the client is responsible for getting the data to and from the server and is unaware of the details of how that data is stored or accessed behind the scenes.

There are lots of ways of passing data between the client and the server. One of the most common is to use *Asynchronous JavaScript and XML* (Ajax) requests to call server-side code, getting the server to send JSON and making changes to data using HTML forms.

This approach can work well and is the foundation of *RESTful web services*, which use the nature of HTTP requests to perform CRUD operations on data.

■ **Note** REST is a style of API rather than a well-defined specification, and there is disagreement about what exactly makes a web service RESTful. One point of contention is that purists do not consider web services that return JSON to be RESTful. Like any disagreement about an architectural pattern, the reasons for the disagreement are arbitrary and dull and not at all worth worrying about. As far as I am concerned, JSON services *are* RESTful, and I treat them as such in this book.

In a RESTful web service, the operation that is being requested is expressed through a combination of the HTTP method and the URL. So, for example, imagine a URL like this one:

```
http://myserver.mydomain.com/people/bob
```

There is no standard URL specification for a RESTful web service, but the idea is to make the URL self-explanatory, such that it is obvious what the URL refers to. In this case, it is obvious that there is a collection of data objects called `people` and that the URL refers to the specific object within that collection whose identity is `bob`.

■ **Tip** It isn't always possible to create such self-evident URLs in a real project, but you should make a serious effort to keep things simple and not expose the internal structure of the data store through the URL (because this is just another kind of coupling between components). Keep your URLs as simple and clear as possible, and keep the mappings between the URL format and the data store structure within the server.

The URL identifies the data object that I want to operate on, and the HTTP method specifies what operation I want performed, as described in Table 3-1.

Table 3-1. *The Operations Commonly Performed in Response to HTTP Methods*

Method	Description
`GET`	Retrieves the data object specified by the URL
`PUT`	Updates the data object specified by the URL
`POST`	Creates a new data object, typically using form data values as the data fields
`DELETE`	Deletes the data object specified by the URL

You don't have to use the HTTP methods to perform the operations I describe in the table. A common variation is that the POST method is often used to serve double duty and will update an object if one exists and create one if not, meaning that the PUT method isn't used. I describe the support that Angular provides for Ajax and for easily working with RESTful services in Chapter 24.

IDEMPOTENT HTTP METHODS

You can implement any mapping between HTTP methods and operations on the data store, although I recommend you stick as closely as possible to the convention I describe in the table.

If you depart from the normal approach, make sure you honor the nature of the HTTP methods as defined in the HTTP specification. The GET method is *nullipotent*, which means that the operations you perform in response to this method should only retrieve data and not modify it. A browser (or any intermediate device, such as a proxy) expects to be able to repeatedly make a GET request without altering the state of the server (although this doesn't mean the state of the server won't change between identical GET requests because of requests from other clients).

The PUT and DELETE methods are *idempotent*, which means that multiple identical requests should have the same effect as a single request. So, for example, using the DELETE method with the `/people/bob` URL should delete the `bob` object from the `people` collection for the first request and then do nothing for subsequent requests. (Again, of course, this won't be true if another client re-creates the `bob` object.)

The POST method is neither nullipotent nor idempotent, which is why a common RESTful optimization is to handle object creation *and* updates. If there is no `bob` object, using the POST method will create one, and subsequent POST requests to the same URL will update the object that was created.

All of this is important only if you are implementing your own RESTful web service. If you are writing a client that consumes a RESTful service, then you just need to know what data operation each HTTP method corresponds to. I demonstrate consuming such a service in Chapter 8 and describe the Angular features for HTTP requests in more detail in Chapter 24.

Common Design Pitfalls

In this section, I describe the three most common design pitfalls that I encounter in Angular projects. These are not coding errors but rather problems with the overall shape of the web app that prevent the project team from getting the benefits that Angular and the MVC pattern can provide.

Putting the Logic in the Wrong Place

The most common problem is logic put into the wrong component such that it undermines the MVC separation of concerns. Here are the three most common varieties of this problem:

- Putting business logic in templates, rather than in components
- Putting domain logic in components, rather than in the model
- Putting data store logic in the client model when using a RESTful service

These are tricky issues because they take a while to manifest themselves as problems. The application still runs, but it will become harder to enhance and maintain over time. In the case of the third variety, the problem will become apparent only when the data store is changed (which rarely happens until a project is mature and has grown beyond its initial user projections).

■ **Tip** Getting a feel for where logic should go takes some experience, but you'll spot problems earlier if you are using unit testing because the tests you have to write to cover the logic won't fit nicely into the MVC pattern. I describe the Angular support for unit testing in Chapter 29.

Knowing where to put logic becomes second nature as you get more experience in Angular development, but here are the three rules:

- Template logic should prepare data only for display and never modify the model.
- Component logic should never directly create, update, or delete data from the model.
- The templates and components should never directly access the data store.

If you keep these in mind as you develop, you'll head off the most common problems.

Adopting the Data Store Data Format

The next problem arises when the development team builds an application that depends on the quirks of the server-side data store. I recently worked with a project team that had built their client so that it honored the data format quirks of their SQL database server. The problem they ran into—and the reason why I was involved—was they needed to upgrade to a more robust database, which used different representations for key data types.

In a well-designed Angular application that gets its data from a RESTful service, it is the job of the server to hide the data store implementation details and present the client with data in a suitable data format that favors simplicity in the client. Decide how the client needs to represent dates, for example, and then ensure you use that format within the data store—and if the data store can't support that format natively, then it is the job of the server to perform the translation.

Just Enough Knowledge to Cause Trouble

Angular is a complex framework that can be bewildering until you get used it. There are lots of different building blocks available, and they can be combined in different ways to achieve the similar results. This makes Angular development flexible and means you will develop your own style of problem-solving by creating combinations of features that suit your project and working style.

The problem this presents, however, is that becoming proficient in Angular takes time. The temptation is to jump into creating your own projects before understanding how the different parts of Angular fit together. You might produce something that works without really understanding why it works, and that's a recipe for disaster when you need to make changes. My advice is to go slow and take the time to understand all the features that Angular provides. By all means start creating projects early, but make sure you really understand how they work and be prepared to make changes as you find better ways of achieving the results you require.

Summary

In this chapter, I provided some context for Angular. I described the kinds of project where it makes sense to use Angular (and where it doesn't), I explained how Angular supports the MVC pattern for app development, and I gave a brief overview of REST and how it is used to express data operations over HTTP requests. I finished the chapter by describing the three most common design problems in Angular projects. In the next chapter, I provide a quick primer for HTML and the Bootstrap CSS framework that I use for examples throughout this book.

CHAPTER 4

An HTML and CSS Primer

Developers come to the world of web app development via many paths and are not always grounded in the basic technologies that web apps rely on. In this chapter, I provide a brief primer for HTML and introduce the Bootstrap CSS library, which I use to style the examples in this book. In Chapters 5 and 6, I introduce the basics of JavaScript and TypeScript and give you the information you need to understand the examples in the rest of the book. If you are an experienced developer, you can skip these primer chapters and jump right to Chapter 7, where I use Angular to create a more complex and realistic application.

Preparing the Example Project

For this chapter, I need only a simple example project. I started by creating a folder called `HtmlCssPrimer`, created a file called `package.json` within it, and added the content shown in Listing 4-1.

Listing 4-1. The Contents of the package.json File in the HtmlCssPrimer Folder

```
{
  "dependencies": {
    "bootstrap": "4.0.0-alpha.4"
  },

  "devDependencies": {
    "lite-server": "2.2.2"
  },

  "scripts": {
    "start": "npm run lite",
    "lite": "lite-server"
  }
}
```

Run the following command within the `HtmlCssPrimer` folder to download and install the NPM packages specified in the `package.json` file:

```
npm install
```

Next, I created a file called `index.html` in the `HtmlCssPrimer` folder and added the content shown in Listing 4-2.

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A. Freeman, *Pro Angular*, DOI 10.1007/978-1-4842-2307-9_4

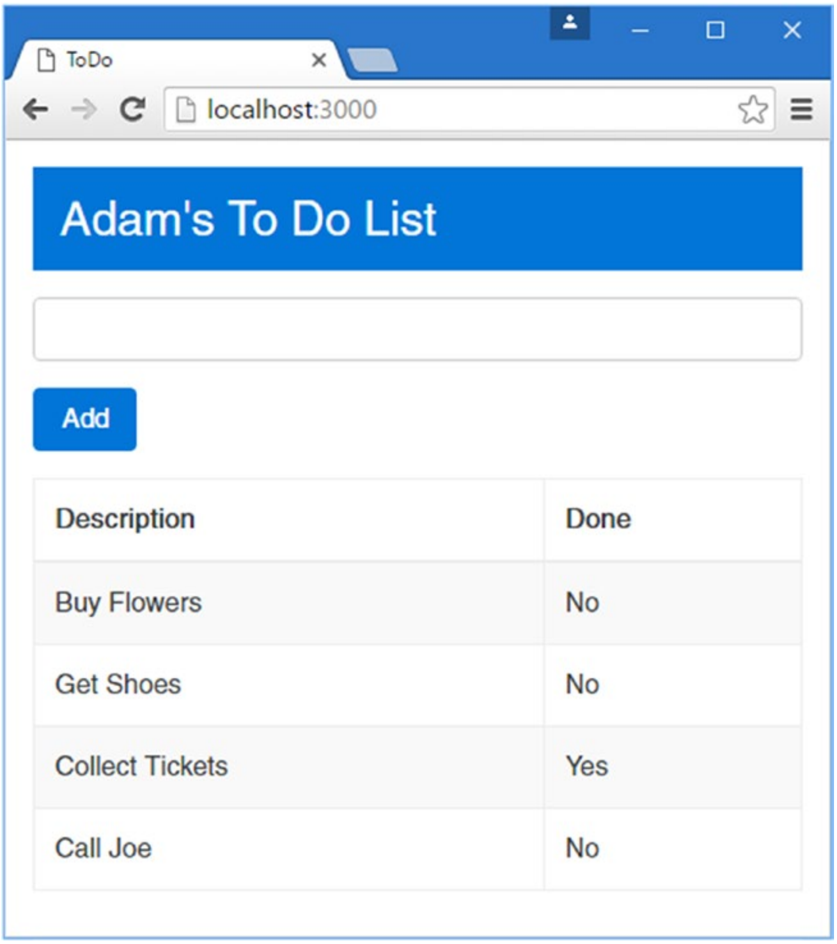
Listing 4-2. The Contents of the index.html File in the HtmlCssPrimer Folder

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
</head>
<body class="m-a-1">

    <h3 class="bg-primary p-a-1">Adam's To Do List</h3>

    <div class="m-t-1 m-b-1">
        <input class="form-control" />
        <button class="btn btn-primary m-t-1">Add</button>
    </div>

    <table class="table table-striped table-bordered">
        <thead>
            <tr>
                <th>Description</th>
                <th>Done</th>
            </tr>
        </thead>
        <tbody>
            <tr><td>Buy Flowers</td><td>No</td></tr>
            <tr><td>Get Shoes</td><td>No</td></tr>
            <tr><td>Collect Tickets</td><td>Yes</td></tr>
            <tr><td>Call Joe</td><td>No</td></tr>
        </tbody>
    </table>
</body>
</html>
```

This is the HTML content I used in Chapter 2 to mock up the appearance of the example application. Run the following command in the `HtmlCssPrimer` folder to start the development HTTP server:

```
npm start
```

A new browser tab or window will open and show the content in Figure 4-1.



Description	Done
Buy Flowers	No
Get Shoes	No
Collect Tickets	Yes
Call Joe	No

Figure 4-1. *Running the example application*

Understanding HTML

At the heart of HTML is the *element*, which tells the browser what kind of content each part of an HTML document represents. Here is an element from the example HTML document:

```
...
<td>Buy Flowers</td>
...
```

As illustrated by Figure 4-2, this element has three parts: the start tag, the end tag, and the content.

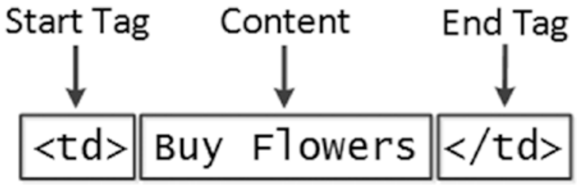


Figure 4-2. *The anatomy of a simple HTML element*

The *name* of this element (also referred to as the *tag name* or just the *tag*) is `td`, and it tells the browser that the content between the tags should be treated as a table cell. You start an element by placing the tag name in angle brackets (the < and > characters) and end an element by using the tag in a similar way, except that you also add a `/` character after the left-angle bracket (`<`). Whatever appears between the tags is the element's content, which can be text (such as `Buy Flowers` in this case) or other HTML elements.

Understanding Void Elements

The HTML specification includes elements that may not contain content. These are called *void* or *self-closing* elements, and they are written without a separate end tag, like this:

```
...
<input />
...
```

A void element is defined in a single tag, and you add a `/` character before the last angle bracket (the > character).

Understanding Attributes

You can provide additional information to the browser by adding *attributes* to your elements. Here is an element with an attribute from the example document:

```
...
<link href="node_modules/bootstrap/dist/css/bootstrap.min.css" rel="stylesheet" />
...
```

This is a `link` element, and it imports content into the document. There are two attributes, which I have emphasized so they are easier to see. Attributes are always defined as part of the start tag and have a *name* and a *value*.

The names of the two attributes in this example are `href` and `rel`. For the `link` element, the `href` attribute specifies the content to import, and the `rel` attribute tells the browser what kind of content it is. The attributes on this `link` element tell the browser to import the `bootstrap.min.css` file and to treat it as a style sheet, which is a file that contains CSS styles.

Applying Attributes Without Values

Not all attributes require a value; just defining them sends a signal to the browser that you want a certain kind of behavior associated with the element. Here is an example of an element with such an attribute (not from the example document; I just made up this example element):

```
...
<input class="form-control" required />
...
```

This element has two attributes. The first is `class`, which is assigned a value just like the previous example. The other attribute is just the word `required`. This is an example of an attribute that doesn't need a value.

Quoting Literal Values in Attributes

Angular relies on HTML element attributes to apply a lot of its functionality. Most of the time, the values of attributes are evaluated as JavaScript expressions, such as with this element, taken from Chapter 2:

```
...
<td [ngSwitch]="item.done">
...
```

The attribute applied to the `td` element tells Angular to read the value of a property called `done` on an object that has been assigned to a variable called `item`. There will be occasions when you need to provide a specific value rather than have Angular read a value from the data model, and this requires additional quoting to tell Angular that it is dealing with a literal value, like this:

```
...
<td [ngSwitch]="'Apples'">
...
```

The attribute value contains the string `Apples`, which is quoted in both single and double quotes. When Angular evaluates the attribute value, it will see the single quotes and process the value as a literal string.

Understanding Element Content

Elements can contain text, but they can also contain other elements, like this:

```
...
<thead>
    <tr>
        <th>Description</th>
        <th>Done</th>
    </tr>
</thead>
...
```

The elements in an HTML document form a natural hierarchy. The `html` element contains the `body` element, which contains content elements, each of which can contain other elements, and so on. In the listing, the `thead` element contains `tr` elements that, in turn, contain `th` elements. Nesting elements like this is a key concept in HTML because it imparts the significance of the outer element to those contained within.

Understanding the Document Structure

There are some key elements that define the basic structure of any HTML document: the `DOCTYPE`, `html`, `head`, and `body` elements. Here is the relationship between these elements with the rest of the content removed:

```
<!DOCTYPE html>
<html>
<head>
    ...head content...
</head>
<body>
    ...body content...
</body>
</html>
```

Each of these elements has a specific role to play in an HTML document. The DOCTYPE element tells the browser that this is an HTML document and, more specifically, that this is an *HTML5* document. Earlier versions of HTML required additional information. For example, here is the DOCTYPE element for an HTML4 document:

```
...
<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01//EN"
    "http://www.w3.org/TR/html4/strict.dtd">
...
```

The html element denotes the region of the document that contains the HTML content. This element always contains the other two key structural elements: head and body. As I explained at the start of the chapter, I am not going to cover the individual HTML elements. There are too many of them, and describing HTML5 completely took me more than 1,000 pages in my HTML book. That said, Table 4-1 provides brief descriptions of the elements I used in the index.html file in Listing 4-2 to help you understand how elements tell the browser what kind of content they represent.

UNDERSTANDING THE DOCUMENT OBJECT MODEL

When the browser loads and processes an HTML document, it creates the *Document Object Model* (DOM). The DOM is a model in which JavaScript objects are used to represent each element in the document, and the DOM is the mechanism by which you can programmatically engage with the content of an HTML document.

You rarely work directly with the DOM in Angular, but it is important to understand that the browser maintains a live model of the HTML document represented by JavaScript objects. When Angular modifies these objects, the browser updates the content it displays to reflect the modifications. This is one of the key foundations of web applications. If we were not able to modify the DOM, we would not be able to create client-side web apps.

***Table 4-1.** HTML Elements Used in the Example Document*

Element	Description
`DOCTYPE`	Indicates the type of content in the document
`body`	Denotes the region of the document that contains content elements
`button`	Denotes a button; often used to submit a form to the server
`div`	A generic element; often used to add structure to a document for presentation purposes
`h3`	Denotes a header
`head`	Denotes the region of the document that contains metadata
`html`	Denotes the region of the document that contains HTML (which is usually the entire document)
`input`	Denotes a field used to gather a single data item from the user
`link`	Imports content into the HTML document
`meta`	Provides descriptive data about the document, such as the character encoding
`table`	Denotes a table, used to organize content into rows and columns
`tbody`	Denotes the body of the table (as opposed to the header or footer)
`td`	Denotes a content cell in a table row
`th`	Denotes a header cell in a table row
`thead`	Denotes the header of a table
`title`	Denotes the title of the document; used by the browser to set the title of the window or tab
`tr`	Denotes a row in a table

Understanding Bootstrap

HTML elements tell the browser what kind of content they represent, but they don't provide any information about how that content should be displayed. The information about how to display elements is provided using *Cascading Style Sheets* (CSS). CSS consists of a comprehensive set of *properties* that can be used to configure every aspect of an element's appearance and a set of *selectors* that allow those properties to be applied.

One of the main problems with CSS is that some browsers interpret properties slightly differently, which can lead to variations in the way that HTML content is displayed on different devices. It can be difficult to track down and correct these problems, and CSS frameworks have emerged to help web app developers style their HTML content in a simple and consistent way.

One CSS framework that has gained a lot of popularity is Bootstrap, which was originally developed at Twitter but has become a widely used open source project. Bootstrap consists of a set of CSS classes that can be applied to elements to style them consistently and some JavaScript code that performs additional enhancement. I use Bootstrap frequently in my own projects; it works well across browsers, and it is simple to use. I use the Bootstrap CSS styles in this book because they let me style my examples without having to define and then list my own custom CSS in each chapter. Bootstrap provides a lot more features than the ones I use and describe in this book; see `http://getbootstrap.com` for full details.

USING THE BOOTSTRAP PRE-RELEASE

As I mentioned in Chapter 2, I use a pre-release version of the Bootstrap CSS framework throughout this book. Given the choice of writing this book using the soon-to-be-obsolete Bootstrap 3 and a pre-release version of Bootstrap 4, I decided to use the new version, even though some of the class names that are used to style HTML elements are likely to change before the final release. This means you must use the same version of Bootstrap to get the expected results from the examples.

I don't want to get into too much detail about Bootstrap because it isn't the topic of this book, but I do want to give you enough information so you can tell which parts of an example are Angular features and which are Bootstrap styling.

Applying Basic Bootstrap Classes

Bootstrap styles are applied via the `class` attribute, which is used to group together related elements. The `class` attribute isn't just used to apply CSS styles, but it is the most common use, and it underpins the way that Bootstrap and similar frameworks operate. Here is an HTML element with a `class` attribute, taken from the `index.html` file:

```
...
<button class="btn btn-primary m-t-1">Add</button>
...
```

The `class` attribute assigns the `button` element to three classes, whose names are separated by spaces: `btn`, `btn-primary`, and `m-t-1`. These classes correspond to collections of styles defined by Bootstrap, as described in Table 4-2.

***Table 4-2.** The Three Button Element Classes*

Name	Description
`btn`	This class applies the basic styling for a button. It can be applied to `button` or `a` elements to provide a consistent appearance.
`btn-primary`	This class applies a style context to provide a visual cue about the purpose of the button. See the "Using Contextual Classes" section.
`m-t-1`	This class adds a gap between the top of the element and the content that surrounds it. See the "Using Margin and Padding" section.

Using Contextual Classes

One of the main advantages of using a CSS framework like Bootstrap is to simplify the process of creating a consistent theme throughout an application. Bootstrap defines a set of *style contexts* that are used to style related elements consistently. These contexts, which are described in Table 4-3, are used in the names of the classes that apply Bootstrap styles to elements.

Table 4-3. *The Bootstrap Style Contexts*

Name	Description
`primary`	This context is used to indicate the main action or area of content.
`success`	This context is used to indicate a successful outcome.
`info`	This context is used to present additional information.
`warning`	This context is used to present warnings.
`danger`	This context is used to present serious warnings.
`muted`	This context is used to de-emphasize content.

Bootstrap provides classes that allow the style contexts to be applied to different types of elements. Here is the `primary` context applied to the `h3` element, taken from the `index.html` file created at the start of the chapter:

```
...
<h3 class="bg-primary p-a-1">Adam's To Do List</h3>
...
```

One of the classes that the element has been assigned to is `bg-primary`, which styles the background color of an element using the style context's color. Here is the same style context applied to a `button` element:

```
...
<button class="btn btn-primary m-t-1">Add</button>
...
```

The `btn-primary` class styles a button or anchor element using the style context's colors. Using the same context to style different elements will ensure their appearance is consistent and complementary, as shown in Figure 4-3, which highlights the elements to which the style context has been applied.

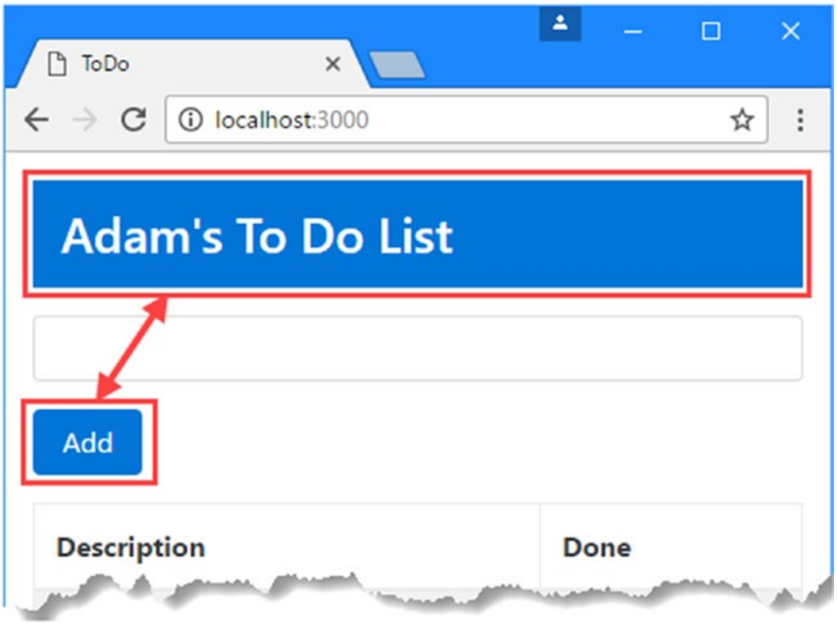


Figure 4-3. *Using style contexts for consistency*

Using Margin and Padding

Bootstrap includes a set of utility classes that are used to add padding, which is space between an element's edge and its content, and margin, which is space between an element's edge and the surrounding elements. The benefit of using these classes is that they apply a consistent amount of spacing throughout the application.

The names of these classes follow a well-defined pattern. Here is the body element from the index.html file created at the start of the chapter, to which margin has been applied:

```
...
<body class="m-a-1">
...
```

The classes that apply margin and padding to elements follow a well-defined naming schema: first, the letter m (for margin) or p (for padding), followed by a hyphen, followed by a letter selecting some or all element edges (a for all edges, t for top, b for bottom, l for left, or r for right), then a hyphen, and, finally, a number indicating how much space should be applied (0 for no spacing, or 1, 2, or 3 for increasing amounts). To help put this scheme in context, Table 4-4 lists the combinations used in the index.html file.

Table 4-4. *Sample Bootstrap Margin and Padding Classes*

Name	Description
`p-a-1`	This class applies padding to all edges of an element.
`m-a-1`	This class applies margin to all edges of an element.
`m-t-1`	This class applies margin to the top edge of an element.
`m-b-1`	This class applies margin to the bottom edge of an element.

Changing Element Sizes

You can change the way that some elements are styled by using a size modification class. These are specified by combining a basic class name, a hyphen, and `lg` or `sm`. In Listing 4-3, I have added `button` elements to the `index.html` file, using the size modification classes that Bootstrap provides for buttons.

Listing 4-3. Using Button Size Modification Classes in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
</head>
<body class="m-a-1">

    <h3 class="bg-primary p-a-1">Adam's To Do List</h3>

    <div class="m-t-1 m-b-1">
        <input class="form-control" />
        <button class="btn btn-lg btn-primary m-t-1">Add</button>
        <button class="btn btn-primary m-t-1">Add</button>
        <button class="btn btn-sm btn-primary m-t-1">Add</button>
    </div>

    <table class="table table-striped table-bordered">
        <thead>
            <tr>
                <th>Description</th>
                <th>Done</th>
            </tr>
        </thead>
        <tbody>
            <tr><td>Buy Flowers</td><td>No</td></tr>
            <tr><td>Get Shoes</td><td>No</td></tr>
            <tr><td>Collect Tickets</td><td>Yes</td></tr>
            <tr><td>Call Joe</td><td>No</td></tr>
        </tbody>
    </table>
</body>
</html>
```

The btn-lg class creates a large button, and the btn-sm class creates a small button. Omitting a size class uses the default size for the element. Notice that I am able to combine a context class and a size class. Bootstrap class modifications work together to give you complete control over how elements are styled, creating the effect shown in Figure 4-4.

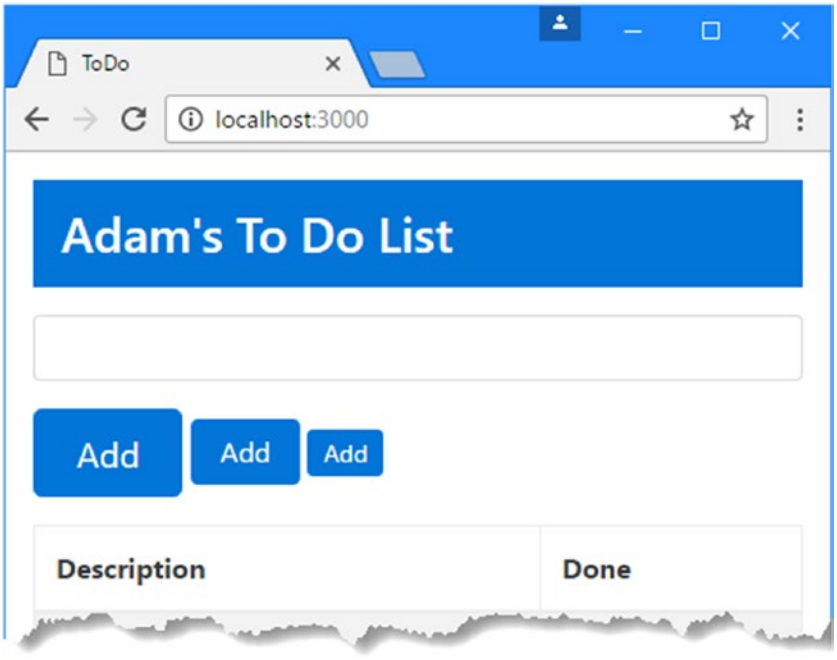


Figure 4-4. *Changing element size*

Using Bootstrap to Style Tables

Bootstrap includes support for styling table elements and their contents, which is a feature I use throughout this book. Table 4-5 lists the key Bootstrap classes for working with tables.

Table 4-5. *The Bootstrap CSS Classes for Tables*

Name	Description
table	Applies general styling to a table elements and its rows
table-striped	Applies alternate-row striping to the rows in the table body
table-inverse	Applies inverted colors to the table and its rows
table-bordered	Applies borders to all rows and columns
table-hover	Displays a different style when the mouse hovers over a row in the table
table-sm	Reduces the spacing in the table to create a more compact layout

All these classes are applied directly to the table element, as shown in Listing 4-4, which highlights the Bootstrap classes applied to the table in the index.html file.

Listing 4-4. Using Bootstrap to Style Tables

```
...
<table class="table table-striped table-bordered">
    <thead>
        <tr>
            <th>Description</th>
            <th>Done</th>
        </tr>
    </thead>
    <tbody>
        <tr><td>Buy Flowers</td><td>No</td></tr>
        <tr><td>Get Shoes</td><td>No</td></tr>
        <tr><td>Collect Tickets</td><td>Yes</td></tr>
        <tr><td>Call Joe</td><td>No</td></tr>
    </tbody>
</table>
...
```

■ **Tip** Notice that I have used the `thead` element when defining the tables in Listing 4-4. Browsers will automatically add any `tr` elements that are direct descendants of `table` elements to a `tbody` element if one has not been used. You will get odd results if you rely on this behavior when working with Bootstrap because most of the CSS classes that are applied to the `table` element cause styles to be added to the descendants of the `tbody` element.

Using Bootstrap to Create Forms

Bootstrap includes styling for form elements, allowing them to be styled consistently with other elements in the application. In Listing 4-5, I have expanded the form elements in the `index.html` file and temporarily removed the table.

Listing 4-5. Defining Additional Form Elements in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
</head>
<body class="m-a-1">
    <h3 class="bg-primary p-a-1">Adam's To Do List</h3>
    <form>
        <div class="form-group">
            <label>Task</label>
            <input class="form-control" />
        </div>
        <div class="form-group">
            <label>Location</label>
            <input class="form-control" />
        </div>
        <div class="form-group">
            <input type="checkbox" />
            <label>Done</label>
        </div>
        <button class="btn btn-primary">Add</button>
    </form>
</body>
</html>
```

The basic styling for forms is achieved by applying the `form-group` class to a `div` element that contains a `label` and an `input` element, where the input element is assigned to the `form-control` class. Bootstrap styles the elements so that the `label` is shown above the `input` element and the `input` element occupies 100 percent of the available horizontal space, as shown in Figure 4-5.

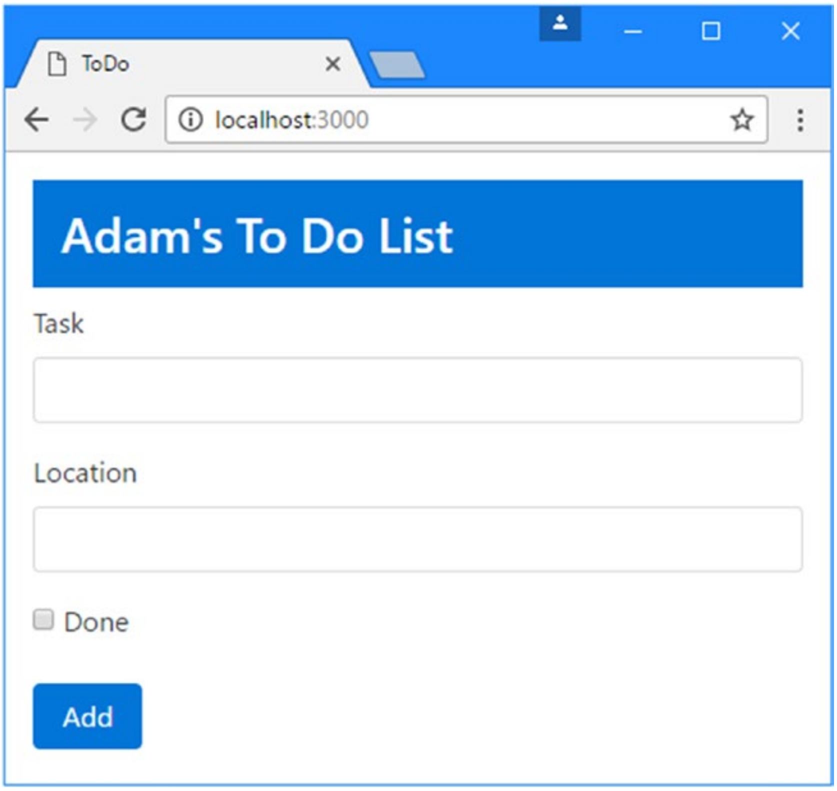


Figure 4-5. *Styling form elements*

Using Bootstrap to Create Grids

Bootstrap provides style classes that can be used to create different kinds of grid layout, ranging from one to twelve columns and with support for responsive layouts, where the layout of the grid changes based on the width of the screen. Listing 4-6 replaces the content of the example HTML file to demonstrate the grid feature.

Listing 4-6. Using a Bootstrap Grid in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
    <style>
        #gridContainer {padding: 20px;}
        .row > div { border: 1px solid lightgrey; padding: 10px;
                         background-color: aliceblue; margin: 5px 0; }
    </style>
</head>
<body class="m-a-1">
    <h3 class="panel-header">
        Grid Layout
    </h3>

    <div id="gridContainer">

        <div class="row">
            <div class="col-xs-1">1</div>
            <div class="col-xs-1">1</div>
            <div class="col-xs-2">2</div>
            <div class="col-xs-2">2</div>
            <div class="col-xs-6">6</div>
        </div>

        <div class="row">
            <div class="col-xs-3">3</div>
            <div class="col-xs-4">4</div>
            <div class="col-xs-5">5</div>
        </div>

        <div class="row">
            <div class="col-xs-6">6</div>
            <div class="col-xs-6">6</div>
        </div>

        <div class="row">
            <div class="col-xs-11">11</div>
            <div class="col-xs-1">1</div>
        </div>
        <div class="row">
            <div class="col-xs-12">12</div>
        </div>
    </div>
</body>
</html>
```

The Bootstrap grid layout system is simple to use. You specify a column by applying the `row` class to a `div` element, which has the effect of setting up the grid layout for the content that the `div` element contains.

Each row defines 12 columns, and you specify how many columns each child element will occupy by assigning a class whose name is `col-xs` followed by the number of columns. For example, the class `col-xs-1` specifies that an element occupies one column, `col-xs-2` specifies two columns, and so on, right through to `col-xs-12`, which specifies that an element fills the entire row. In the listing, I have created a series of `div` elements with the `row` class, each of which contains further `div` elements to which I have applied `col-xs-*` classes. You can see the effect in the browser in Figure 4-6.

■ **Tip** Bootstrap doesn't apply any styling to the elements within a row, which I why I have used a `style` element to create a custom CSS style that sets a background color, sets up some spacing between rows, and adds a border.

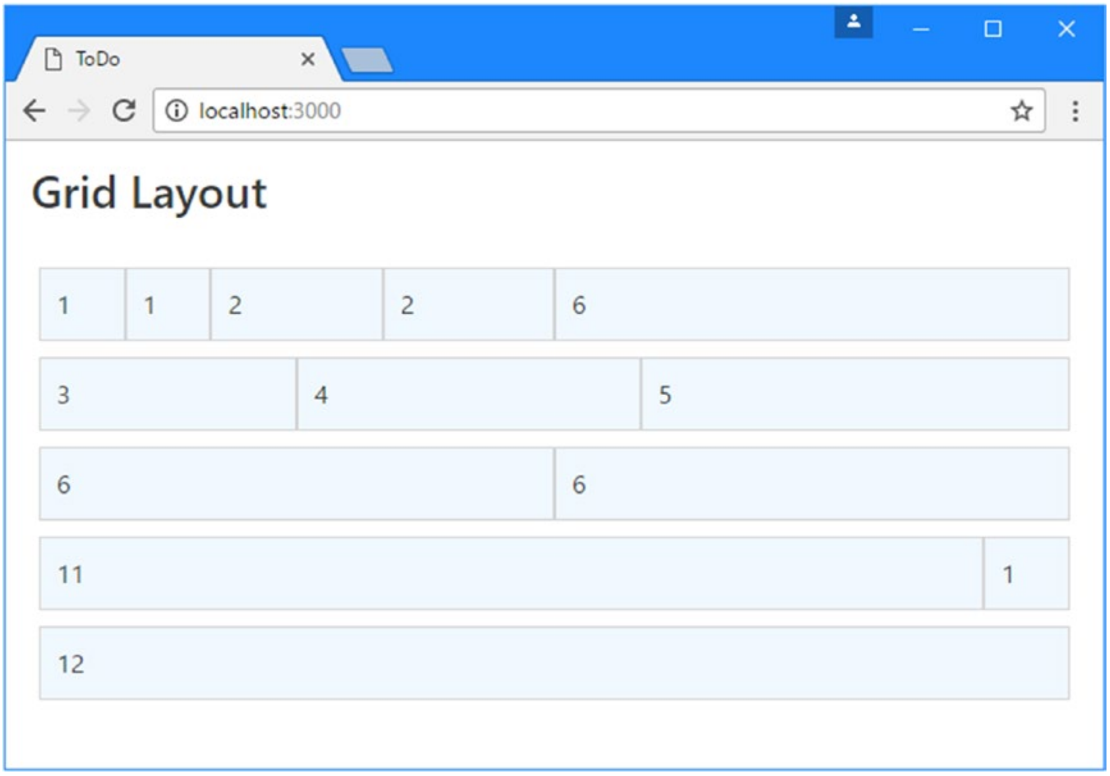


Figure 4-6. *Creating a Bootstrap grid layout*

Creating Responsive Grids

Responsive grids adapt their layout based on the size of the browser window. The main use for responsive grids is to allow mobile devices and desktops to display the same content, taking advantage of whatever screen space is available. To create a responsive grid, replace the `col-*` class on individual cells with one of the classes shown in Table 4-6.

Table 4-6. *The Bootstrap CSS Classes for Responsive Grids*

Bootstrap Class	Description
`col-sm-*`	Grid cells are displayed horizontally when the screen width is greater than 768 pixels.
`col-md-*`	Grid cells are displayed horizontally when the screen width is greater than 940 pixels.
`col-lg-*`	Grid cells are displayed horizontally when the screen width is greater than 1170 pixels.

When the width of the screen is less than the class supports, the cells in the grid row are stacked vertically rather than horizontally. Listing 4-7 demonstrates a responsive grid in the `index.html` file.

Listing 4-7. Creating a Responsive Grid in the bootstrap.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
    <style>
        #gridContainer {padding: 20px;}
        .row > div { border: 1px solid lightgrey; padding: 10px;
                          background-color: aliceblue; margin: 5px 0; }
    </style>

</head>
<body class="m-a-1">

    <h3 class="panel-header">
        Grid Layout
    </h3>
    <div id="gridContainer">
            <div class="row">
                <div class="col-sm-3">3</div>
                <div class="col-sm-4">4</div>
                <div class="col-sm-5">5</div>
            </div>

            <div class="row">
                <div class="col-sm-6">6</div>
                <div class="col-sm-6">6</div>
            </div>
            <div class="row">
                <div class="col-sm-11">11</div>
                <div class="col-sm-1">1</div>
            </div>
    </div>
</body>
</html>
```

I removed some grid rows from the previous example and replaced the col-xs* classes with col-sm-*. The effect is that the cells in the row will be stacked horizontally when the browser window is greater than 768 pixels wide and stacked horizontally when it is smaller, as shown in Figure 4-7.

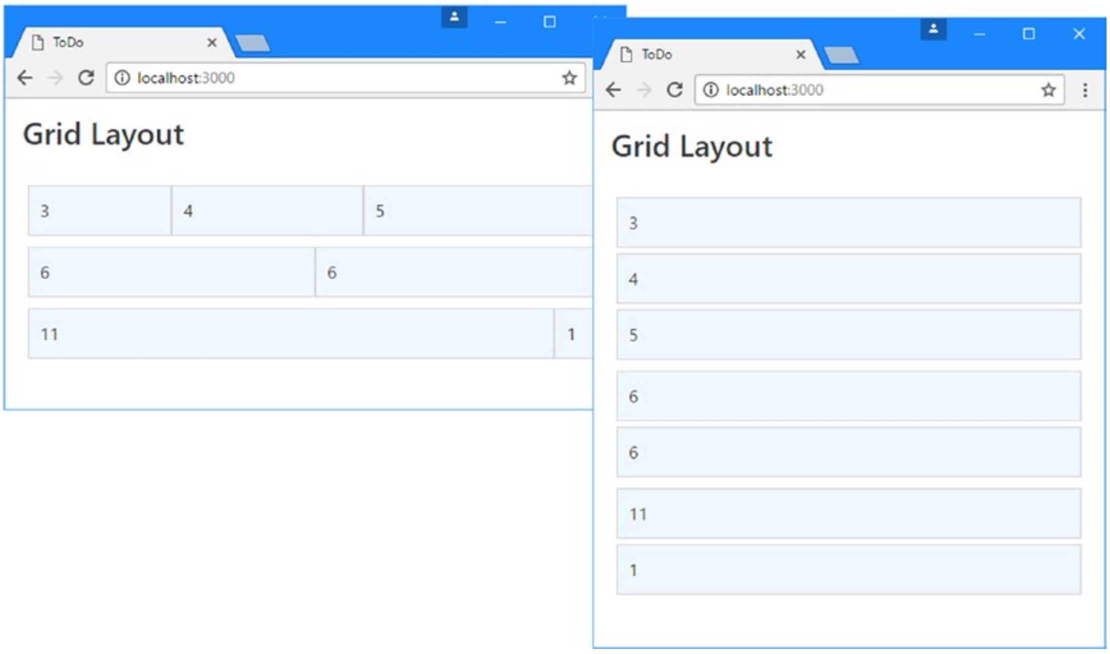


Figure 4-7. *Creating a responsive grid layout*

Creating a Simplified Grid Layout

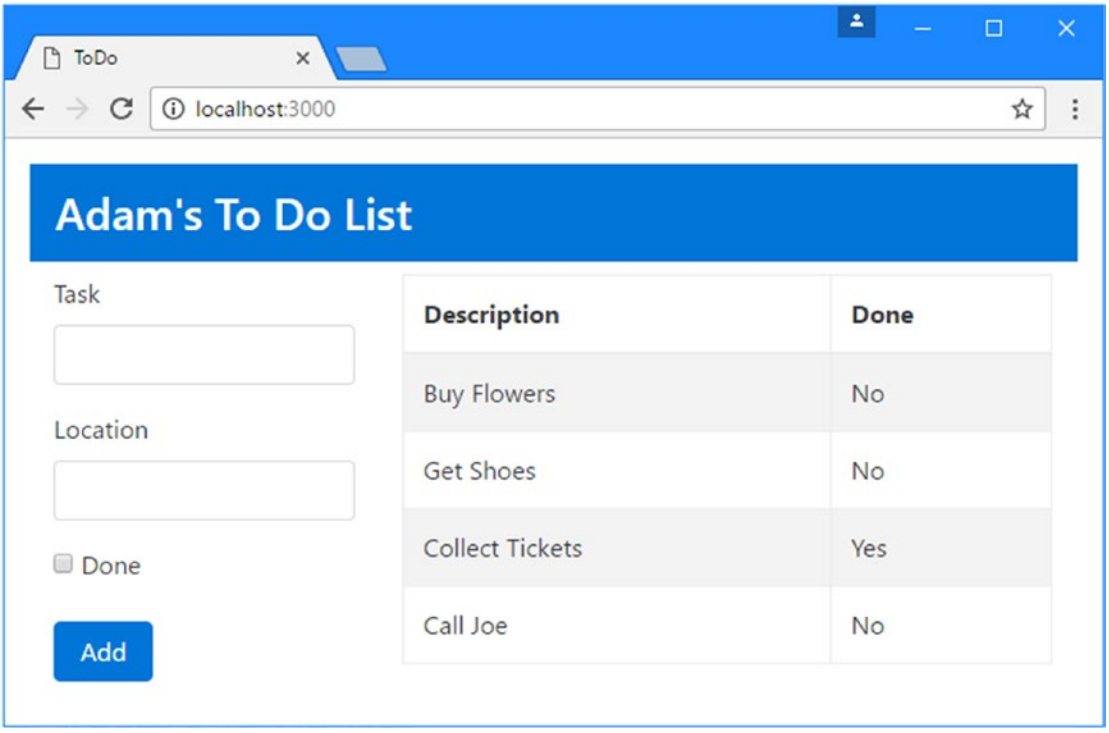
For most of the examples in this book that rely on the Bootstrap grid, I use a simplified approach that displays content in a single row and requires only the number of columns to be specified, as shown in Listing 4-8.

Listing 4-8. Using a Simplified Grid Layout in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>ToDo</title>
    <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
```

```
</head>
<body class="m-a-1">
    <h3 class="bg-primary p-a-1">Adam's To Do List</h3>

    <div class="col-xs-4">
        <form>
            <div class="form-group">
                <label>Task</label>
                <input class="form-control" />
            </div>
            <div class="form-group">
                <label>Location</label>
                <input class="form-control" />
            </div>
            <div class="form-group">
                <input type="checkbox" />
                <label>Done</label>
            </div>
            <button class="btn btn-primary">Add</button>
        </form>
    </div>
    <div class="col-xs-8">
        <table class="table table-striped table-bordered">
            <thead>
                <tr>
                    <th>Description</th>
                    <th>Done</th>
                </tr>
            </thead>
            <tbody>
                <tr><td>Buy Flowers</td><td>No</td></tr>
                <tr><td>Get Shoes</td><td>No</td></tr>
                <tr><td>Collect Tickets</td><td>Yes</td></tr>
                <tr><td>Call Joe</td><td>No</td></tr>
            </tbody>
        </table>
    </div>
</body>
</html>
```

This listing uses the `col-xs-4` and `col-xs-8` classes to display two `div` elements side-by-side, allowing the form and the table that displays the to-do items to be displayed horizontally, as illustrated in Figure 4-8.



Description	Done
Buy Flowers	No
Get Shoes	No
Collect Tickets	Yes
Call Joe	No

Figure 4-8. *Using a simplified grid layout*

Summary

In this chapter, I provided a brief overview of HTML and the Bootstrap CSS framework. You need to have a good grasp of HTML and CSS to be truly effective in web application development, but the best way to learn is by firsthand experience, and the descriptions and examples in this chapter will be enough to get you started and provide just enough background information for the examples ahead. In the next chapter, I continue the primer theme and introduce the basic features of JavaScript that I use in this book.

CHAPTER 5

JavaScript and TypeScript: Part 1

In this chapter I provide a quick tour of the most important basic features of the JavaScript language as they apply to Angular development. I don't have the space to describe JavaScript completely, so I have focused on the essentials that you'll need to get up to speed and follow the examples in this book. In Chapter 6, I describe some of the more advanced JavaScript features that you will need and some of the additional features provided by TypeScript.

The JavaScript language is managed through a standard process that defines new features. Modern browsers have started to implement features from the ECMAScript 6 standard (also known as *ES6*), and the process for defining ECMAScript 7 (ES7) is underway as I write this. The new standards broaden the features available to JavaScript developers and make using JavaScript more consistent with more conventional languages such as C# or Java.

Modern browsers update themselves, which means that a Google Chrome user, for example, is likely to have a recent release of the browser that implements at least some of the most recent JavaScript features. Sadly, older browsers that don't update themselves are still in widespread use, which means you can't rely on modern features being available for use in your application.

There are two ways to approach this problem. The first is to use only the core JavaScript features that you can rely on being present in the browsers that your application targets. The second is to use a compiler that processes your JavaScript files and converts them into code that can run on older browsers. It is the second approach that Angular takes and that I describe in this chapter. Table 5-1 summarizes this chapter.

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Table 5-1. *Chapter Summary*

Problem	Solution	Listing
Add JavaScript to an HTML document	Use the `script` element or a JavaScript module loader	1–6
Create JavaScript functionality	Use JavaScript statements	7
Create groups of statements that are executed on command	Use functions	8, 9, 12–14
Define functions that can handle more or fewer arguments that parameters	Use default or rest parameters	10–11
Express functions more concisely	Use arrow functions	15
Store values and objects for later use	Declare variables using the `let` or `var` keywords	16–17
Store basic data values	Use the JavaScript primitive types	18–21
Control the flow of JavaScript code	Use conditional statements	22
Determine whether two objects or values are the same	Use the quality and identity operators	23–24
Explicitly convert types	Use the `to<type>` methods	25–27
Store related objects or values together in sequence	Use an array	28–33

USING “CLASSIC” JAVASCRIPT FOR ANGULAR

You can write Angular applications using just the JavaScript features that work in older browsers, without needing to add the additional step of using the TypeScript compiler to process files.

The problem with this approach is that it results in code that is difficult to read and difficult to manage. There are some recent JavaScript features that simplify the way that Angular features are defined and applied and one feature, called *decorators*, that is essential for effective Angular development but that is only a proposal for the JavaScript standardization process and isn’t supported by any browser.

My advice is to embrace the complete Angular experience, even though it can take some time and effort to master the new JavaScript features. The result will be a better development experience, containing code that is more concise, easier to read, and simpler to maintain. This is the approach I have taken in this book, and every example assumes that this is the path you are following.

This book doesn’t explain how to create Angular applications using just classic JavaScript features. If this is the path that you want to follow, then the best place to start is the JavaScript section of the Angular website, `https://angular.io/docs/js/latest`, which contains basic information to help you get started.

Preparing the Example Project

To prepare for this chapter, I started a new project by creating a folder called `JavaScriptPrimer`. I added a file called `package.json` within the `JavaScriptPrimer` folder and added the configuration shown in Listing 5-1.

Listing 5-1. The Contents of the package.json File in the JavaScriptPrimer Folder

```
{
  "dependencies": {
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.3",
    "typings": "1.4.0",
    "concurrently": "3.1.0"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "typings": "typings"
  }
}
```

The packages that are specified in the `package.json` file include polyfill libraries that add support for essential features to older JavaScript browsers, a JavaScript module loader, and the Bootstrap CSS framework. The tools required to use TypeScript to generate JavaScript files are also included. Run the following command in the `JavaScriptPrimer` folder to download and install the packages:

```
npm install
```

Creating the HTML and JavaScript Files

I created a file called `primer.ts` in the `JavaScriptPrimer` folder and added the code shown in Listing 5-2. This is just a placeholder to get the project started.

■ **Tip** Pay attention to the extension of the file. Even though this chapter uses only JavaScript features, it relies on the TypeScript compiler to convert them into code that will run in any browser. That means the `.ts` file must be used, which then allows the TypeScript compiler to create the corresponding `.js` file that will be used by the browser.

Listing 5-2. The Contents of the primer.ts File in the JavaScriptPrimer Folder

```
console.log("Hello");
```

I also added a file called `index.html` to the `JavaScriptPrimer` folder and added the HTML elements shown in Listing 5-3.

Listing 5-3. The Contents of the index.html File in the JavaScriptPrimer Folder

```
<!DOCTYPE html>
<html>
<head>
    <title>Primer</title>
        <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
    <script src="primer.js"></script>
</head>
<body class="m-a-1">
    <h3>JavaScript Primer</h3>
</body>
</html>
```

The HTML file includes a `script` element that loads a file called `primer.js`. This file doesn't exist yet, but the TypeScript compiler will generate it when it processes the `primer.ts` file.

Configuring the TypeScript Compiler

The TypeScript compiler requires a configuration file that specifies how it should generate JavaScript files. I created a file called `tsconfig.json` in the `JavaScriptPrimer` folder and added the configuration shown in Listing 5-4.

Listing 5-4. The Contents of the tsconfig.json File in the JavaScriptPrimer Folder

```
{
  "compilerOptions": {
    "target": "es5",
    "module": "commonjs",
    "moduleResolution": "node",
    "emitDecoratorMetadata": true,
    "experimentalDecorators": true
  },
  "exclude": [ "node_modules" ]
}
```

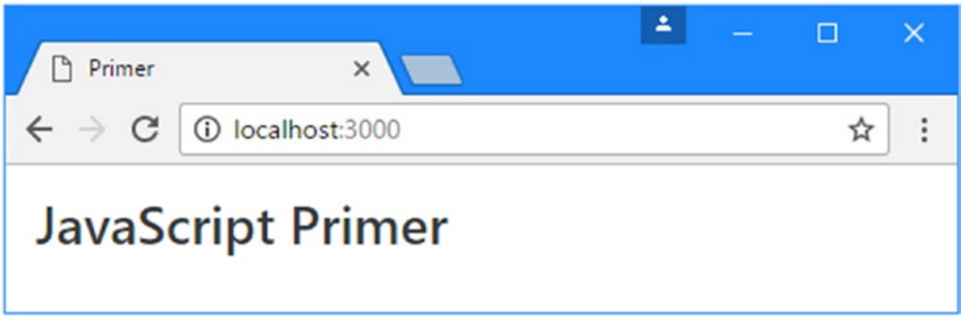
I explain what each configuration setting does in Chapter 11, but for now, it is enough to just create the file.

Running the Example Project

Once you have created all the required files, run the following command to start the TypeScript compiler and the development HTTP server:

```
npm start
```

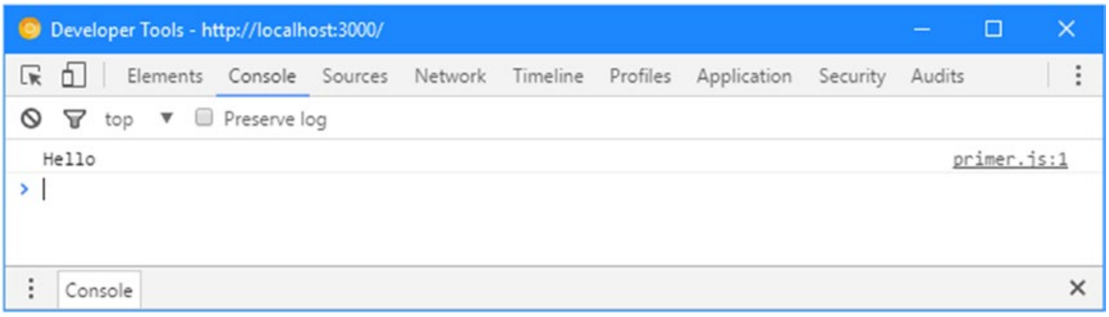
A new browser tab or window will open and display the contents of the index.html file, as shown in Figure 5-1.



JavaScript Primer

Figure 5-1. *Running the example application*

Open the browser's F12 developer tools (so called because they are typically opened by pressing the F12 key) and look at the JavaScript console, which is shown in Figure 5-2.



```
Hello
```

Figure 5-2. *The Google Chrome JavaScript console*

The JavaScript console shows the result of the call to the `console.log` function from Listing 5-3. Rather than show a screenshot of the browser's JavaScript console for each example, I'll just show the result text, like this:

```
Hello
```

Understanding the Script Element

JavaScript code is added to an HTML document using the `script` element. The `src` attribute is used to specify which JavaScript file should be loaded. Here is the `script` element from Listing 5-3:

```
...
<script src="primer.js"></script>
...
```

The name of the file loaded by this element is `primer.js`. When using the TypeScript compiler, there is an indirection relationship between the files that contain the JavaScript code that you write and the files that are loaded by the browser.

This can be an awkward transition to make if you are used to writing JavaScript files directly, but it allows the TypeScript compiler to translate the most recent features from the JavaScript specification into code that will run on older browsers.

Using a JavaScript Module Loader

Manually keeping track of two sets of files and making sure that the HTML file contains the correct set of `script` elements is an error-prone process. You are likely to add a `script` element that includes a file with the `.ts` extension rather than its `.js` counterpart or forget to add a `script` element for a new file. It is also hard to correctly order the `script` elements. Browsers execute the content of JavaScript files in the order defined by the `script` elements in the HTML document, and it is easy to create a situation where code in the file loaded by one `script` element depends on functionality loaded by another `script` element that the browser has yet to load.

Managing the JavaScript content in an application can be simplified by using a module loader, which takes responsibility for detecting and resolving dependencies between JavaScript files, loading them, and ensuring their contents are executed in the right order. The `package.json` file I created at the start of the chapter included the SystemJS module loader, and Listing 5-5 shows how it can be applied to the HTML document to manage the JavaScript files.

Listing 5-5. Using a JavaScript Module Loader in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>Primer</title>
        <meta charset="utf-8" />
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
          rel="stylesheet" />
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script>
        System.config({ packages: {"": {}}});
        System.import("primer").catch(function(err){ console.error(err); });
    </script>
</head>
<body class="m-a-1">
    <h3>JavaScript Primer</h3>
</body>
</html>
```

I explain how to create JavaScript modules in Chapter 6 and how the `SystemJS` module loader is used in more detail in Chapter 11, where I also use it to load Angular and some of the libraries it depends on. In this listing, there is a `script` element that loads the `SystemJS` module loader and another that configures and applies it. The most important change in the listing is this statement:

```
...
System.import("primer").catch(function(err){ console.error(err); });
...
```

This statement tells the module loader to load a module called `primer`, which is translated into a request for the `primer.js` file. One benefit of using the module loader is that you don't have to pay attention to the file extensions in individual `script` elements.

Understanding the Basic Workflow

To understand the way that the different workflow steps relate to one another, add a statement to the `primer.ts` file, as shown in Listing 5-6.

Listing 5-6. Adding a Statement in the primer.ts File

```
console.log("Hello");
console.log("Apples");
```

When you save the change to the `primer.ts` file, the following process will occur:

1. The TypeScript compiler will detect the change to the `primer.ts` file and compile it to generate a new `primer.js` file that can run in any browser.
2. The development HTTP server detects the change to the `primer.js` file and signals the browser to reload the HTML document.
3. The browser reloads the HTML document and starts processing the elements it contains. It loads the JavaScript files specified by the `script` elements in the HTML document, including those for the JavaScript module loader.
4. The JavaScript module loader processes its configuration and asynchronously requests the `primer.js` file from the HTTP server.
5. The JavaScript module loader asks the browser to execute the code in the `primer.js` file, which writes out two messages to the browser's JavaScript console.

The overall result is that you will see the following messages displayed:

```
Hello
Apples
```

This may seem like a large number of steps for a simple application, but this is an approach that scales up to handle complex projects and allows recent JavaScript features to be used.

Getting used to the extra steps required in Angular development can take a while and the development workflow can feel indirect and cumbersome, but it does eventually become second nature, especially when the changes to the code files lead to the browser being automatically reloaded.

Using Statements

The basic JavaScript building block is the *statement*. Each statement represents a single command, and statements are usually terminated by a semicolon (`;`). The semicolon is optional, but using them makes your code easier to read and allows for multiple statements on a single line. In Listing 5-7, I have added a pair of statements to the JavaScript file.

Listing 5-7. Adding JavaScript Statements in the primer.ts File

```
console.log("Hello");
console.log("Apples");
console.log("This is a statement");
console.log("This is also a statement");
```

The browser executes each statement in turn. In this example, all the statements simply write messages to the console. The results are as follows:

```
Hello
Apples
This is a statement
This is also a statement
```

Defining and Using Functions

When the browser receives JavaScript code, either directly through a `script` element or indirectly through the module loader, it executes the statements it contains in the order in which they have been defined. This is what happened in the previous example. The module loader loaded the `primer.js` file, and the statements it contains were executed one by one, all of which wrote a message to the console.

You can also package statements into a *function*, which won't be executed until the browser encounters a statement that *invokes* the function, as shown in Listing 5-8.

Listing 5-8. Defining a JavaScript Function in the primer.ts File

```
let myFunc = function () {
    console.log("This is a statement");
};

myFunc();
```

Defining a function simple: use the `let` keyword followed by the name you want to give the function, followed by the equal sign (`=`) and the `function` keyword, followed by parentheses (the `(` and `)` characters). The statements you want the function to contain are enclosed between braces (the `{` and `}` characters).

In the listing I used the name `myFunc`, and the function contains a single statement that writes a message to the JavaScript console. The statement in the function won't be executed until the browser reaches another statement that calls the `myFunc` function, like this:

```
...
myFunc();
...
```

Executing the statement in the function produces the following output:

```
This is a statement
```

Other than demonstrating how functions are defined, this example isn't especially useful because the function is invoked immediately after it has been defined. Functions are much more useful when they are invoked in response to some kind of change or event, such as user interaction.

THE OTHER WAY TO DEFINE FUNCTIONS

There are two ways in which you can define functions in JavaScript. The approach I used in Listing 5-8 is known as a *function expression*. The same function can also be defined like this:

```
...
function myFunc() {
    console.log("This is a statement");
}
...
```

This is known as a *function declaration*. The result is the same: a function called `myFunc` that writes a message to the console. The difference is how the functions are processed by the browser when a JavaScript file is loaded. Function declarations are processed before the code in a JavaScript file is executed, which means you can use a statement that calls a function before it is defined, like this:

```
...
myFunc();

function myFunc() {
    console.log("This is a statement");
}
...
```

This works because the browser finds the function declaration when it parses the JavaScript file and sets up the function before the remaining statements are executed, a process known as *function hoisting*. Function expressions, however, are not subject to hoisting, which means that this code will not work:

```
...
myFunc();

let myFunc = function() {
    console.log("This is a statement");
};
...
```

This code will generate an error reporting that `myFunc` is not a function. Developers who are new to JavaScript tend to prefer using function declarations because the syntax is more consistent with languages like C# or Java. The technique you use is entirely up to you, although you should aim to be consistent throughout your project to make your code easier to understand.

Defining Functions with Parameters

JavaScript allows you to define parameters for functions, as shown in Listing 5-9.

Listing 5-9. Defining Functions with Parameters in the primer.ts File

```
let myFunc = function(name, weather) {
    console.log("Hello " + name + ".");
    console.log("It is " + weather + " today");
};

myFunc("Adam", "sunny");
```

I added two parameters to the `myFunc` function, called `name` and `weather`. JavaScript is a dynamically typed language, which means you don't have to declare the data type of the parameters when you define the function. I'll come back to dynamic typing later in the chapter when I cover JavaScript variables. To invoke a function with parameters, you provide values as arguments when you invoke the function, like this:

```
...
myFunc("Adam", "sunny");
...
```

The results from this listing are as follows:

```
Hello Adam.
It is sunny today
```

Using Default and Rest Parameters

The number of arguments you provide when you invoke a function doesn't need to match the number of parameters in the function. If you call the function with fewer arguments than it has parameters, then the value of any parameters you have not supplied values for is `undefined`, which is a special JavaScript value. If you call the function with more arguments than there are parameters, then the additional arguments are ignored.

The consequence of this is that you can't create two functions with the same name and different parameters and expect JavaScript to differentiate between them based on the arguments you provide when invoking the function. This is called *polymorphism*, and although it is supported in languages such as Java and C#, it isn't available in JavaScript. Instead, if you define two functions with the same name, then the second definition replaces the first.

There are two ways that you can modify a function to respond to a mismatch between the number of parameters it defines and the number of arguments used to invoke it. *Default parameters* deal with the situation where there are fewer arguments than parameters and allow you to provide a default value for the parameters for which there are no arguments, as shown in Listing 5-10.

Listing 5-10. Using a Default Parameter in the primer.ts File

```
let myFunc = function (name, weather = "raining") {
    console.log("Hello " + name + ".");
    console.log("It is " + weather + " today");
};

myFunc("Adam");
```

The `weather` parameter in the function has been assigned a default value of `raining`, which will be used if the function is invoked with only one argument, producing the following results:

```
Hello Adam.
It is raining today
```

Rest parameters are used to capture any additional arguments when a function is invoked with additional arguments, as shown in Listing 5-11.

Listing 5-11. Using a Rest Parameter in the primer.ts File

```
let myFunc = function (name, weather, ...extraArgs) {
    console.log("Hello " + name + ".");
    console.log("It is " + weather + " today");
    for (let i = 0; i < extraArgs.length; i++) {
        console.log("Extra Arg: " + extraArgs[i]);
    }
};

myFunc("Adam", "sunny", "one", "two", "three");
```

The rest parameter must be the last parameter defined by the function, and its name is prefixed with an ellipsis (three periods, `...`). The rest parameter is an array to which any extra arguments will be assigned. In the listing, the function prints out each extra argument to the console, producing the following results:

```
Hello Adam.
It is sunny today
Extra Arg: one
Extra Arg: two
Extra Arg: three
```

Defining Functions That Return Results

You can return results from functions using the `return` keyword. Listing 5-12 shows a function that returns a result.

Listing 5-12. Returning a Result from a Function in the primer.ts File

```
let myFunc = function(name) {
    return ("Hello " + name + ".");
};

console.log(myFunc("Adam"));
```

This function defines one parameter and uses it to produce a result. I invoke the function and pass the result as the argument to the `console.log` function, like this:

```
...
console.log(myFunc("Adam"));
...
```

Notice that you don't have to declare that the function will return a result or denote the data type of the result. The result from this listing is as follows:

```
Hello Adam.
```

Using Functions as Arguments to Other Functions

JavaScript functions can be passed around as objects, which means you can use one function as the argument to another, as demonstrated in Listing 5-13.

Listing 5-13. Using a Function as an Arguments to Another Function in the primer.ts File

```
let myFunc = function (nameFunction) {
    return ("Hello " + nameFunction() + ".");
};

console.log(myFunc(function () {
    return "Adam";
}));
```

The `myFunc` function defines a parameter called `nameFunction` that it invokes to get the value to insert into the string that it returns. I pass a function that returns Adam as the argument to `myFunc`, which produces the following output:

```
Hello Adam.
```

Functions can be chained together, building up more complex functionality from small and easily tested pieces of code, as shown in Listing 5-14.

Listing 5-14. Chaining Functions Calls in the primer.ts File

```
let myFunc = function (nameFunction) {
    return ("Hello " + nameFunction() + ".");
};
```

```
let printName = function (nameFunction, printFunction) {
    printFunction(myFunc(nameFunction));
}

printName(function () { return "Adam" }, console.log);
```

This example produces the same result as Listing 5-13.

Using Arrow Functions

Arrow functions—also known as fat arrow functions or lambda expressions—are an alternative way of defining functions and are often used to define functions that are used only as arguments to other functions. Listing 5-15 replaces the functions from the previous example with arrow functions.

Listing 5-15. Using Arrow Functions in the primer.ts File

```
let myFunc = (nameFunction) => ("Hello " + nameFunction() + ".");

let printName = (nameFunction, printFunction) => printFunction(myFunc(nameFunction));

printName(function () { return "Adam" }, console.log);
```

These functions perform the same work as the ones in Listing 5-14. There are three parts to an arrow function: the input parameters, then an equal sign and a greater-than sign (the "arrow"), and finally the function result. The `return` keyword and curly braces are required only if the arrow function needs to execute more than one statement. There are more examples of arrow functions later in this chapter.

Using Variables and Types

The `let` keyword is used to declare variables and, optionally, assign a value to the variable in a single statement. Variables declared with `let` are scoped to the region of code in which they are defined, as shown in Listing 5-16.

Listing 5-16. Using let to Declare Variables in the primer.ts File

```
let messageFunction = function (name, weather) {
    let message = "Hello, Adam";
    if (weather == "sunny") {
        let message = "It is a nice day";
        console.log(message);
    } else {
        let message = "It is " + weather + " today";
        console.log(message);
    }
    console.log(message);
}

messageFunction("Adam", "raining");
```

In this example, there are three statements that use the let keyword to define a variable called message. The scope of each variable is limited to the region of code that it is defined in, producing the following results:

```
It is raining today
Hello, Adam
```

This may seem like an odd example, but there is another keyword that can be used to declare variables: var. The let keyword is a relatively new addition to the JavaScript specification that is intended to address some oddities in the way var behaves. Listing 5-17 takes the example from Listing 5-16 and replaces let with var.

Listing 5-17. Using var to Declare Variables in the primer.ts File

```
let messageFunction = function (name, weather) {
    var message = "Hello, Adam";
    if (weather == "sunny") {
        var message = "It is a nice day";
        console.log(message);
    } else {
        var message = "It is " + weather + " today";
        console.log(message);
    }
    console.log(message);
}

messageFunction("Adam", "raining");
```

When you save the changes in the listing, you will see the following results:

```
It is raining today
It is raining today
```

The problem is that the var keyword creates variables whose scope is the containing function, which means that all the references to message are referring to the same variable. This can cause unexpected results for even experienced JavaScript developers and is the reason that the more conventional let keyword was introduced. You are free to use let or var in Angular development; I have used let throughout this book.

USING VARIABLE CLOSURE

If you define a function inside another function—creating *inner* and *outer* functions—then the inner function is able to access the outer functions variables, using a feature called *closure*, like this:

```
let myGlobalVar = "apples";

let myFunc = function(name) {
    let myLocalVar = "sunny";
    let innerFunction = function () {
        return ("Hello " + name + ". Today is " + myLocalVar + ".");
    }
```

```
        return innerFunction();
    };
    console.log(myFunc("Adam"));
```

The inner function in this example is able to access the local variables of the outer function, including its parameter. This is a powerful feature that means you don't have to define parameters on inner functions to pass around data values, but caution is required because it is easy to get unexpected results when using common variable names like `counter` or `index`, where you may not realize that you are reusing a variable name from the outer function.

Using the Primitive Types

JavaScript defines a basic set of primitive types: `string`, `number`, and `boolean`. This may seem like a short list, but JavaScript manages to fit a lot of flexibility into these three types.

Working with Booleans

The `boolean` type has two values: `true` and `false`. Listing 5-18 shows both values being used, but this type is most useful when used in conditional statements, such as an `if` statement. There is no console output from this listing.

Listing 5-18. Defining boolean Values in the primer.ts File

```
let firstBool = true;
let secondBool = false;
```

Working with Strings

You define `string` values using either the double quote or single quote characters, as shown in Listing 5-19.

Listing 5-19. Defining string Variables in the primer.ts File

```
let firstString = "This is a string";
let secondString = 'And so is this';
```

The quote characters you use must match. You can't start a string with a single quote and finish with a double quote, for example. There is no console output for this listing. JavaScript provides `string` objects with a basic set of properties and methods, the most useful of which are described in Table 5-2.

Table 5-2. *Useful string Properties and Methods*

Name	Description
`length`	This property returns the number of characters in the string.
`charAt(index)`	This method returns a string containing the character at the specified index.
`concat(string)`	This method returns a new string that concatenates together the string on which the method is called and the string provided as an argument.
`indexOf(term, start)`	This method returns the first index at which `term` appears in the string or -1 if there is no match. The optional `start` argument specifies the start index for the search.
`replace(term, newTerm)`	This method returns a new string in which all instances of `term` are replaced with `newTerm`.
`slice(start, end)`	This method returns a substring containing the characters between the start and end indices.
`split(term)`	This method splits up a string into an array of values that were separated by `term`.
`toUpperCase() toLowerCase()`	These methods return new strings in which all the characters are uppercase or lowercase.
`trim()`	This method returns a new string from which all the leading and trailing whitespace characters have been removed.

Using Template Strings

A common programming task is to combine static content with data values to produce a string that can be presented to the user. The traditional way to do this is through string concatenation, which is the approach I have been using in the examples so far in this chapter, as follows:

```
...
let message = "It is " + weather + " today";
...
```

JavaScript also now supports template strings, which allow data values to be specified inline, which can help reduce errors and result in a more natural development experience. Listing 5-20 shows the use of a template string.

Listing 5-20. Using a Template String in the primer.js File

```
let messageFunction = function (weather) {
    let message = `It is ${weather} today`;
    console.log(message);
}

messageFunction("raining");
```

Template strings begin and end with backticks (the ` character), and data values are denoted by curly braces preceded by a dollar sign. This string, for example, incorporates the value of the `weather` variable into the template string:

```
...
let message = `It is ${weather} today`;
...
```

Working with Numbers

The number type is used to represent both *integer* and *floating-point* numbers (also known as *real numbers*). Listing 5-21 provides a demonstration.

Listing 5-21. Defining number Values in the primer.ts File

```
let daysInWeek = 7;
let pi = 3.14;
let hexValue = 0xFFFF;
```

You don't have to specify which kind of number you are using. You just express the value you require, and JavaScript will act accordingly. In the listing, I have defined an integer value, defined a floating-point value, and prefixed a value with 0x to denote a hexadecimal value.

Using JavaScript Operators

JavaScript defines a largely standard set of operators. I've summarized the most useful in Table 5-3.

Table 5-3. *Useful JavaScript Operators*

Operator	Description
`++, --`	Pre- or post-increment and decrement
`+, -, *, /, %`	Addition, subtraction, multiplication, division, remainder
`<, <=, >, >=`	Less than, less than or equal to, more than, more than or equal to
`==, !=`	Equality and inequality tests
`===, !==`	Identity and nonidentity tests
`&&, ||`	Logical AND and OR (|| is used to coalesce null values)
`=`	Assignment
`+`	String concatenation
`?:`	Three operand conditional statement

Using Conditional Statements

Many of the JavaScript operators are used in conjunction with conditional statements. In this book, I tend to use the if/else and switch statements. Listing 5-22 shows the use of both, which will be familiar if you have worked with pretty much any programming language.

Listing 5-22. Using the if/else and switch Conditional Statements in the primer.ts File

```
let name = "Adam";

if (name == "Adam") {
    console.log("Name is Adam");
} else if (name == "Jacqui") {
    console.log("Name is Jacqui");
} else {
    console.log("Name is neither Adam or Jacqui");
}

switch (name) {
    case "Adam":
        console.log("Name is Adam");
        break;
    case "Jacqui":
        console.log("Name is Jacqui");
        break;
    default:
        console.log("Name is neither Adam or Jacqui");
        break;
}
```

The results from the listing are as follows:

```
Name is Adam
Name is Adam
```

The Equality Operator vs. the Identity Operator

The equality and identity operators are of particular note. The equality operator will attempt to coerce (convert) operands to the same type in order to assess equality. This is a handy feature, as long as you are aware it is happening. Listing 5-23 shows the equality operator in action.

Listing 5-23. Using the Equality Operator in the primer.ts File

```
let firstVal = 5;
let secondVal = "5";

if (firstVal == secondVal) {
    console.log("They are the same");
} else {
    console.log("They are NOT the same");
}
```

The output from this script is as follows:

```
They are the same
```

JavaScript is converting the two operands into the same type and comparing them. In essence, the equality operator tests that values are the same irrespective of their type. If you want to test to ensure that the values *and* the types are the same, then you need to use the identity operator (===, three equal signs, rather than the two of the equality operator), as shown in Listing 5-24.

Listing 5-24. Using the Identity Operator in the primer.ts File

```
let firstVal = 5;
let secondVal = "5";

if (firstVal === secondVal) {
    console.log("They are the same");
} else {
    console.log("They are NOT the same");
}
```

In this example, the identity operator will consider the two variables to be different. This operator doesn't coerce types. The result from this script is as follows:

```
They are NOT the same
```

Explicitly Converting Types

The string concatenation operator (+) has a higher precedence than the addition operator (also +), which means that JavaScript will concatenate variables in preference to adding. This can cause confusion because JavaScript will also convert types freely to produce a result—and not always the result that is expected, as shown in Listing 5-25.

Listing 5-25. String Concatentation Operator Precedence in the primer.ts File

```
let myData1 = 5 + 5;
let myData2 = 5 + "5";

console.log("Result 1: " + myData1);
console.log("Result 2: " + myData2);
```

The result from this script is as follows:

```
Result 1: 10
Result 2: 55
```

The second result is the kind that causes confusion. What might be intended to be an addition operation is interpreted as string concatenation through a combination of operator precedence and over-eager type conversion. To avoid this, you can explicitly convert the types of values to ensure you perform the right kind of operation, as described in the following sections.

Converting Numbers to Strings

If you are working with multiple number variables and want to concatenate them as strings, then you can convert the numbers to strings with the `toString` method, as shown in Listing 5-26.

Listing 5-26. Using the number.toString Method in the primer.ts File

```
let myData1 = (5).toString() + String(5);
console.log("Result: " + myData1);
```

Notice that I placed the numeric value in parentheses, and then I called the `toString` method. This is because you have to allow JavaScript to convert the literal value into a `number` before you can call the methods that the `number` type defines. I have also shown an alternative approach to achieve the same effect, which is to call the `String` function and pass in the numeric value as an argument. Both of these techniques have the same effect, which is to convert a `number` to a `string`, meaning that the + operator is used for string concatenation and not addition. The output from this script is as follows:

```
Result: 55
```

There are some other methods that allow you to exert more control over how a number is represented as a string. I briefly describe these methods in Table 5-4. All of the methods shown in the table are defined by the `number` type.

Table 5-4. *Useful Number-to-String Methods*

Method	Description
`toString()`	This method returns a string that represents a number in base 10.
`toString(2)` `toString(8)` `toString(16)`	This method returns a string that represents a number in binary, octal, or hexadecimal notation.
`toFixed(n)`	This method returns a string representing a real number with the n digits after the decimal point.
`toExponential(n)`	This method returns a string that represents a number using exponential notation with one digit before the decimal point and n digits after.
`toPrecision(n)`	This method returns a string that represents a number with n significant digits, using exponential notation if required.

Converting Strings to Numbers

The complementary technique is to convert strings to numbers so that you can perform addition rather than concatenation. You can do this with the `Number` function, as shown in Listing 5-27.

Listing 5-27. Converting Strings to Numbers in the primer.ts File

```
let firstVal = "5";
let secondVal = "5";

let result = Number(firstVal) + Number(secondVal);
console.log("Result: " + result);
```

The output from this script is as follows:

```
Result: 10
```

The `Number` function is strict in the way that is parses string values, but there are two other functions you can use that are more flexible and will ignore trailing non-number characters. These functions are `parseInt` and `parseFloat`. I have described all three methods in Table 5-5.

Table 5-5. *Useful String to Number Methods*

Method	Description
`Number(str)`	This method parses the specified string to create an integer or real value.
`parseInt(str)`	This method parses the specified string to create an integer value.
`parseFloat(str)`	This method parses the specified string to create an integer or real value.

Working with Arrays

JavaScript arrays work like arrays in most other programming languages. Listing 5-28 shows how you can create and populate an array.

Listing 5-28. Creating and Populating an Array in the primer.ts File

```
let myArray = new Array();
myArray[0] = 100;
myArray[1] = "Adam";
myArray[2] = true;
```

I have created a new array by calling `new Array()`. This creates an empty array, which I assign to the variable `myArray`. In the subsequent statements, I assign values to various index positions in the array. (There is no console output from this listing.)

There are a couple of things to note in this example. First, I didn't need to declare the number of items in the array when I created it. JavaScript arrays will resize themselves to hold any number of items. The second point is that I didn't have to declare the data types that the array will hold. Any JavaScript array can hold any mix of data types. In the example, I have assigned three items to the array: a `number`, a `string`, and a `boolean`.

Using an Array Literal

The array literal style lets you create and populate an array in a single statement, as shown in Listing 5-29.

Listing 5-29. Using the Array Literal Style in the primer.ts File

```
let myArray = [100, "Adam", true];
```

In this example, I specified that the `myArray` variable should be assigned a new array by specifying the items I wanted in the array between square brackets (`[` and `]`). (There is no console output from this listing.)

Reading and Modifying the Contents of an Array

You read the value at a given index using square braces ([and]), placing the index you require between the braces, as shown in Listing 5-30.

Listing 5-30. Reading the Data from an Array Index in the primer.ts File

```
let myArray = [100, "Adam", true];
console.log("Index 0: " + myArray[0]);
```

You can modify the data held in any position in a JavaScript array simply by assigning a new value to the index. Just as with regular variables, you can switch the data type at an index without any problems. The output from the listing is as follows:

```
Index 0: 100
```

Listing 5-31 demonstrates modifying the contents of an array.

Listing 5-31. Modifying the Contents of an Array in the primer.ts File

```
let myArray = [100, "Adam", true];
myArray[0] = "Tuesday";
console.log("Index 0: " + myArray[0]);
```

In this example, I have assigned a `string` to position `0` in the array, a position that was previously held by a `number` and produces this output:

```
Index 0: Tuesday
```

Enumerating the Contents of an Array

You enumerate the content of an array using a `for` loop or using the `forEach` method, which receives a function that is called to process each element in the array. Both approaches are shown in Listing 5-32.

Listing 5-32. Enumerating the Contents of an Array in the primer.ts File

```
let myArray = [100, "Adam", true];


for (let i = 0; i < myArray.length; i++) {
    console.log("Index " + i + ": " + myArray[i]);
}

console.log("---");

myArray.forEach((value, index) => console.log("Index " + index + ": " + value));
```

The JavaScript `for` loop works just the same way as loops in many other languages. You determine how many elements there are in the array by using the `length` property.

The function passed to the `forEach` method is given two arguments: the value of the current item to be processed and the position of that item in the array. In this listing, I have used an arrow function as the argument to the `forEach` method and is the kind of use for which they excel (and you will see used throughout this book). The output from the listing is as follows:

```
Index 0: 100
Index 1: Adam
Index 2: true
```

```
Index 0: 100
Index 1: Adam
Index 2: true
```

Using the Built-in Array Methods

The JavaScript `Array` object defines a number of methods that you can use to work with arrays, the most useful of which are described in Table 5-6.

Table 5-6. *Useful Array Methods*

Method	Description
`concat(otherArray)`	This method returns a new array that concatenates the array on which it has been called with the array specified as the argument. Multiple arrays can be specified.
`join(separator)`	This method joins all the elements in the array to form a string. The argument specifies the character used to delimit the items.
`pop()`	This method removes and returns the last item in the array.
`shift()`	This method removes and returns the first element in the array.
`push(item)`	This method appends the specified item to the end of the array.
`unshift(item)`	This method inserts a new item at the start of the array.
`reverse()`	This method returns a new array that contains the items in reverse order.
`slice(start,end)`	This method returns a section of the array.
`sort()`	This method sorts the array. An optional comparison function can be used to perform custom comparisons.
`splice(index, count)`	This method removes `count` items from the array, starting at the specified `index`. The removed items are returned as the result of the method.
`unshift(item)`	This method inserts a new item at the start of the array.
`every(test)`	This method calls the `test` function for each item in the array and returns `true` if the function returns `true` for all of them and false otherwise.
`some(test)`	This method returns `true` if calling the `test` function for each item in the array returns `true` at least once.

(*continued*)

Table 5-6. (*continued*)

Method	Description
`filter(test)`	This method returns a new array containing the items for which the `test` function returns `true`.
`find(test)`	This method returns first item in the array for which the `test` function returns `true`.
`findIndex(test)`	This method returns the index of the first item in the array for which the `test` function returns `true`.
`foreach(callback)`	This method invokes the `callback` function for each item in the array, as described in the previous section.
`includes(value)`	This method returns `true` if the array contains the specified value.
`map(callback)`	This method returns a new array containing the result of invoking the `callback` function for every item in the array.
`reduce(callback)`	This method returns the accumulated value produced by invoking the callback function for every item in the array.

Since many of the methods in Table 5-6 return a new array, these methods can be chained together to process a data array, as shown in Listing 5-33.

Listing 5-33. Processing a Data Array in the primer.ts File

```
let products = [
    { name: "Hat", price: 24.5, stock: 10 },
    { name: "Kayak", price: 289.99, stock: 1 },
    { name: "Soccer Ball", price: 10, stock: 0 },
    { name: "Running Shoes", price: 116.50, stock: 20 }
];

let totalValue = products
    .filter(item => item.stock > 0)
    .reduce((prev, item) => prev + (item.price * item.stock), 0);

console.log("Total value: $" + totalValue.toFixed(2));
```

I use the `filter` method to select the items in the array whose `stock` value is greater than zero and use the `reduce` method to determine the total value of those items, producing the following output:

```
Total value: $2864.99
```

Summary

In this chapter I provided a brief primer on the JavaScript, focusing on the core functionality that will get you started with the language. Some of the features that I described in this chapter are recent additions to the JavaScript specification and require the TypeScript compiler to convert them to code that can run in older browsers. I continue this theme in the next chapter and introduce some of the more advanced JavaScript features that are used in Angular development.

CHAPTER 6

JavaScript and TypeScript: Part 2

In this chapter, I describe some of the more advanced JavaScript features that are useful for Angular development. I explain how JavaScript deals with objects, including support for classes, and I explain how JavaScript functionality is packaged into JavaScript modules. I also introduce some of the features that TypeScript provides that are not part of the JavaScript specification and that I rely on for some of the examples later in the book. Table 6-1 summarizes the chapter.

Table 6-1. *Chapter Summary*

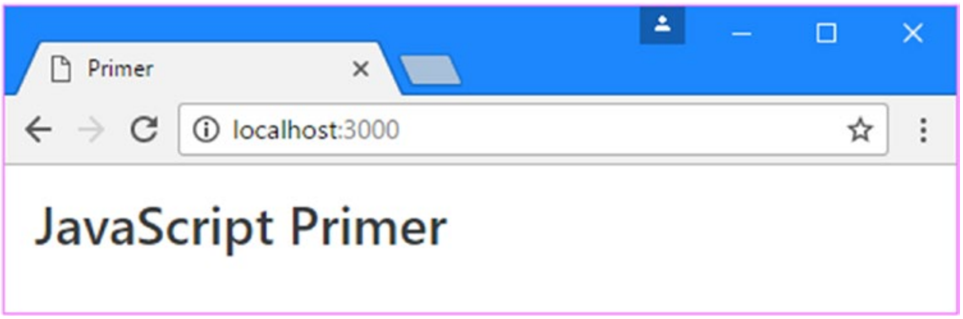
Problem	Solution	Listing
Create an object by specifying properties and values	Use the `new` keyword or use an object literal	1–3
Create an object using a template	Define a class	4, 5
Inherit behavior from another class	Use the `extends` keyword	6
Package JavaScript features together	Create a JavaScript module	7
Declare a dependency on a module	Use the `import` keyword	8–12
Declare the types used by properties, parameters, and variables	Use TypeScript type annotations	13–18
Specify multiple types	Use union types	19–21
Create ad hoc groups of types	Use tuples	22
Group values together by key	Use indexable types	23
Control access to the methods and properties in a class	Use the access control modifiers	24

Preparing the Example Project

For this chapter, I continue using the JavaScriptPrimer project from Chapter 5. No changes are required to prepare for this chapter, and running the following command in the `JavaScriptPrimer` folder will start the TypeScript compiler and the development HTTP server:

```
npm start
```

A new browser window will open and show the content in Figure 6-1.



JavaScript Primer

Figure 6-1. *Running the example application*

The examples in this chapter rely on the browser's JavaScript console to display messages. If you look at the console, you will see the following result:

```
Total value: $2864.99
```

Working with Objects

There are several ways to create objects in JavaScript. Listing 6-1 gives a simple example to get started.

■ **Note** Some of the examples in this chapter cause the TypeScript compiler to report errors. The examples still work, and you can ignore these messages, which arise because TypeScript provides some extra features that I don't describe until later in this chapter.

Listing 6-1. Creating an Object in the primer.ts File

```
let myData = new Object();
myData.name = "Adam";
myData.weather = "sunny";

console.log("Hello " + myData.name + ".");
console.log("Today is " + myData.weather + ".");
```

I create an object by calling `new Object()`, and I assign the result (the newly created object) to a variable called `myData`. Once the object is created, I can define properties on the object just by assigning values, like this:

```
...
myData.name = "Adam";
...
```

Prior to this statement, my object doesn't have a property called name. When the statement has executed, the property does exist, and it has been assigned the value Adam. You can read the value of a property by combining the variable name and the property name with a period, like this:

```
...
console.log("Hello " + myData.name + ".");
...
```

The result from the listing is as follows:

```
Hello Adam.
Today is sunny.
```

Using Object Literals

You can define an object and its properties in a single step using the *object literal* format, as shown in Listing 6-2.

Listing 6-2. Using the Object Literal Format in the primer.ts File

```
let myData = {
    name: "Adam",
    weather: "sunny"
};

console.log("Hello " + myData.name + ". ");
console.log("Today is " + myData.weather + ".");
```

Each property that you want to define is separated from its value using a colon (:), and properties are separated using a comma (,). The effect is the same as in the previous example, and the result from the listing is as follows:

```
Hello Adam.
Today is sunny.
```

Using Functions as Methods

One of the features that I like most about JavaScript is the way you can add functions to objects. A function defined on an object is called a *method*. Listing 6-3 shows how you can add methods in this manner.

Listing 6-3. Adding Methods to an Object in the primer.ts File

```
let myData = {
    name: "Adam",
    weather: "sunny",
    printMessages: function () {
        console.log("Hello " + this.name + ". ");
        console.log("Today is " + this.weather + ".");
    }
};
myData.printMessages();
```

In this example, I have used a function to create a method called `printMessages`. Notice that to refer to the properties defined by the object, I have to use the `this` keyword. When a function is used as a method, the function is implicitly passed the object on which the method has been called as an argument through the special variable `this`. The output from the listing is as follows:

```
Hello Adam.
Today is sunny.
```

Defining Classes

Classes are templates that are used to create objects that have identical functionality. Support for classes is a recent addition to the JavaScript specification intended to make working with JavaScript more consistent with other mainstream programming languages, and they are used throughout Angular development. Listing 6-4 shows how the functionality defined by the object in the previous section can be expressed using a class.

Listing 6-4. Defining a Class in the primer.ts File

```
class MyClass {

    constructor(name, weather) {
        this.name = name;
        this.weather = weather;
    }

    printMessages() {
        console.log("Hello " + this.name + ". ");
        console.log("Today is " + this.weather + ".");
    }
}

let myData = new MyClass("Adam", "sunny");
myData.printMessages();
```

JavaScript classes will be familiar if you have used another mainstream language such as Java or C#. The `class` keyword is used to declare a class, followed by the name of the class, which is `MyClass` in this case.

The `constructor` function is invoked when a new object is created using the class, and it provides an opportunity to receive data values and do any initial setup that the class requires. In the example, the constructor defines `name` and `weather` parameters that are used to create variables with the same names. Variables defined like this are known as properties.

Classes can have methods, which defined as functions, albeit without needing to use the function keyword. There is one method in the example, called `printMessages`, and it uses the values of the `name` and `weather` properties to write messages to the browser’s JavaScript console.

■ **Tip** Classes can also have static methods, denoted by the `static` keyword. Static methods belong to the class rather than the objects they create. I have included an example of a static method in Listing 6-14.

The `new` keyword is used to create an object from a class, like this:

```
...
let myData = new MyClass("Adam", "sunny");
...
```

This statement creates a new object using the `MyClass` class as its template. `MyClass` is used like a function in this situation, and the arguments passed to it will be received by the `constructor` function defined by the class. The result of this expression is a new object that is assigned to a variable called `myData`. Once you have created an object, you can access its properties and methods through the variable to which it has been assigned, like this:

```
...
myData.printMessages();
...
```

This example produces the following results in the browser's JavaScript console:

```
Hello Adam.
Today is sunny.
```

JAVASCRIPT CLASSES VS PROTOTYPES

The class feature doesn't change the underlying way that JavaScript handles types. Instead, it simply provides a way to use them that is more familiar to the majority of programmers. Behind the scenes, JavaScript still uses its traditional type system, which is based on prototypes. As an example, the code in Listing 6-4 can also be written like this:

```
var MyClass = function MyClass(name, weather) {
    this.name = name;
    this.weather = weather;
}

MyClass.prototype.printMessages = function () {
    console.log("Hello " + this.name + ". ");
    console.log("Today is " + this.weather + ".");
};

var myData = new MyClass("Adam", "sunny");
myData.printMessages();
```

Angular development is easier when using classes, which is the approach that I have taken throughout this book. A lot of the features introduced in ES6 are classified as syntactic sugar, which means that they make aspects of JavaScript easier to understand and use. The term *syntactic sugar* may seem pejorative, but JavaScript has some odd quirks, and many of these features help developers avoid common pitfalls.

Defining Class Getter and Setter Properties

JavaScript classes can define properties in their constructor, resulting in a variable that can be read and modified elsewhere in the application. Getters and setters appear as regular properties outside of the class, but they allow the introduction of additional logic, which is useful for validating or transforming new values or generating values programmatically, as shown in Listing 6-5.

Listing 6-5. Using Getters and Setters in the primer.ts File

```
class MyClass {
    constructor(name, weather) {
        this.name = name;
        this._weather = weather;
    }

    set weather(value) {
        this._weather = value;
    }

    get weather() {
        return `Today is ${this._weather}`;
    }

    printMessages() {
        console.log("Hello " + this.name + ". ");
        console.log(this.weather);
    }
}

let myData = new MyClass("Adam", "sunny");
myData.printMessages();
```

The getter and setter are implemented as functions preceded by the get or set keyword. There is no notion of access control in JavaScript classes, and the convention is to prefix the names of internal properties with an underscore (the _ character). In the listing, the weather property is implemented with a setter that updates a property called _weather and a getter that incorporates the _weather value in a template string. This example produces the following results in the browser's JavaScript console:

```
Hello Adam.
Today is sunny
```

Using Class Inheritance

Classes can inherit behavior from other classes using the extends keyword, as shown in Listing 6-6.

Listing 6-6. Using Class Inheritance in the primer.ts File

```
class MyClass {
    constructor(name, weather) {
        this.name = name;
        this._weather = weather;
    }

    set weather(value) {
        this._weather = value;
    }

    get weather() {
        return `Today is ${this._weather}`;
    }

    printMessages() {
        console.log("Hello " + this.name + ". ");
        console.log(this.weather);
    }
}

class MySubClass extends MyClass {

    constructor(name, weather, city) {
        super(name, weather);
        this.city = city;
    }

    printMessages() {
        super.printMessages();
        console.log(`You are in ${this.city}`);
    }
}

let myData = new MySubClass("Adam", "sunny", "London");
myData.printMessages();
```

The extends keyword is used to declare the class that will be inherited from, known as the *super class* or *base class*. In the listing, the MySubClass inherits from MyClass. The super keyword is used to invoke the super class's constructor and methods. The MySubClass builds on the MyClass functionality to add support for a city, producing the following results in the browser's JavaScript console:

```
Hello Adam.
Today is sunny
You are in London
```

Working with JavaScript Modules

JavaScript modules are used to manage the dependencies in a web application, which means you don't need to manage a set of `script` elements in the HTML document. Instead, a module loader is responsible for figuring out which files are required to run an application, loading those files and executing them in the right order. In a complex application, this is a difficult task to perform manually, and it is something that is well-suited to automation.

Creating Modules

Creating modules is simple and is performed automatically when TypeScript compiles a file, because each file is treated as a module. The `export` keyword is used to denote variables and classes that can be used outside of the file, which means that any other variables or classes can be used only within the file. To demonstrate how modules work, I created a folder called `modules` in the `JavaScriptPrimer` folder, added to it a file called `NameAndWeather.ts`, and used it to define the classes shown in Listing 6-7.

■ **Tip** Angular has a convention of defining one class per file, which means that every class in an Angular project is contained in a separate module, and you will see the `export` keyword used throughout the examples in this book.

Listing 6-7. The Contents of the NameAndWeather.ts File in the JavaScriptPrimer/modules Folder

```
export class Name {
    constructor(first, second) {
        this.first = first;
        this.second = second;
    }

    get nameMessage() {
        return `Hello ${this.first} ${this.second}`;
    }
}

export class WeatherLocation {
    constructor(weather, city) {
        this.weather = weather;
        this.city = city;
    }

    get weatherMessage() {
        return `It is ${this.weather} in ${this.city}`;
    }
}
```

The `export` keyword has been applied to each of the classes in the new file, which means they can be used elsewhere in the application.

DIFFERENT MODULE FORMATS

There are different types of JavaScript module, each of which is supported by a different set of module loaders. The TypeScript compiler can be configured to produce the most popular formats, specified through the `module` property in the `tsconfig.json` file. The `commonjs` format is used for Angular development, which can be seen in the `tsconfig.json` file created in Chapter 5.

```
{
  "compilerOptions": {
    "target": "es5",
    "module": "commonjs",
    "moduleResolution": "node",
    "emitDecoratorMetadata": true,
    "experimentalDecorators": true
  },
  "exclude": [ "node_modules" ]
}
```

This format can be handled by the SystemJS module loader that I used for the examples in this book and that I describe in Chapter 11.

Importing from JavaScript Modules

The `import` keyword is used to declare dependencies on the contents of a module. There are different ways to use the `import` keyword, as described in the following sections.

Importing Specific Types

The conventional way to use the `import` keyword is to declare dependencies on specific types, as shown in Listing 6-8. This has the advantage of minimizing the dependencies in the application, which can be used to optimize the application for deployment, as described in Chapter 10.

Listing 6-8. Importing Specific Types in the primer.ts File

```
import { Name, WeatherLocation } from "./modules/NameAndWeather";

let name = new Name("Adam", "Freeman");
let loc = new WeatherLocation("raining", "London");

console.log(name.nameMessage);
console.log(loc.weatherMessage);
```

This is the way that I have used the `import` keyword in most of the examples in this book. The keyword is followed by curly braces that contain a comma-separated list of the classes that the code in the current files depends on, followed by the `from` keyword, followed by the module name. In this case, I have imported the `Name` and `WeatherLocation` classes from the `NameAndWeather` module in the modules folder. Notice that the file extension is not included when specifying the module.

■ **Tip** Notice that I didn't have to make any changes to the project to start using the `NameAndWeather` module. The `import` statement in the `primer.ts` file declares a dependency on the module, which the module loader resolves automatically.

The example in Listing 6-8 produces the following messages in the browser's JavaScript console:

```
Hello Adam Freeman
It is raining in London
```

UNDERSTANDING MODULE RESOLUTION

You will see two different ways of specifying modules in the `import` statements in this book. The first is a relative module, in which the name of the module is prefixed with `./`, like this example from Listing 6-8:

```
...
import { Name, WeatherLocation } from "./modules/NameAndWeather";
...
```

This kind of import tells the TypeScript compiler that the module is located relative to the file that contains the `import` statement. In this case, the `NameAndWeather.ts` file is in the `modules` directory, which is in the same directory as the `primer.ts` file. The other type of import is nonrelative. Here is an example of a nonrelative import from Chapter 2 and one that you will see in just about every chapter in this book:

```
...
import { Component } from "@angular/core";
...
```

This import statement doesn't begin with `./` and so the TypeScript compiler resolves it using the NPM packages in the `node_modules` folder.

The JavaScript module loader must also be configured so that it knows how to resolve both relative and nonrelative modules using HTTP requests. I describe this process in detail in Chapter 11.

Renaming Imports

In complex projects that have lots of dependencies, it is possible that you will need to use two classes with the same name from different modules. To re-create this problem, I created a file called `DuplicateName.ts` in the `JavaScriptPrimer/modules` folder and defined the class shown in Listing 6-9.

Listing 6-9. The Contents of the DuplicateName.ts File in the JavaScriptPrimer/modules Folder

```
export class Name {

    get message() {
        return "Other Name";
    }
}
```

This class doesn't do anything useful, but it is called Name, which means that importing it using the approach in Listing 6-8 will cause a conflict because the compiler won't be able to differentiate between the classes. The solution is to use the as keyword, which allows an alias to be created for a class when it is important from a module, as shown in Listing 6-10.

Listing 6-10. Using a Module Alias in the primer.ts File

```
import { Name, WeatherLocation } from "./modules/NameAndWeather";
import { Name as OtherName } from "./modules/DuplicateName";

let name = new Name("Adam", "Freeman");
let loc = new WeatherLocation("raining", "London");
let other = new OtherName();

console.log(name.nameMessage);
console.log(loc.weatherMessage);
console.log(other.message);
```

The Name class in the DupliateName module is imported as OtherName, which allows it to be used without conflicting with the Name class in the NameAndWeather module. This example produces the following output:

```
Hello Adam Freeman
It is raining in London
Other Name
```

Importing All of the Types in a Module

An alternative approach is to import the module as an object that has properties for each of the types it contains, as shown in Listing 6-11.

Listing 6-11. Importing a Module as an Object in the primer.ts File

```
import * as NameAndWeatherLocation from "./modules/NameAndWeather";
import { Name as OtherName } from "./modules/DuplicateName";

let name = new NameAndWeatherLocation.Name("Adam", "Freeman");
let loc = new NameAndWeatherLocation.WeatherLocation("raining", "London");
let other = new OtherName();
```

```
console.log(name.nameMessage);
console.log(loc.weatherMessage);
console.log(other.message);
```

The import statement in this example imports the contents of the NameAndWeather module and creates an object called NameAndWeatherLocation. This object has Name and Weather properties that correspond to the classes defined in the module. This example produces the same output as Listing 6-10.

■ **Tip** Not all modules export types, which means you can't specify the names that you want to import. In this situation, you can use an import statement that specifies the JavaScript file name, without the file extension. There are some examples in this that use this technique, which is why you will see statements such as `import "rxjs/add/operator/map"` used in the SportsStore application in Chapter 8. This statement causes the module loader to execute the contents of the `rxjs/add/operator/map.js` file, which adds a method used to process data received from an HTTP request.

Useful TypeScript Features

TypeScript is a superset of JavaScript, which means it isn't just a compiler for working with the latest JavaScript features. In the sections that follow, I demonstrate the most useful TypeScript features for Angular development, many of which I have used in the examples in this book.

You don't have to use any of the features that I describe in this section. All of these features are optional for Angular development, and you can create complex and fully functioning applications with just the JavaScript features described in Chapter 5 and the previous sections of this chapter. But these TypeScript features can make some Angular features easier to use, as I explain in later chapters.

■ **Tip** TypeScript supports more features than I describe in this chapter. I introduce some additional features as I use them in later chapters, but for a full reference, see the TypeScript homepage at `www.typescriptlang.org`.

Using Type Annotations

The flexibility of the JavaScript type system tends to polarize developers. For some developers, the fluidity of JavaScript types is powerful, expressive, and dynamic. For others, it is a recipe for chaos, to the extent that many developers are left with the impression that JavaScript doesn't have a type system at all.

The headline TypeScript feature is support for type annotations, which can help reduce common JavaScript errors by applying type checking when the code is compiled, in a way that is reminiscent of languages like C# or Java. If you have struggled to come to terms with the JavaScript type system (or didn't even realize that there was one), then type annotations can go a long way to preventing the most common errors. (On the other hand, if you like the freedom of regular JavaScript types, you may find TypeScript type annotations restrictive and annoying.)

To show the kind of problem that type annotations solve, I created a file called tempConverter.ts in the JavaScriptPrimer folder and added the code in Listing 6-12.

Listing 6-12. The Contents of the tempConverter.ts in the JavaScriptPrimer Folder

```
export class TempConverter {

    static convertFtoC(temp) {
        return ((parseFloat(temp.toPrecision(2)) - 32) / 1.8).toFixed(1);
    }
}
```

The `TempConverter` class contains a simple static method called `convertFtoC` that accepts a temperature value expressed in degrees Fahrenheit and returns the same temperature expressed in degrees Celsius.

The problem is that there are some assumptions in this code that are not explicit. The `convertFtoC` method expected to receive a `number` value, on which the `toPrecision` method is called to set the number of floating-point digits. The method returns a `string`, although that is difficult to tell without inspecting the code carefully (the result of the `toFixed` method is a `string`).

These implicit assumptions lead to problems, especially when one developer is using JavaScript code written by another developer. In Listing 6-13, I have deliberately created an error by passing the temperature as a `string` value, instead of the `number` that the method expects.

Listing 6-13. Using the Wrong Type in the primer.ts File

```
import { Name, WeatherLocation } from "./modules/NameAndWeather";
import { Name as OtherName } from "./modules/DuplicateName";
import { TempConverter } from "./tempConverter";

let name = new Name("Adam", "Freeman");
let loc = new WeatherLocation("raining", "London");
let other = new OtherName();

let cTemp = TempConverter.convertFtoC("38");

console.log(name.nameMessage);
console.log(loc.weatherMessage);
console.log(`The temp is ${cTemp}C`);
```

When the code is executed by the browser, you will see the following message in the browser's JavaScript console (the exact working may differ based on the browser you are using):

```
temp.toPrecision is not a function
```

This kind of issue can be fixed without using TypeScript, of course, but it does mean that a substantial amount of the code in any JavaScript application is given over to checking the types that are being used. The TypeScript solution is to make type enforcement the job of the compiler, using type annotations that are added to the JavaScript code. In Listing 6-14, I have added type annotations to the `TempConverter` class.

Listing 6-14. Adding Type Annotations in the tempConverter.ts File

```
export class TempConverter {

    static convertFtoC(temp: number) : string {
        return ((parseFloat(temp.toPrecision(2)) - 32) / 1.8).toFixed(1);
    }
}
```

Type annotations are expressed using a colon (the `:` character) followed by the type. There are two annotations in the example. The first specifies that the parameter to the `convertFtoC` method should be a `number`.

```
...
static convertFtoC(temp: number) : string {
...
```

The other annotation specifies that the result of the method is a string.

```
...
static convertFtoC(temp: number) : string {
...
```

When you save the changes to the file, the TypeScript compiler will run. Among the errors that are reported will be this one:

```
primer.ts(8,39): error TS2345: Argument of type 'string' is not assignable to parameter of
type 'number'.
```

The TypeScript compiler has examined that the type of the value passed to the `convertFtoC` method in the `primer.ts` file doesn't match the type annotation and has reported an error. This is the core of the TypeScript type system; it means you don't have to write additional code in your classes to check that you have received the expected types, and it also makes it easy to determine the type of a method result. To resolve the error reported to the compiler, Listing 6-15 updates the statement that invokes the `convertFtoC` method so that it uses a `number`.

Listing 6-15. Using a Number Argument in the primer.ts File

```
import { Name, WeatherLocation } from "./modules/NameAndWeather";
import { Name as OtherName } from "./modules/DuplicateName";
import { TempConverter } from "./tempConverter";

let name = new Name("Adam", "Freeman");
let loc = new WeatherLocation("raining", "London");
let other = new OtherName();

let cTemp = TempConverter.convertFtoC(38);

console.log(name.nameMessage);
console.log(loc.weatherMessage);
console.log(other.message);
console.log(`The temp is ${cTemp}C`);
```

When you save the changes, you will see the following messages displayed in the browser's JavaScript console:

```
Hello Adam Freeman
It is raining in London
Other Name
The temp is 3.3C
```

Type Annotating Properties and Variables

It isn't just methods that type annotations can be applied to. They can also be applied to properties and variables, ensuring that all of the types used in an application can be verified by the compiler. In Listing 6-16, I have added type annotations to the classes in the NameAndWeather module.

TYPE DEFINITION FOR JAVASCRIPT LIBRARIES

TypeScript works best when it has type information for all the packages that you are working with, including the ones from third parties. Some of the packages required for Angular (including the Angular framework itself) include the information that TypeScript needs. For other packages, type information must be downloaded and added to the package.

This is done using the `typings` tool, which you can see used in Chapter 7 and is explained in more detail in Chapter 11.

Listing 6-16. Applying Type Annotations in the NameAndWeather.ts File

```
export class Name {
    first: string;
    second: string;

    constructor(first: string, second: string) {
        this.first = first;
        this.second = second;
    }

    get nameMessage() : string {
        return `Hello ${this.first} ${this.second}`;
    }
}

export class WeatherLocation {
    weather: string;
    city: string;

    constructor(weather: string, city: string) {
        this.weather = weather;
        this.city = city;
    }
    get weatherMessage() : string {
        return `It is ${this.weather} in ${this.city}`;
    }
}
```

Properties are declared with a type annotation, following the same pattern as for parameter and result annotations. The changes in Listing 6-17 resolve the remaining errors reported by the TypeScript compiler, which was complaining because it didn't know what the types were for the properties created in the constructors.

The pattern of receiving constructor parameters and assigning their values to variables is so common that TypeScript includes an optimization, as shown in Listing 6-17.

Listing 6-17. Creating Properties from Constructor Parameters in the NameAndWeather.ts File

```
export class Name {
    constructor(private first: string, private second: string) {}

    get nameMessage() : string {
        return `Hello ${this.first} ${this.second}`;
    }
}

export class WeatherLocation {

    constructor(private weather: string, private city: string) {}

    get weatherMessage() : string {
        return `It is ${this.weather} in ${this.city}`;
    }
}
```

The keyword `private` is an example of an access control modifier, which I describe in the "Using Access Modifiers" section. Applying the keyword to the constructor parameter has the effect of automatically defining the class property and assigning it the parameter value. The code in Listing 6-17 has the same effect as Listing 6-16 but is more concise.

Specifying Multiple Types or Any Type

TypeScript allows multiple types to be specified, separated using a bar (the | character). This can be useful when a method can accept or return multiple types or when a variable can be assigned values of different types. Listing 6-18 modifies the `convertFtoC` method so that it will accept `number` or `string` values.

Listing 6-18. Accepting Multiple Values in the tempConverter.ts File

```
export class TempConverter {

    static convertFtoC(temp: number | string): string {
        let value: number = (<number>temp).toPrecision
            ? <number>temp : parseFloat(<string>temp);
        return ((parseFloat(value.toPrecision(2)) - 32) / 1.8).toFixed(1);
    }
}
```

The type declaration for the temp parameter has changes to number | string, which means that the method can accept either value. This is called a *union type*. Within the method, a type assertion is used to work out which type has been received. This is a slightly awkward process, but the parameter value is cast to a number value in order to check is there is a toPrecision method defined on the result, like this:

```
...
(<number>temp).toPrecision
...
```

The angle brackets (the < and > characters) are to declare a type assertion, which will attempt to convert an object to the specified type. You can also achieve the same result using the as keyword, as shown in Listing 6-19.

Listing 6-19. Using the as Keyword in the tempConverter.ts File

```
export class TempConverter {

    static convertFtoC(temp: number | string): string {
        let value: number = (temp as number).toPrecision
            ? temp as number : parseFloat(<string>temp);
        return ((parseFloat(value.toPrecision(2)) - 32) / 1.8).toFixed(1);
    }
}
```

An alternative to specifying a union type is to use the any keyword, which allows any type to be assigned to a variable, used as an argument, or returned from a method. Listing 6-20 replaces the union type in the convertFtoC method with the any keyword.

■ **Tip** The TypeScript compiler will implicitly apply the any keyword when you omit a type annotation.

Listing 6-20. Specifying Any Type in the tempConverter.ts File

```
export class TempConverter {

    static convertFtoC(temp: any): string {
        let value: number;
        if ((temp as number).toPrecision) {
            value = temp;
        } else if ((temp as string).indexOf) {
            value = parseFloat(<string>temp);
        } else {
            value = 0;
        }
        return ((parseFloat(value.toPrecision(2)) - 32) / 1.8).toFixed(1);
    }
}
```

■ **Tip** At the opposite end of the spectrum is `void`, which is used to indicate that a method returns no result. You don't have to use `void`, but it makes the fact that there is no result obvious.

Using Tuples

Tuples are fixed-length arrays, where each item in the array is of a specified type. This is a vague-sounding description because tuples are so flexible. As an example, Listing 6-21 uses a tuple to represent a city and its current weather and temperature.

Listing 6-21. Using a Tuple in the primer.ts File

```
import { Name, WeatherLocation } from "./modules/NameAndWeather";
import { Name as OtherName } from "./modules/DuplicateName";
import { TempConverter } from "./tempConverter";

let name = new Name("Adam", "Freeman");
let loc = new WeatherLocation("raining", "London");
let other = new OtherName();

let cTemp = TempConverter.convertFtoC("38");

let tuple: [string, string, string];
tuple = ["London", "raining", TempConverter.convertFtoC("38")]

console.log(`It is ${tuple[2]} degrees C and ${tuple[1]} in ${tuple[0]}`);
```

Tuples are defined as an array of types, and individual elements are accessed using array indexers. This example produces the following message in the browser's JavaScript console:

```
It is 3.3 degrees C and raining in London
```

Using Indexable Types

Indexable types associate a key with a value, creating a map-like collection that can be used to gather related data items together. In Listing 6-22, I have used an indexable type to collect together information about multiple cities.

Listing 6-22. Using Indexable Types in the primer.ts File

```
import { Name, WeatherLocation } from "./modules/NameAndWeather";
import { Name as OtherName } from "./modules/DuplicateName";
import { TempConverter } from "./tempConverter";

let cities: { [index: string]: [string, string] } = {};

cities["London"] = ["raining", TempConverter.convertFtoC("38")];
cities["Paris"] = ["sunny", TempConverter.convertFtoC("52")];
```

```
cities["Berlin"] = ["snowing", TempConverter.convertFtoC("23")];

for (let key in cities) {
    console.log(`${key}: ${cities[key][0]}, ${cities[key][1]}`);
}
```

The `cities` variable is defined as an indexable type, with the key as a string and the data value a `[string, string]` tuple. Values are assigned and read using array-style indexers, such as `cities["London"]`. The collection of keys in an indexable type can be accessed using a `for...in` loop, as shown in the example, which produces the following output in the browser's JavaScript console:

```
London: raining, 3.3
Paris: sunny, 11.1
Berlin: snowing, -5.0
```

Only `number` and `string` values can be used as the keys for indexable types, but this is a helpful feature that I use in examples in later chapters.

Using Access Modifiers

JavaScript doesn't support access protection, which means that classes, their properties, and their methods can all be accessed from any part of the application. There is a convention of prefixing the name of implementation members with an underscore (the _ character), but this is just a warning to other developers and is not enforced.

TypeScript provides three keywords that are used to manage access and that are enforced by the compiler. Table 6-2 describes the keywords.

■ **Caution** During development, these keywords have limited effect in Angular applications because a lot of functionality is delivered through properties and methods that are specified in fragments of code embedded in data binding expressions. These expressions are evaluated at runtime in the browser, where there is no enforcement of TypeScript features. They become more important when you come to deploy the application, and it is important to ensure that any property or method that is accessed in a data binding expression is marked as `public` or has no access modified (which has the same effect as using the `public` keyword).

***Table 6-2.** The TypeScript Access Modifier Keywords*

Keyword	Description
public	This keyword is used to denote a property or method that can be accessed anywhere. This is the default access protection if no keyword is used.
private	This keyword is used to denote a property or method that can be accessed only within the class that defines it.
protected	This keyword is used to denote a property or method that can be accessed only within the class that defines it or by classes that extend that class.

Listing 6-23 adds a private method to the TempConverter class.

Listing 6-23. Using an Access Modifier in the tempConverter.ts File

```
export class TempConverter {

    static convertFtoC(temp: any): string {
        let value: number;
        if ((temp as number).toPrecision) {
            value = temp;
        } else if ((temp as string).indexOf) {
            value = parseFloat(<string>temp);
        } else {
            value = 0;
        }
        return TempConverter.performCalculation(value).toFixed(1);
    }

    private static performCalculation(value: number): number {
        return (parseFloat(value.toPrecision(2)) - 32) / 1.8;
    }
}
```

The performCalculation method is marked as private, which means that the TypeScript compiler will report an error code if any other part of the application tries to invoke the method.

Summary

In this chapter, I described the way that JavaScript supports working with objects and classes, explained how JavaScript modules work, and introduced the TypeScript features that are useful for Angular development. In the next chapter, I start the process of creating a realistic project that provides an overview of how different Angular features work together to create applications before digging into individual details in Part 2 of this book.

CHAPTER 7

SportsStore: A Real Application

In Chapter 2, I built a quick and simple Angular application. Small and focused examples allow me to demonstrate specific Angular features, but they can lack context. To help overcome this problem, I am going to create a simple but realistic e-commerce application.

My application, called SportsStore, will follow the classic approach taken by online stores everywhere. I will create an online product catalog that customers can browse by category and page, a shopping cart where users can add and remove products, and a checkout where customers can enter their shipping details and place their orders. I will also create an administration area that includes create, read, update, and delete (CRUD) facilities for managing the catalog—and I will protect it so that only logged-in administrators can make changes. Finally, I show you how to prepare and deploy an Angular application.

My goal in this chapter and those that follow is to give you a sense of what real Angular development is like by creating as realistic an example as possible. I want to focus on Angular, of course, and so I have simplified the integration with external systems, such as the data store, and omitted others entirely, such as payment processing.

The SportsStore example is one that I use in a few of my books, not least because it demonstrates the ways in which different frameworks, languages, and development styles can be used to achieve the same result. You don't need to have read any of my other books to follow this chapter, but you will find the contrasts interesting if you already own my *Pro ASP.NET Core MVC* book, for example.

The Angular features that I use in the SportsStore application are covered in-depth in later chapters. Rather than duplicate everything here, I tell you just enough to make sense for the example application and refer you to other chapters for in-depth information. You can either read the SportsStore chapters end-to-end and get a sense of how Angular works or jump to and from the detail chapters to get into the depth. Either way, don't expect to understand everything right away—Angular has a lot of moving parts, and the SportsStore application is intended to show you how they fit together without diving too deeply into the details that I spend the rest of the book covering.

UNIT TESTING

Angular provides some excellent support for unit testing, but I don't describe it until the final chapter in the book. That's because you really need to understand how Angular works before you can write comprehensive unit tests, and I don't want to include all of the required information and then duplicate it throughout the rest of the book.

That's not to say that unit testing with Angular is difficult or that you need to be an expert in Angular to write a unit test. Rather, the features that make unit testing simple depend on some key concepts that I don't describe until Parts 2 and 3. You can skip ahead to Chapter 29 now if you want to get an early start on unit testing, but my advice is to read the book in sequence so that you understand the foundation on which the unit test features are built.

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Preparing the Project

There is a degree of preparation required for all Angular projects. For the SportsStore application, that includes setting up the development tools that will be used to create the Angular client side of the application and preparing the back-end services that will support Angular by providing storing application data, responding to HTTP requests, and authenticating users. In the sections that follow, I get everything I need to create the SportsStore application in place and ready to use.

Creating the Folder Structure

The starting point for any Angular application is to create the folder structure. Select a location for developing the project and create the folders shown in Table 7-1.

Table 7-1. *The Types of Web Forms Code Nuggets*

Folder	Description
`SportsStore`	This is the main folder for the project and contains the development packages, the configuration files, and the HTML file that will be loaded by the browser to start the project.
`SportsStore/app`	This is the folder that will contain the application's code.
`SportsStore/app/model`	This folder will contain the code for the data model.
`SportsStore/app/store`	This folder will contain the functionality for basic shopping.
`SportsStore/app/admin`	This folder will contain the functionality for administration.

Installing the NPM Packages

Angular development relies on a number of packages, including the Angular framework, libraries that it depends on, polyfill libraries to support essential features on older browsers, and the tools required to compile TypeScript files and handle HTTP requests. The simplest way to manage these packages is to use the NPM tool. I created a file called `package.json` in the `SportsStore` folder and added the configuration shown in Listing 7-1.

■ **Caution** For all the examples in this book, it is important that you use the exact package versions that are shown in the listing in order to ensure that the examples produce the expected results. If you have problems, try using the project for this chapter that is included in the source code download that accompanies this book and that contains additional configuration information for NPM that specifies the version of every package and its dependencies. If all else fails, you can email me at `adam@adam-freeman.com` and I will try to help figure out what's causing the problem.

Listing 7-1. The Contents of the package.json File in the SportsStore Folder

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/forms": "2.2.0",
    "@angular/http": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/router": "3.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4",
    "font-awesome": "4.7.0",
    "intl": "1.2.5",
    "html5-history-api": "4.2.7"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.2",
    "typings": "1.3.2",
    "concurrently": "2.2.0",
    "systemjs-builder": "0.15.32",
    "json-server": "0.8.21",
    "jsonwebtoken": "7.1.9"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" \"npm run json\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "json": "json-server data.js -p 3500 -m authMiddleware.js",
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

Save the package.json file and run the following command in the SportsStore folder to download and install the packages required for the project:

```
npm install
```

NPM will display a list of packages once they have all been installed. There are usually some noncritical warnings during the installation process, which can be ignored.

Preparing the RESTful Web Service

The SportsStore application will use asynchronous HTTP requests to get model data provided by a RESTful web service. As I describe in Chapter 24, REST is an approach to designing web services that uses the HTTP method or verb to specify an operation and the URL to select the data objects that the operation applies to.

I included `json-server` in the project's `package.json` file, which is an excellent package for quickly creating web services from JSON data or JavaScript code. To ensure that there is a fixed state that the project can be reset to, I am going to take advantage of the feature that allows the RESTful web service to be provided with data using JavaScript code, which means that restarting the web service will reset the application data. I created a file called `data.js` in the `SportsStore` folder and added the code shown in Listing 7-2.

■ **Tip** It is important to pay attention to the file names when creating the configuration files. Some have the `.json` extension, which means they contain static data formatted as JSON. Other files have the `.js` extension, which means they contain JavaScript code. Each tool required for Angular development has expectations about its configuration file.

Listing 7-2. The Contents of the data.js File in the SportsStore Folder

```
module.exports = function () {
    return {
        products: [
            { id: 1, name: "Kayak", category: "Watersports",
              description: "A boat for one person", price: 275 },
            { id: 2, name: "Lifejacket", category: "Watersports",
              description: "Protective and fashionable", price: 48.95 },
            { id: 3, name: "Soccer Ball", category: "Soccer",
              description: "FIFA-approved size and weight", price: 19.50 },
            { id: 4, name: "Corner Flags", category: "Soccer",
              description: "Give your playing field a professional touch",
              price: 34.95 },
            { id: 5, name: "Stadium", category: "Soccer",
              description: "Flat-packed 35,000-seat stadium", price: 79500 },
            { id: 6, name: "Thinking Cap", category: "Chess",
              description: "Improve brain efficiency by 75%", price: 16 },
            { id: 7, name: "Unsteady Chair", category: "Chess",
              description: "Secretly give your opponent a disadvantage",
              price: 29.95 },
            { id: 8, name: "Human Chess Board", category: "Chess",
              description: "A fun game for the family", price: 75 },
            { id: 9, name: "Bling Bling King", category: "Chess",
              description: "Gold-plated, diamond-studded King", price: 1200 }
        ],
        orders: []
    }
}
```

This code defines two data collections that will be presented by the RESTful web service. The `products` collection contains the products for sale to the customer, while the `orders` collection will contain the orders that customers have placed (but which is currently empty).

The data stored by the RESTful web service needs to be protected so that ordinary users can't modify the products or change the status or orders. The `json-server` package doesn't include any built-in authentication features, so I created a file called `authMiddleware.js` in the `SportsStore` folder and added the code shown in Listing 7-3.

Listing 7-3. The Contents of the authMiddleware.js File in the SportsStore Folder

```
const jwt = require("jsonwebtoken");

const APP_SECRET = "myappsecret";
const USERNAME = "admin";
const PASSWORD = "secret";

module.exports = function (req, res, next) {
    if (req.url == "/login" && req.method == "POST") {
        if (req.body != null && req.body.name == USERNAME
                && req.body.password == PASSWORD) {
            let token = jwt.sign({ data: USERNAME, expiresIn: "1h" }, APP_SECRET);
            res.json({ success: true, token: token });
        } else {
            res.json({ success: false });
        }
        res.end();
        return;
    } else if ((req.url.startsWith("/products") && req.method != "GET")
                || (req.url.startsWith("/orders") && req.method != "POST")) {
         let token = req.headers["authorization"];
         if (token != null && token.startsWith("Bearer<")) {
            token = token.substring(7, token.length - 1);
            try {
                jwt.verify(token, APP_SECRET);
                next();
                return;
            } catch (err) {}
         }
        res.statusCode = 401;
        res.end();
        return;
    }
    next();
}
```

This code inspects HTTP requests sent to the RESTful web service and implements some basic security features. This is server-side code that is not directly related to Angular development, so don't worry if its purpose isn't immediately obvious. I explain the authentication and authorization process in Chapter 9, including how to authenticate users with Angular.

■ **Caution** Don't use the code in Listing 7-3 other than for the SportsStore application. It contains weak passwords that are hardwired into the code. This is fine for the SportsStore project because the emphasis is on the development client side with Angular, but this is not suitable for real projects.

Configuring TypeScript

I will be using the TypeScript compiler to generate the JavaScript files that will be executed by the browser, as explained in Chapters 5 and 6. I will use type annotations throughout the SportsStore project because they help make the code easier to understand and make some Angular features easier to use.

The TypeScript compiler relies on type definition files to provide it with type information for JavaScript libraries that are not written in TypeScript. Run the following commands in the `SportsStore` folder to download and install the type definition files required for this project:

```
npm run typings -- install dt~core-js --save -global
npm run typings -- install dt~node --save --global
```

The `typings` package will get the latest type information for the Core-JS and Node packages and save them in a folder called `typings`. It will also generate a file called `typings.json` in the `SportsStore` folder that will contain references to the packages, as follows:

```
{
  "globalDependencies": {
    "core-js": "registry:dt/core-js#0.0.0+20160914114559",
    "node": "registry:dt/node#6.0.0+20161110151007"
  }
}
```

TypeScript also requires a configuration for its compiler so that it will generate JavaScript code that works in Angular applications. I created a file called `tsconfig.json` in the SportsStore folder and added the configuration properties shown in Listing 7-4. I explain the configuration properties for the compiler in Chapter 11.

Listing 7-4. The Contents of the tsconfig.json File in the SportsStore Folder

```
{
  "compilerOptions": {
    "target": "es5",
    "module": "commonjs",
    "moduleResolution": "node",
    "emitDecoratorMetadata": true,
    "experimentalDecorators": true
  },
  "exclude": [ "node_modules" ]
}
```

Configuring the Development HTTP Server

The `lite-server` package that I am using as a development HTTP server builds on the `BrowserSync` package. To configure the way that the browser is updated when a change to a project file is detected, I created a file called `bs-config.js` in the `SportsStore` folder and added the configuration shown in Listing 7-5. The configuration properties are described in Chapter 11.

Listing 7-5. The Contents of the bs-config.js File in the SportsStore Folder

```
module.exports = {
    ghostMode: false,
    reloadDelay: 1000,
    reloadDebounce: 1000,
    injectChanges: false,
    minify: false
}
```

Configuring the JavaScript Module Loader

To prepare the SystemJS module loader, I added a file called `systemjs.config.js` in the `SportsStore` folder and used it to define the configuration shown in Listing 7-6.

Listing 7-6. The Contents of the systemjs.config.js File in the SportsStore Folder

```
(function (global) {

    var paths = {
        "@angular/*": "node_modules/@angular/*"
    }

    var packages = { "app": {} };

    var angularModules = ["common", "compiler",
     "core", "platform-browser", "platform-browser-dynamic",
     "forms", "http", "router"];

    angularModules.forEach(function (pkg) {
        packages["@angular/" + pkg] = {
            main: "/bundles/" + pkg + ".umd.min.js"
        };
    });

    System.config({ paths: paths, packages: packages });
})(this);
```

This configuration will allow the module loader to handle the Angular packages and the custom application code. I explain the process for configuring the JavaScript module loader in Chapter 11.

Creating the Reactive Extensions JavaScript Module

Angular depends on Reactive Extensions, which is a package for managing events and change notifications. Some Angular features require you to work directly with Reactive Extensions, but the NPM package doesn't contain the information that the SystemJS JavaScript module loader requires to load a module and resolve its dependencies. That means I need to create my own JavaScript module containing the Reactive Extensions code. The `systemjs-builder` package that I added to the project in Listing 7-1 is used to build modules, and to configure it, I added a file called `rxModuleBuilder.js` to the `SportsStore` folder and added the code shown in Listing 7-7.

■ **Tip** I describe the functionality provided by Reactive Extensions in Chapter 23.

Listing 7-7. The Contents of the rxModuleBuilder.js File in the SportsStore Folder

```
var Builder = require("systemjs-builder");

var builder = new Builder("./");
builder.config({
    paths: {
        "rxjs/*": "node_modules/rxjs/*.js"
    },
    map: {
        "rxjs": "node_modules/rxjs"
    },
    packages: {
        "rxjs": { main: "Rx.js", defaultExtension: "js" }
    }
});
builder.bundle("rxjs", "rxjs.module.min.js", {
    normalize: true,
    runtime: false,
    minify: true,
    mangle: false
});
```

This configuration creates a module containing all of the Reactive Extensions functionality, along with the additional information that SystemJS needs to resolve dependencies. Run the following command in the `SportsStore` folder:

```
node ./rxModuleBuilder.js
```

It can take a few minutes to process the package, but when the command finishes, you will see a file called `rxjs.module.min.js` in the `SportsStore` folder. This is the file that will be used in the project to provide access to the Reactive Extensions package.

Creating the HTML File

Every Angular web application relies on an HTML file that is loaded by the browser and that loads and starts the application. I created a file called `index.html` in the `SportsStore` folder and added the elements shown in Listing 7-8.

Listing 7-8. The Contents of the index.html File in the SportsStore Folder

```
<!DOCTYPE html>
<html>
<head>
    <base href="/" />
    <title>SportsStore</title>
    <meta charset="utf-8" />
    <script src="node_modules/html5-history-api/history.min.js"></script>
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/intl/dist/Intl.complete.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="rxjs.module.min.js"></script>
    <script src="systemjs.config.js"></script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
    <link href="node_modules/font-awesome/css/font-awesome.min.css"
          rel="stylesheet"/>
</head>
<body class="m-a-1">
    <app>SportsStore Will Go Here</app>
</body>
</html>
```

The HTML document includes `script` elements for the polyfill libraries required to support older browsers, a `link` element to load the Bootstrap stylesheet, and an app element, which is the placeholder for the SportsStore functionality.

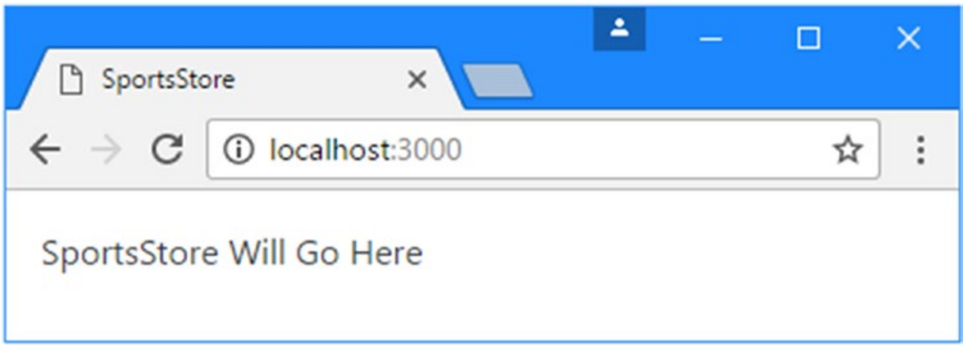
■ **Tip** The HTML document includes a `base` element, which is required by the Angular URL routing features, which I add to the SportsStore project in Chapter 8.

Running the Example Application

Make sure that all the files have been saved, and run the following command in the SportsStore folder:

```
npm start
```

This command will start the TypeScript compiler, the development HTTP server, and the RESTful web service. A new browser window will open and show the content illustrated by Figure 7-1.



SportsStore Will Go Here

Figure 7-1. *Running the example application*

The development web server will start on port 3000, so the URL for the application will be `http://localhost:3000`. You don't have to include the name of the HTML document because `index.html` is the default name that the server responds with.

The RESTful web service is configured to run on port 3500. To test the web service request, use the browser to request the URL `http://localhost:3500/products/1`. The browser will display a JSON representation of one of the products defined in Listing 7-2, as follows:

```
{
  "id": 1,
  "name": "Kayak",
  "category": "Watersports",
  "description": "A boat for one person",
  "price": 275
}
```

Preparing the Angular Project Features

Every Angular project requires some basic preparation, just to get to the point where the application can be loaded and started by the browser. In the sections that follow, I build the foundation on which the SportsStore application will be created.

Creating the Root Component

I started with the root component, which is the Angular building block that will manage the contents of the app element in the HTML document. An application can contain many components, but there is always a root component that takes responsibility for the top-level content presented to the user.

I created a file called `app.component.ts` in the `SportsStore/app` folder and added the code shown in Listing 7-9.

Listing 7-9. The Contents of the app.component.ts File in the SportsStore/app Folder

```
import { Component } from "@angular/core";

@Component({
    selector: "app",
    template: `<div class="bg-success p-a-1 text-xs-center">
                    This is SportsStore
               </div>`
})
export class AppComponent { }
```

The `@Component` decorator tells Angular that the `AppComponent` class is a component and its properties configure how the component is applied. The complete set of component properties are described in Chapter 17, but the three properties shown in the listing are the most basic and most frequently used. The `selector` property tells Angular how to apply the component in the HTML document, and the `template` property defines the content that the component will display. Components can define inline templates, like this one, or use external HTML files, which can make managing complex content easier.

There is no code in the `AppComponent` class because the root component in an Angular project exists just to manage the content shown to the user. Initially, I'll manage the content displayed by the root component manually, but in Chapter 8, I use a feature called *URL routing* to adapt the content automatically based on user actions.

Creating the Root Module

There are two types of Angular module: feature modules and the root module. Features modules are used to group related application functionality to make the application easier to manage. I create feature modules for each major functional area of the application, including the data model, the store interface presented to users, and the administration interface.

The root module is used to describe the application to Angular. The description includes which feature modules are required to run the application, which custom features should be loaded, and the name of the root component. The conventional name of the root component file is `app.module.ts`, and I created a file with this name in the `SportsStore/app` folder and added the code shown in Listing 7-10.

Listing 7-10. The Contents of the app.module.ts File in the SportsStore/app Folder

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { AppComponent } from "./app.component";

@NgModule({
    imports: [BrowserModule],
    declarations: [AppComponent],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

Similar to the root component, there is no code in the root module's class. That's because the root module only really exists to provide information through the `@NgModule` decorator. The `imports` property tells Angular that it should load the `BrowserModule` feature module, which contains all the core Angular features required for a web application.

The `declarations` property tells Angular that it should load the root component, and the `bootstrap` property tells Angular that the root component is the `AppModule` class. I'll add information to this decorator's properties as I add features to the SportsStore application, but this basic configuration will be enough to start the application.

Creating the Bootstrap File

The next piece of plumbing is the bootstrap file, which starts the application. This book is focused on using Angular to create applications that work in web browsers, but the Angular platform can be ported to different environments. The bootstrap file uses the Angular browser platform to load the root module and start the application. I created a file called `main.ts`, which is the conventional name for the bootstrap file, in the `SportsStore/app` folder and added the code shown in Listing 7-11.

Listing 7-11. The Contents of the main.ts File in the SportsStore/app Folder

```
import { platformBrowserDynamic } from "@angular/platform-browser-dynamic";
import { AppModule } from "./app.module";

platformBrowserDynamic().bootstrapModule(AppModule);
```

Adding the JavaScript Module Loader to the HTML Document

The final Angular preparation is to update the HTML document so that the JavaScript module loader will load the bootstrap file and execute it to start Angular and the SportsStore application. The changes to the `index.html` file are shown in Listing 7-12.

Listing 7-12. Configuring the JavaScript Module Loader in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <base href="/" />
    <title>SportsStore</title>
    <meta charset="utf-8" />
    <script src="node_modules/html5-history-api/history.min.js"></script>
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/intl/dist/Intl.complete.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="rxjs.module.min.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
    <link href="node_modules/font-awesome/css/font-awesome.min.css"
          rel="stylesheet"/>
</head>
<body class="m-a-1">
    <app>SportsStore Will Go Here</app>
</body>
</html>
```

The TypeScript compiler will generate JavaScript files each time that it detects a change, and, in turn, this will trigger an update from the development HTTP server that will refresh the browser. When all the changes have been saved, you should see the content in Figure 7-2, which demonstrates that the browser has executed the bootstrap file, which has loaded the root module, which has loaded the root component and, finally, displayed the placeholder content.

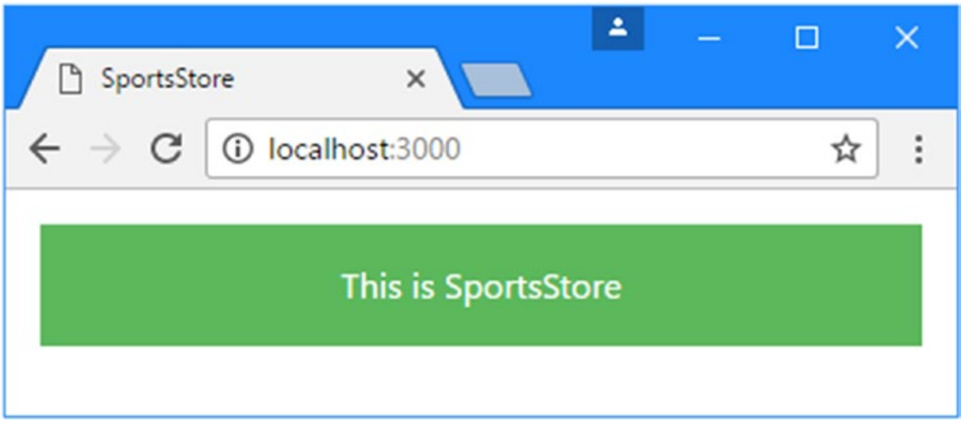


Figure 7-2. *Starting the SportsStore application*

If you examine the browser's Document Object Model, you will see that Angular has inserted the placeholder content from the root component's template within the start and end tags of the app element, like this:

```
<body class="m-a-1">
    <app>
        <div class="bg-success p-a-1 text-xs-center">
            This is SportsStore
        </div>
    </app>
</body>
```

Starting the Data Model

The best place to start any new project is with the data model. I want to get to the point where you can see some Angular features at work, so rather than define the data model end-to-end, I am going to put some basic functionality in place using dummy data. I'll then start using this data to create user-facing features, returning to the data model to wire it up to the RESTful web service in Chapter 8.

Creating the Model Classes

Every data model needs classes that describe the types of data that will be contained in the data model. For the SportsStore application, this means classes that describe the products sold in the store and the orders that are received from customers.

Being able to describe products will be enough to get started with the SportsStore application, and I'll create other model classes to support features as I implement them. I created a file called `product.model.ts` in the `SportsStore/app/model` folder and added the code shown in Listing 7-13.

Listing 7-13. The Contents of the product.model.ts File in the SportsStore/app/model Folder

```
export class Product {

    constructor(
        public id?: number,
        public name?: string,
        public category?: string,
        public description?: string,
        public price?: number) { }
}
```

The `Product` class defines a constructor that accepts `id`, `name`, `category`, `description`, and `price` properties, which correspond to the structure of the data used to populate the RESTful web service in Listing 7-13. The question marks (the ? characters) that follow the parameter names indicate that these are optional parameters that can be omitted when creating new objects using the `Product` class, which can be useful when writing applications where model object properties will be populated using HTML forms.

Creating the Dummy Data Source

To prepare for the transition from dummy to real data, I am going to feed the application data using a data source. The rest of the application won't know where the data is coming from, which will make the switch to getting data using HTTP requests seamless.

I added a file called `static.datasource.ts` to the `SportsStore/app/model` folder and defined the class shown in Listing 7-14.

Listing 7-14. The Contents of the static.datasource.ts in the SportsStore/app/model Folder

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";
import { Observable } from "rxjs/Observable";
import "rxjs/add/observable/from";

@Injectable()
export class StaticDataSource {
    private products: Product[] = [
        new Product(1, "Product 1", "Category 1", "Product 1 (Category 1)", 100),
        new Product(2, "Product 2", "Category 1", "Product 2 (Category 1)", 100),
        new Product(3, "Product 3", "Category 1", "Product 3 (Category 1)", 100),
        new Product(4, "Product 4", "Category 1", "Product 4 (Category 1)", 100),
        new Product(5, "Product 5", "Category 1", "Product 5 (Category 1)", 100),
        new Product(6, "Product 6", "Category 2", "Product 6 (Category 2)", 100),
        new Product(7, "Product 7", "Category 2", "Product 7 (Category 2)", 100),
        new Product(8, "Product 8", "Category 2", "Product 8 (Category 2)", 100),
        new Product(9, "Product 9", "Category 2", "Product 9 (Category 2)", 100),
        new Product(10, "Product 10", "Category 2", "Product 10 (Category 2)", 100),
        new Product(11, "Product 11", "Category 3", "Product 11 (Category 3)", 100),
        new Product(12, "Product 12", "Category 3", "Product 12 (Category 3)", 100),
        new Product(13, "Product 13", "Category 3", "Product 13 (Category 3)", 100),
        new Product(14, "Product 14", "Category 3", "Product 14 (Category 3)", 100),
        new Product(15, "Product 15", "Category 3", "Product 15 (Category 3)", 100),
    ];

    getProducts(): Observable<Product[]> {
        return Observable.from([this.products]);
    }
}
```

The `StaticDataSource` class defines a method called `getProducts`, which returns the dummy data. The result of calling the `getProducts` method is an `Observable<Product[]>`, which is an `Observable` that produces arrays of `Product` objects.

The `Observable` class is provided by the Reactive Extensions package, which is used by Angular to handle state changes in applications. I describe the `Observable` class in Chapter 23 but for this chapter, it is enough to know that an `Observable` object is like a JavaScript Promise, in that it represents an asynchronous task that will produce a result at some point in the future. Angular exposes its use of `Observable` objects for some features, including making HTTP requests, and this is why the `getProducts` method returns an `Observable<Product[]>` rather than simply returning the data synchronously or using a `Promise`.

The `@Injectable` decorator has been applied to the `StaticDataSource` class. This decorator is used to tell Angular that this class will be used as a service, which allows other classes to access its functionality through a feature called *dependency injection*, which is described in Chapters 19 and 20. You'll see how services work as the application takes shape.

■ **Tip** Notice that I have to `import` the Injectable from the `@angular/core` JavaScript module so that I can apply the `@Injectable` decorator. I won't highlight the all the different Angular classes that I import for the SportsStore example, but you can get full details in the chapters that describe the features they relate to.

Creating the Model Repository

The data source is responsible for providing the application with the data it requires, but access to that data is typically mediated by a *repository*, which is responsible for distributing that data to individual application building blocks so that the details of how the data has been obtained are kept hidden. I added a file called `product.repository.ts` in the `SportsStore/app/model` folder and defined the class shown in Listing 7-15.

Listing 7-15. The Contents of the product.repository.ts File in the SportsStore/app/model Folder

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";
import { StaticDataSource } from "./static.datasource";

@Injectable()
export class ProductRepository {
    private products: Product[] = [];
    private categories: string[] = [];

    constructor(private dataSource: StaticDataSource) {
        dataSource.getProducts().subscribe(data => {
            this.products = data;
            this.categories = data.map(p => p.category)
                .filter((c, index, array) => array.indexOf(c) == index).sort();
        });
    }

    getProducts(category: string = null): Product[] {
        return this.products
            .filter(p => category == null || category == p.category);
    }

    getProduct(id: number): Product {
        return this.products.find(p => p.id == id);
    }

    getCategories(): string[] {
        return this.categories;
    }
}
```

When Angular needs to create a new instance of the repository, it will inspect the class and see that it needs a `StaticDataSource` object in order to invoke the `ProductRepository` constructor and create a new object.

The repository constructor calls the data source's `getProducts` method and then uses the `subscribe` method on the `Observable` object that is returned to receive the product data. See Chapter 23 for details of how `Observable` objects work.

USING SIMPLE DATA STRUCTURES

I have used an array to store the model data because, as a general rule, the simplest possible data structures produce the best results in Angular applications. Angular evaluates the expressions in data bindings repeatedly as it generates content in the HTML element, and this means that more complex structures such as the `Map` class, which provides a key/value collection in JavaScript ES6, have to transform their contents over and over again as the state of the Angular application stabilizes. So, the simpler the data structure, the less work required to provide Angular with the data it needs.

Another reason to use simple data structures is because there are limits to the way that new JavaScript features can be supported in older browsers. In the case of the `Map` class, for example, TypeScript restricts the way that the contents of maps can used when the compiler is being used to produce JavaScript code that will run in older browsers.

As a consequence, I tend to use simple data structures, especially arrays, and end up writing more complex classes to manage the data in the array. You will see an example of this when I add functionality to the product repository class for the administration features in Chapter 9, where the new features will have to search through the array to find the objects they need to operate on. This is inefficient, but these operations are performed less often when compared to the frequency that Angular will evaluate a data binding expression.

Creating the Feature Module

I am going to define an Angular feature model that will allow the data model functionality to be easily used elsewhere in the application. I added a file called `model.module.ts` in the `SportsStore/app/model` folder and defined the class shown in Listing 7-16.

■ **Tip** Don't worry if all the file names seem similar and confusing. You will get used to the way that Angular applications are structured as you work through the other chapters in the book, and you will soon be able to look at the files in an Angular project and know what they are all intended to do.

Listing 7-16. The Contents of the model.module.ts File in the SportsStore/app/model Folder

```
import { NgModule } from "@angular/core";
import { ProductRepository } from "./product.repository";
import { StaticDataSource } from "./static.datasource";

@NgModule({
    providers: [ProductRepository, StaticDataSource]
})
export class ModelModule { }
```

The `@NgModule` decorator is used to create feature modules, and its properties tell Angular how the module should be used. There is only one property in this module, `providers`, and it tells Angular which classes should be used as services for the dependency injection feature, which is described in Chapters 19 and 20. Features modules—and the `@NgModule` decorator—are described in Chapter 21.

Starting the Store

Now that the data model is in place, I can start to build out the store functionality, which will let the user see the products for sale and place orders for them. The basic structure of the store will be a two-column layout, with category buttons that allow the list of products to be filtered and a table that contains the list of products, as illustrated by Figure 7-3.

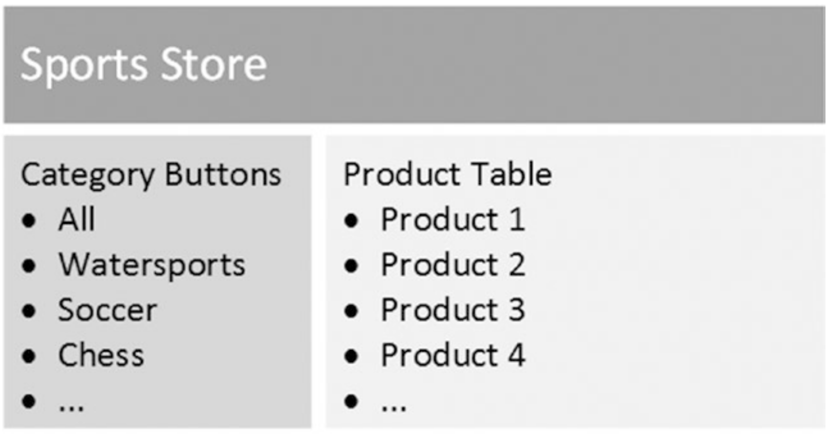


Figure 7-3. *The basic structure of the store*

In the sections that follow, I'll use Angular features and the data in the model to create the layout shown in the figure.

Creating the Store Component and Template

As you become familiar with Angular, you will learn that features can be combined to solve the same problem in different ways. I try to introduce some variety into the SportsStore project to showcase some important Angular features, but I am going to keep things simple for the moment in the interest of being able to get the project started quickly.

With this in mind, the starting point for the store functionality will be a new component, which is a class that provides data and logic to an HTML template, which contains data bindings that generate content dynamically. I created a file called `store.component.ts` in the `SportsStore/app/store` folder and defined the class shown in Listing 7-17.

Listing 7-17. The Contents of the store.component.ts File in the SportsStore/app/store Folder

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { ProductRepository } from "../model/product.repository";

@Component({
    selector: "store",
    moduleId: module.id,
    templateUrl: "store.component.html"
})
export class StoreComponent {

    constructor(private repository: ProductRepository) { }

    get products(): Product[] {
        return this.repository.getProducts();
    }

    get categories(): string[] {
        return this.repository.getCategories();
    }
}
```

The `@Component` decorator has been applied to the `StoreComponent` class, which tells Angular that it is a component. The decorator's properties tell Angular how to apply the component to HTML content (using an element called `store`) and how to find the component's template (in a file called `store.component.html`).

The `StoreComponent` class provides the logic that will support the template content.

The class constructor receives a `ProductRepository` object as an argument, provided through the dependency injection feature described in Chapters 20 and 21. The component defines `products` and `categories` properties that will be used to generate HTML content in the template, using data obtained from the repository.

To provide the component with its template, I created a file called `store.component.html` in the `SportsStore/app/store` folder and added the HTML content shown in Listing 7-18.

Listing 7-18. The Contents of the store.component.html File in the SportsStore/app/store Folder

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
</div>
<div class="col-xs-3 bg-info p-a-1">
    {{categories.length}} Categories
</div>
<div class="col-xs-9 bg-success p-a-1">
    {{products.length}} Products
</div>
```

The template is simple, just to get started. Most of the elements provide the structure for the store layout and apply some Bootstrap CSS classes. There are only two Angular data bindings at the moment, which are denoted by the {{ and }} characters. These are *string interpolation* bindings, and they tell Angular to evaluate the binding expression and insert the result into the element. The expressions in these bindings display the number of products and categories provided by the store component.

Creating the Store Feature Module

There isn't much store functionality in place at the moment, but even so, some additional work is required to wire it up to the rest of the application. To create the Angular feature module for the store functionality, I created a file called `store.module.ts` in the `SportsStore/app/store` folder and added the code shown in Listing 7-19.

Listing 7-19. The Contents of the store.module.ts File in the SportsStore/app/store Folder

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { StoreComponent } from "./store.component";

@NgModule({
    imports: [ModelModule, BrowserModule, FormsModule],
    declarations: [StoreComponent],
    exports: [StoreComponent]
})
export class StoreModule { }
```

The `@NgModule` decorator configures the module, using the `imports` property to tell Angular that the store module depends on the model module as well as `BrowserModule` and `FormsModule`, which contain the standard Angular features for web applications and working with HTML form elements. The decorator uses the `declarations` property to tell Angular about the `StoreComponent` class, which the `exports` property tells Angular can be also used in other parts of the application, which is important because it will be used by the root module.

Updating the Root Component and Root Module

Applying the basic model and store functionality requires updating the application's root module to import the two feature modules and also requires updating the root module's template to add the HTML element to which the component in the store module will be applied. Listing 7-20 shows the change to the root component's template.

Listing 7-20. Adding an Element in the app.component.ts File

```
import { Component } from "@angular/core";

@Component({
    selector: "app",
    template: "<store></store>"
})
export class AppComponent { }
```

The `store` element replaces the previous content in the root component's template and corresponds to the value of the `selector` property of the `@Component` decorator in Listing 7-17. Listing 7-21 shows the change required to the root module so that Angular loads the feature module that contains the store functionality.

Listing 7-21. Importing Feature Modules in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { AppComponent } from "./app.component";
import { StoreModule } from "./store/store.module";

@NgModule({
    imports: [BrowserModule, StoreModule],
    declarations: [AppComponent],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

When you save the changes to the root module, Angular will have all the details it needs to load the application and display the content from the store module, as shown in Figure 7-4.

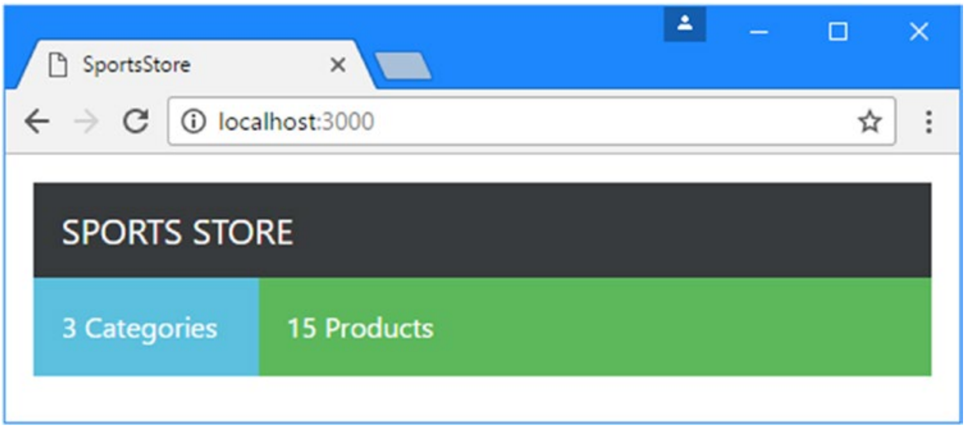


Figure 7-4. *Basic features in the SportsStore application*

All the building blocks created in the previous section work together to display the—admittedly simple—content, which shows how many products there are and how many categories they fit in to.

Adding Store Features the Product Details

The nature of Angular development begins with a slow start as the foundation of the project is put in place and the basic building blocks are created. But once that's done, new features can be created relatively easily. In the sections that follow, I add features to the store so that the user can see the products on offer.

Displaying the Product Details

The obvious place to start is to display details for the products so that the customer can see what's on offer. Listing 7-22 adds HTML elements to the store component's template with data bindings that generate content for each product provided by the component.

Listing 7-22. Adding Elements in the store.component.html File

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
</div>
<div class="col-xs-3 bg-info p-a-1">
    {{categories.length}} Categories
</div>
```

```
<div class="col-xs-9 p-a-1">
    <div *ngFor="let product of products" class="card card-outline-primary">
        <h4 class="card-header">
            {{product.name}}
            <span class="pull-xs-right tag tag-pill tag-primary">
                {{ product.price | currency:"USD":true:"2.2-2" }}
            </span>
        </h4>
        <div class="card-text p-a-1">{{product.description}}</div>
    </div>
</div>
```

Most of the elements control the layout and appearance of the content. The most important change is the addition of an Angular data binding expression.

```
...
<div *ngFor="let product of products" class="card card-outline-primary">
...
```

This is an example of a directive, which transforms the HTML element it is applied to. This specific directive is called `ngFor`, and it transforms the `div` element by duplicating it for each object returned by the component's `products` property. Angular includes a range of built-in directives that perform the most commonly required tasks, as described in Chapter 13.

As it duplicates the `div` element, the current object is assigned to a variable called `product`, which allows it to be easily referred to in other data bindings, such as this one, which inserts the value of the current product's `name` description property as the content of the `div` element:

```
...
<div class="card-text p-a-1">{{product.description}}</div>
...
```

Not all data in an application's data model can be displayed directly to the user. Angular includes a feature called *pipes*, which are classes used to transform or prepare a data value for its use in a data binding. There are several built-in pipes included with Angular, including the `currency` pipe, which formats number values as currencies, like this:

```
...
{{ product.price | currency:"USD":true:"2.2-2" }}
...
```

The syntax for applying pipes can be a little awkward, but the expression in this binding tells Angular to format the `price` property of the current product using the `currency` pipe, with the currency conventions from the United States. Save the changes to the template and you will see a list of the products in the data model displayed as a long list, as illustrated by Figure 7-5.

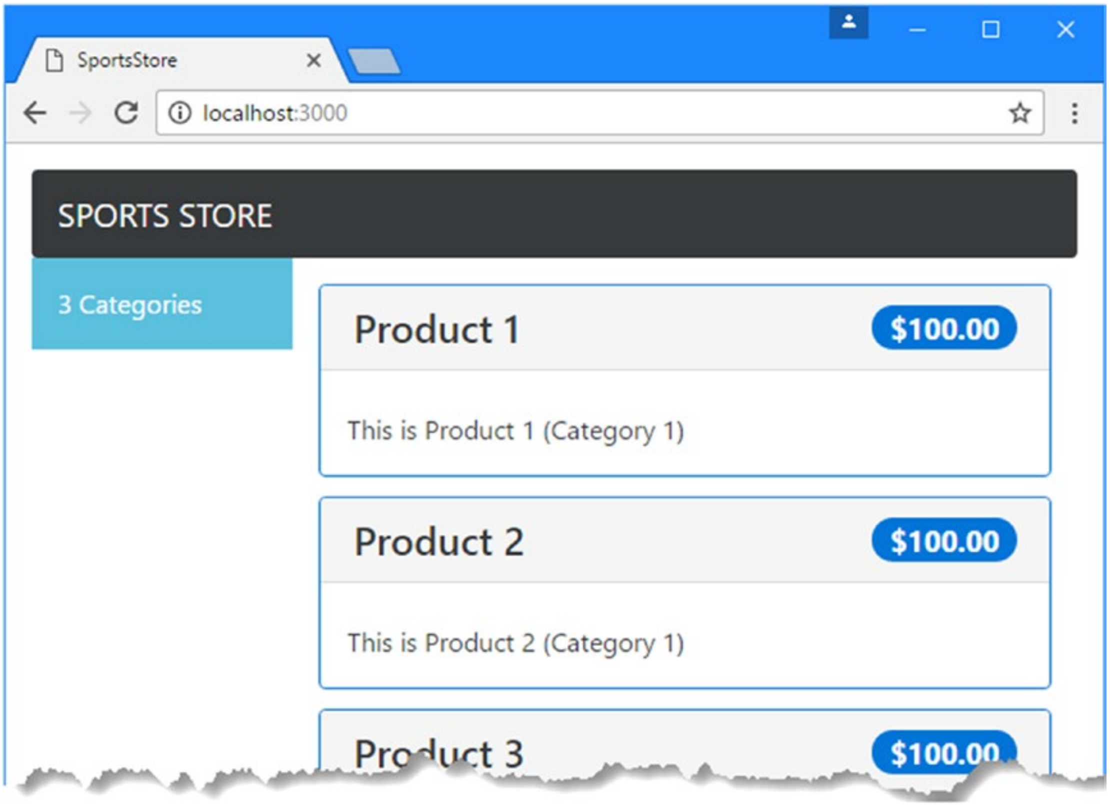


Figure 7-5. *Displaying product information*

Adding Category Selection

Adding support for filtering the list of products by category requires preparing the store component so that it keeps track of which category the user wants to display and requires changing the way that data is retrieved to use that category, as shown in Listing 7-23.

Listing 7-23. Adding Category Filtering in the store.component.ts File

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { ProductRepository } from "../model/product.repository";

@Component({
    selector: "store",
    moduleId: module.id,
    templateUrl: "store.component.html"
})
```

```
export class StoreComponent {
    public selectedCategory = null;

    constructor(private repository: ProductRepository) {}

    get products(): Product[] {
        return this.repository.getProducts(this.selectedCategory);
    }

    get categories(): string[] {
        return this.repository.getCategories();
    }

    changeCategory(newCategory?: string) {
        this.selectedCategory = newCategory;
    }
}
```

The changes are simple because they build on the foundation that took so long to create at the start of the chapter. The `selectedCategory` property is assigned the user's choice of category (where `null` means all categories) and is used in the `updateData` method as an argument to the `getProducts` method, delegating the filtering to the data source. The `changeCategory` method brings these two members together in a method that can be invoked when the user makes a category selection.

Listing 7-24 shows the corresponding changes to the component's template to provide the user with the set of buttons that change the selected category and show which category has been picked.

Listing 7-24. Adding Category Buttons in the store.component.html File

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
</div>
<div class="col-xs-3 p-a-1">
    <button class="btn btn-block btn-outline-primary" (click)="changeCategory()">
        Home
    </button>
    <button *ngFor="let cat of categories" class="btn btn-outline-primary btn-block"
            [class.active]="cat == selectedCategory" (click)="changeCategory(cat)">
        {{cat}}
    </button>
</div>
<div class="col-xs-9 p-a-1">
    <div *ngFor="let product of products" class="card card-outline-primary">
        <h4 class="card-header">
            {{product.name}}
            <span class="pull-xs-right tag tag-pill tag-primary">
                {{ product.price | currency:"USD":true:"2.2-2" }}
            </span>
        </h4>
        <div class="card-text p-a-1">{{product.description}}</div>
    </div>
</div>
```

There are two new `button` elements in the template. The first is a `Home` button, and it has an event binding that invokes the component's `changeCategory` method when the button is clicked. No argument is provided to the method, which has the effect of setting the category to `null` and selecting all the products.

The `ngFor` binding has been applied to the other `button` element, with an expression that will repeat the element for each value in the array returned by the component's `categories` property. The `button` has a `click` event binding whose expression calls the `changeCategory` method to select the current category, which will filter the products displayed to the user. There is also a `class` binding, which adds the button element to the `active` class when the category associated with the button is the selected category. This provides the user with visual feedback when the categories are filtered, as shown in Figure 7-6.

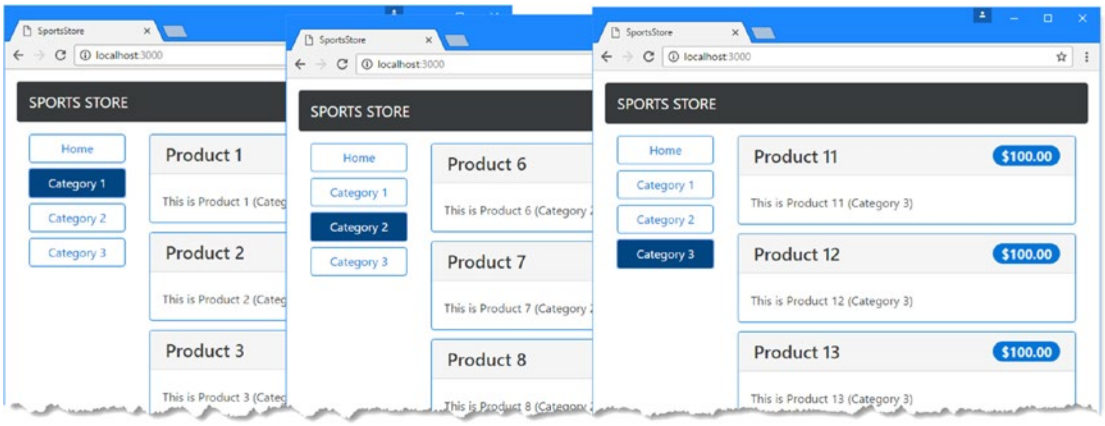


Figure 7-6. *Selecting product categories*

Adding Product Pagination

Filtering the products by category has helped make the product list more manageable, but a more typical approach is to break the list into smaller sections and present each of them as a page, along with navigation buttons that move between the pages.

Listing 7-25 enhances the store component so that it keeps track of the current page and the number of items on a page.

Listing 7-25. Adding Pagination Support in the store.component.ts File

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { ProductRepository } from "../model/product.repository";

@Component({
    selector: "store",
    moduleId: module.id,
    templateUrl: "store.component.html"
})
export class StoreComponent {
    public selectedCategory = null;
    public productsPerPage = 4;
    public selectedPage = 1;
    constructor(private repository: ProductRepository) {}

    get products(): Product[] {
        let pageIndex = (this.selectedPage - 1) * this.productsPerPage
        return this.repository.getProducts(this.selectedCategory)
            .slice(pageIndex, pageIndex + this.productsPerPage);
    }

    get categories(): string[] {
        return this.repository.getCategories();
    }

    changeCategory(newCategory?: string) {
        this.selectedCategory = newCategory;
    }

    changePage(newPage: number) {
        this.selectedPage = newPage;
    }

    changePageSize(newSize: number) {
        this.productsPerPage = Number(newSize);
        this.changePage(1);
    }

    get pageNumbers(): number[] {
        return Array(Math.ceil(this.repository
            .getProducts(this.selectedCategory).length / this.productsPerPage))
                .fill(0).map((x, i) => i + 1);
    }
}
```

There are two new features in this listing. The first is the ability to get a page of products, and the second is to change the size of the pages, allowing the number of products that each page contains to be altered.

There is an oddity that the component has to work around. There is a limitation in the built-in `ngFor` directive that Angular provides, which can generate content only for the objects in an array or a collection, rather than using a counter. Since I need to generate numbered page navigation buttons, this means I need to create an array that contains the numbers I need, like this:

```
...
return Array(Math.ceil(this.repository.getProducts(this.selectedCategory).length
    / this.productsPerPage)).fill(0).map((x, i) => i + 1);
...
```

This statement creates a new array, fills it with the value `0`, and then uses the `map` method to generate a new array with the number sequence. This works well enough to implement the pagination feature, but it feels awkward, and I demonstrate a better approach in the next section. Listing 7-26 shows the changes to the store component's template to implement the pagination feature.

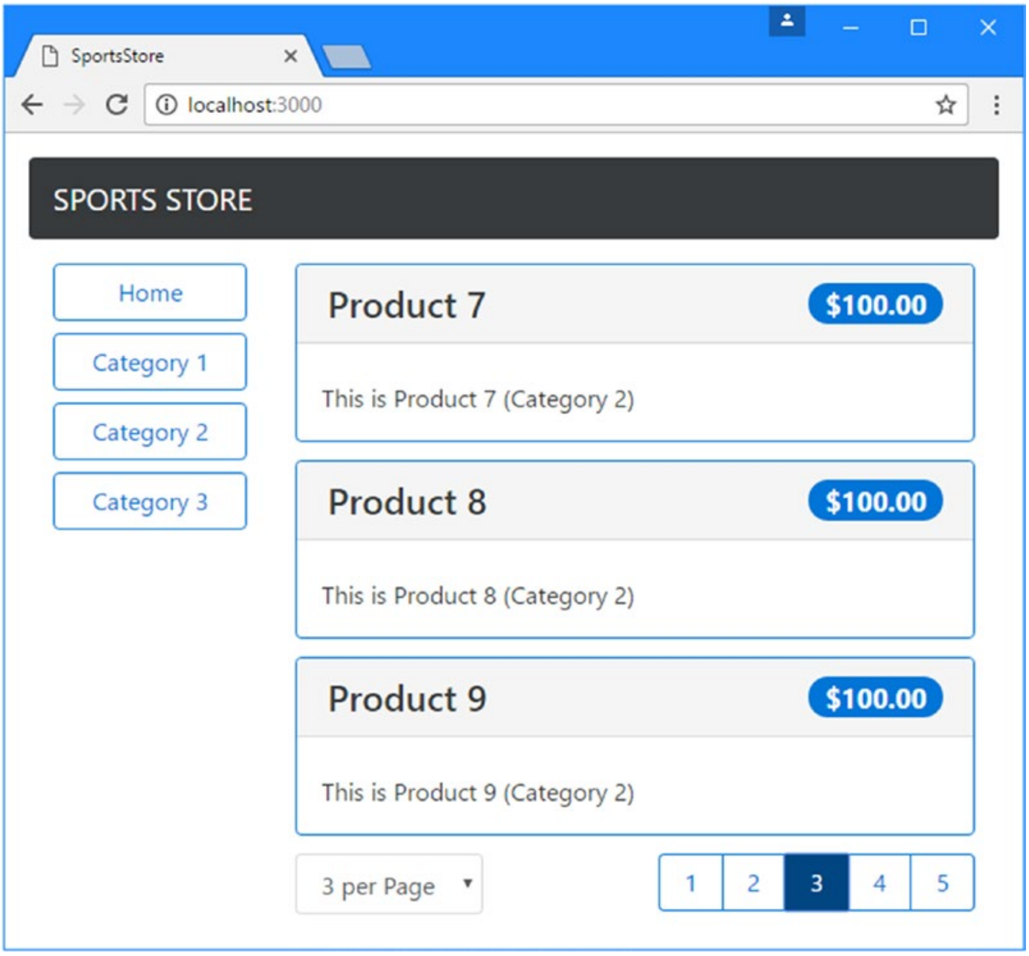
Listing 7-26. Adding Pagination in the store.component.html File

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
</div>
<div class="col-xs-3 p-a-1">
    <button class="btn btn-block btn-outline-primary"
            (click)="changeCategory()">
        Home
    </button>
    <button *ngFor="let cat of categories"
            class="btn btn-outline-primary btn-block"
            [class.active]="cat == selectedCategory"
            (click)="changeCategory(cat)">
        {{cat}}
    </button>
</div>
<div class="col-xs-9 p-a-1">
    <div *ngFor="let product of products" class="card card-outline-primary">
        <h4 class="card-header">
            {{product.name}}
            <span class="pull-xs-right tag tag-pill tag-primary">
                {{ product.price | currency:"USD":true:"2.2-2" }}
            </span>
        </h4>
        <div class="card-text p-a-1">{{product.description}}</div>
    </div>
    <div class="form-inline pull-xs-left m-r-1">
        <select class="form-control" [value]="productsPerPage"
                (change)="changePageSize($event.target.value)">
            <option value="3">3 per Page</option>
            <option value="4">4 per Page</option>
            <option value="6">6 per Page</option>
            <option value="8">8 per Page</option>
        </select>
    </div>

    <div class="btn-group pull-xs-right">
        <button *ngFor="let page of pageNumbers" (click)="changePage(page)"
            class="btn btn-outline-primary" [class.active]="page == selectedPage">
                {{page}}
        </button>
    </div>
</div>
```

The new elements add a select element that allows the size of the page to be changed and a set of buttons that navigate through the product pages. The new elements have data bindings to wire them up to the properties and methods provided by the component. The result is more manageable set of products, as shown in Figure 7-7.

■ **Tip** The `select` element in Listing 7-26 is populated with `option` elements that are statically defined, rather than created using data from the component. One impact of this is that when the selected value is passed to the `changePageSize` method, it will be a `string` value, which is why the argument is parsed to a `number` before being used to set the page size in Listing 7-25. Care must be taken when receiving data values from HTML elements to ensure they are of the expected type. TypeScript type annotations don't help in this situation because the data binding expression is evaluated at runtime, long after the TypeScript compiler has generated JavaScript code that doesn't contain the extra type information.



Product 7 $100.00

This is Product 7 (Category 2)

Product 8 $100.00

This is Product 8 (Category 2)

Product 9 $100.00

This is Product 9 (Category 2)

Figure 7-7. *Pagination for products*

Creating a Custom Directive

In this section, I am going to create a custom directive so that I don't have to generate an array full of numbers to create the page navigation buttons. Angular provides a good range of built-in directives, but it is a simple process to create your own directives to solve problems that are specific to your application or to support features that the built-in directives don't have. I added a file called `counter.directive.ts` in the `SportsStore/app/store` folder and used it to define the class shown in Listing 7-27.

Listing 7-27. The Contents of the counter.directive.ts File in the SportsStore/app/store Folder

```
import {
    Directive, ViewContainerRef, TemplateRef, Input, Attribute, SimpleChanges
} from "@angular/core";

@Directive({
    selector: "[counterOf]"
})
export class CounterDirective {

    constructor(private container: ViewContainerRef,
        private template: TemplateRef<Object>) {
    }

    @Input("counterOf")
    counter: number;

    ngOnChanges(changes: SimpleChanges) {
        this.container.clear();
        for (let i = 0; i < this.counter; i++) {
            this.container.createEmbeddedView(this.template,
                new CounterDirectiveContext(i + 1));
        }
    }
}

class CounterDirectiveContext {
    constructor(public $implicit: any) { }
}
```

This is an example of a structural directive, which is described in detail in Chapter 16. This directive is applied to elements through a `counter` property and relies on special features that Angular provides for creating content repeatedly, just like the built-in `ngFor` directive. In this case, rather than yield each object in a collection, the custom directive yields a series of numbers that can be used to create the page navigation buttons.

■ **Tip** This directive deletes all the content it has created and starts again when the number of pages changes. This can be an expensive process in more complex directives, and I explain how to improve performance in Chapter 16.

To use the directive, it must be added to the `declarations` property of its feature module, as shown in Listing 7-28.

Listing 7-28. Registering the Custom Directive in the store.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { StoreComponent } from "./store.component";
import { CounterDirective } from "./counter.directive";

@NgModule({
    imports: [ModelModule, BrowserModule, FormsModule],
    declarations: [StoreComponent, CounterDirective],
    exports: [StoreComponent]
})
export class StoreModule { }
```

Now that the directive has been registered, it can be used in the store component's template to replace the `ngFor` directive, as shown in Listing 7-29.

Listing 7-29. Replacing the Built-in Directive in the store.component.html File

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
</div>
<div class="col-xs-3 p-a-1">
    <button class="btn btn-block btn-outline-primary"
            (click)="changeCategory()">
        Home
    </button>
    <button *ngFor="let cat of categories"
            class="btn btn-outline-primary btn-block"
            [class.active]="cat == selectedCategory"
            (click)="changeCategory(cat)">
        {{cat}}
    </button>
</div>
<div class="col-xs-9 p-a-1">
    <div *ngFor="let product of products" class="card card-outline-primary">
        <h4 class="card-header">
            {{product.name}}
            <span class="pull-xs-right tag tag-pill tag-primary">
                {{ product.price | currency:"USD":true:"2.2-2" }}
            </span>
        </h4>
        <div class="card-text p-a-1">{{product.description}}</div>
    </div>
    <div class="form-inline pull-xs-left m-r-1">
        <select class="form-control" [value]="productsPerPage"
                (change)="changePageSize($event.target.value)">
            <option value="3">3 per Page</option>
            <option value="4">4 per Page</option>
            <option value="6">6 per Page</option>
            <option value="8">8 per Page</option>
        </select>
    </div>

    <div class="btn-group pull-xs-right">
    <button *counter="let page of pageCount" (click)="changePage(page)"
        class="btn btn-outline-primary" [class.active]="page == selectedPage">
                {{page}}
        </button>
    </div>
</div>
```

The new data binding relies on a property called pageCount to configure the custom directive. In Listing 7-30, I have replaced the array of numbers with a simple number that provides the expression value.

Listing 7-30. Supporting the Custom Directive in the store.component.ts File

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { ProductRepository } from "../model/product.repository";

@Component({
    selector: "store",
    moduleId: module.id,
    templateUrl: "store.component.html"
})
export class StoreComponent {
    public selectedCategory = null;
    public productsPerPage = 4;
    public selectedPage = 1;

    constructor(private repository: ProductRepository) {}

    get products(): Product[] {
        let pageIndex = (this.selectedPage - 1) * this.productsPerPage
        return this.repository.getProducts(this.selectedCategory)
            .slice(pageIndex, pageIndex + this.productsPerPage);
    }

    get categories(): string[] {
        return this.repository.getCategories();
    }

    changeCategory(newCategory?: string) {
        this.selectedCategory = newCategory;
    }
    changePage(newPage: number) {
        this.selectedPage = newPage;
    }

    changePageSize(newSize: number) {
        this.productsPerPage = Number(newSize);
        this.changePage(1);
    }

    get pageCount(): number {
        return Math.ceil(this.repository
            .getProducts(this.selectedCategory).length / this.productsPerPage)
    }

    //get pageNumbers(): number[] {
    //    return Array(Math.ceil(this.repository
    //        .getProducts(this.selectedCategory).length / this.productsPerPage))
    //            .fill(0).map((x, i) => i + 1);
    //}
}
```

There is no visual change to the SportsStore application, but this section has demonstrated this it is possible to supplement the built-in Angular functionality with custom code that is tailored to the needs of a specific project.

Summary

In this chapter, I started the SportsStore project. The early part of the chapter was spent creating the foundation for the project, including installing and configuring the development tools, creating the root building blocks for the application, and starting work on the feature modules. Once the foundation was in place, I was able to rapidly add features to display the dummy model data to the user, add pagination, and filter the products by category. I finished the chapter by creating a custom directive to demonstrate how the built-in features provided by Angular can be supplemented by custom code. In the next chapter, I continue to build the SportsStore application.

CHAPTER 8

SportsStore: Orders and Checkout

In this chapter, I continue adding features to the SportsStore application that I created in Chapter 7. I add support for a shopping cart and a checkout process and replace the dummy data with the data from the RESTful web service.

Preparing the Example Application

No preparation is required for this chapter, which continues using the SportsStore project from Chapter 7. Run the following command in the SportsStore folder to start the TypeScript compiler, the RESTful web service, and the development HTTP server:

```
npm start
```

Tip The free source code download from apress.com that accompanies this book contains the SportsStore project from each individual chapter if you don't want to have to start with Chapter 7.

Creating the Cart

The user needs a cart in which products can be placed and that can then be used to start the checkout process. In the sections that follow, I'll add a cart to the application and integrate it into the store so that the user can select the products they want.

Creating the Cart Model

The starting point for the cart feature is a new model class, which will be used to gather together the products that the user has selected. I added a file called `cart.model.ts` in the `SportsStore/app/model` folder and used it to define the class shown in Listing 8-1.

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A. Freeman, *Pro Angular*, DOI 10.1007/978-1-4842-2307-9_8

Listing 8-1. The Contents of the cart.model.ts File in the SportsStore/app/model Folder

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";

@Injectable()
export class Cart {
    public lines: CartLine[] = [];
    public itemCount: number = 0;
    public cartPrice: number = 0;

    addLine(product: Product, quantity: number = 1) {
        let line = this.lines.find(line => line.product.id == product.id);
        if (line != undefined) {
            line.quantity += quantity;
        } else {
            this.lines.push(new CartLine(product, quantity));
        }
        this.recalculate();
    }

    updateQuantity(product: Product, quantity: number) {
        let line = this.lines.find(line => line.product.id == product.id);
        if (line != undefined) {
            line.quantity = Number(quantity);
        }
        this.recalculate();
    }

    removeLine(id: number) {
        let index = this.lines.findIndex(line => line.product.id == id);
        this.lines.splice(index);
        this.recalculate();
    }

    clear() {
        this.lines = [];
        this.itemCount = 0;
        this.cartPrice = 0;
    }

    private recalculate() {
        this.itemCount = 0;
        this.cartPrice = 0;
        this.lines.forEach(l => {
            this.itemCount += l.quantity;
            this.cartPrice += (l.quantity * l.product.price);
        })

    }
}
```

```
export class CartLine {

    constructor(public product: Product,
        public quantity: number) {}

    get lineTotal() {
        return this.quantity * this.product.price;
    }
}
```

Individual product selections are represented as an array of `CartLine` objects, each of which contains a `Product` object and a quantity. The `Cart` class keeps track of the total number of items that have been selected and the total cost of them, which will be presented to the user while shopping.

There should be a single `Cart` object used throughout the entire application, ensuring that any part of the application can access the user's product selections. To achieve this, I am going to make the `Cart` a service, which means that Angular will take responsibility for creating an instance of the `Cart` class and will use it when it needs to create a component that has a `Cart` constructor argument. This is another use of the Angular dependency injection feature, which can be used to share objects throughout an application and which is described in detail in Chapters 19 and 20. The `@Injectable` decorator, which has been applied to the `Cart` class in the listing, indicates that this class will be used as a service. (Strictly speaking, the `@Injectable` decorator is required only when a class has its own constructor arguments to resolve, but it is a good idea to apply it anyway because it serves as a signal that the class is intended for use as a service.) Listing 8-2 registers the `Cart` class as a service in the `providers` property of the model feature module class.

Listing 8-2. Registering the Cart as a Service in the model.module.ts File

```
import { NgModule } from "@angular/core";
import { ProductRepository } from "./product.repository";
import { StaticDataSource } from "./static.datasource";
import { Cart } from "./cart.model";

@NgModule({
    providers: [ProductRepository, StaticDataSource, Cart]
})
export class ModelModule { }
```

Creating the Cart Summary Components

Components are the essential building blocks for Angular applications because they allow discrete units of code and content to be easily created. The SportsStore application will show users a summary of their product selections in the title area of the page, which I am going to implement by creating a component. I added a file called `cartSummary.component.ts` in the `SportsStore/app/store` folder and used it to define the component shown in Listing 8-3.

Listing 8-3. The Contents of the cartSummary.component.ts File in the SportsStore/app/store Folder

```
import { Component } from "@angular/core";
import { Cart } from "../model/cart.model";

@Component({
    selector: "cart-summary",
    moduleId: module.id,
    templateUrl: "cartSummary.component.html"
})
export class CartSummaryComponent {

    constructor(public cart: Cart) { }
}
```

When Angular needs to create an instance of this component, it will have to provide a `Cart` object as a constructor argument, using the service that I configured in the previous section by adding the `Cart` class to the feature module's `providers` property. The default behavior for services means that a single `Cart` object will be created and shared throughout the application, although there are different service behaviors available (as described in Chapter 20).

To provide the component with a template, I created an HTML file called `cartSummary.component.html` in the same folder as the component class file and added the markup shown in Listing 8-4.

Listing 8-4. The Contents of the cartSummary.component.html File in the SportsStore/app/store Folder

```
<div class="pull-xs-right">
    <small>
        Your cart:
        <span *ngIf="cart.itemCount > 0">
            {{ cart.itemCount }} item(s)
            {{ cart.cartPrice | currency:"USD":true:"2.2-2" }}
        </span>
        <span *ngIf="cart.itemCount == 0">
            (empty)
        </span>
    </small>
    <button class="btn btn-sm bg-inverse" [disabled]="cart.itemCount == 0">
        <i class="fa fa-shopping-cart"></i>
    </button>
</div>
```

This template uses the `Cart` object provided by its component to display the number of items in the cart and the total cost. There is also a button that will start the checkout process when I add it to the application later in the chapter.

■ **Tip** The button element in Listing 8-4 is styled using classes defined by Font Awesome, which is one of the packages in the `package.json` file from Chapter 7. This open source package provides excellent support for icons in web applications, including the shopping cart I need for the SportsStore application. See `http://fontawesome.io` for details.

Listing 8-5 registers the new component with the store feature module, in preparation for using it in the next section.

Listing 8-5. Registering the Component in the store.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { StoreComponent } from "./store.component";
import { CounterDirective } from "./counter.directive";
import { CartSummaryComponent } from "./cartsummary.component";

@NgModule({
    imports: [ModelModule, BrowserModule, FormsModule],
    declarations: [StoreComponent, CounterDirective, CartSummaryComponent],
    exports: [StoreComponent]
})
export class StoreModule { }
```

Integrating the Cart into the Store

The store component is the key to integrating the cart and the cart widget into the application. Listing 8-6 updates the store component so that its constructor has a `Cart` parameter and defines a method that will add a product to the cart.

Listing 8-6. Adding Cart Support in the store.component.ts File

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { ProductRepository } from "../model/product.repository";
import { Cart } from "../model/cart.model";

@Component({
    selector: "store",
    moduleId: module.id,
    templateUrl: "store.component.html"
})
export class StoreComponent {
    public selectedCategory = null;
    public productsPerPage = 4;
    public selectedPage = 1;

    constructor(private repository: ProductRepository,
                private cart: Cart) { }

    get products(): Product[] {
        let pageIndex = (this.selectedPage - 1) * this.productsPerPage
        return this.repository.getProducts(this.selectedCategory)
            .slice(pageIndex, pageIndex + this.productsPerPage);
    }
    get categories(): string[] {
        return this.repository.getCategories();
    }

    changeCategory(newCategory?: string) {
        this.selectedCategory = newCategory;
    }

    changePage(newPage: number) {
        this.selectedPage = newPage;
    }

    changePageSize(newSize: number) {
        this.productsPerPage = Number(newSize);
        this.changePage(1);
    }

    get pageCount(): number {
        return Math.ceil(this.repository
            .getProducts(this.selectedCategory).length / this.productsPerPage)
    }

    addProductToCart(product: Product) {
        this.cart.addLine(product);
    }
}
```

To complete the integration of the cart into the store component, Listing 8-7 adds the element that will apply the cart summary component to the store component's template and adds a button to each product description with the event binding that calls the addProductToCart method.

Listing 8-7. Applying the Component in the store.component.html File

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
    <cart-summary></cart-summary>
</div>
<div class="col-xs-3 p-a-1">
    <button class="btn btn-block btn-outline-primary"
            (click)="changeCategory()">
        Home
    </button>
    <button *ngFor="let cat of categories"
            class="btn btn-outline-primary btn-block"
            [class.active]="cat == selectedCategory"
            (click)="changeCategory(cat)">
        {{cat}}
    </button>
</div>
<div class="col-xs-9 p-a-1">
    <div *ngFor="let product of products" class="card card-outline-primary">
        <h4 class="card-header">
            {{product.name}}
```

```
                <span class="pull-xs-right tag tag-pill tag-primary">
                    {{ product.price | currency:"USD":true:"2.2-2" }}
                </span>
            </h4>
            <div class="card-text p-a-1">
                {{product.description}}
                <button class="btn btn-success btn-sm pull-xs-right"
                        (click)="addProductToCart(product)">
                    Add To Cart
                </button>
            </div>
        </div>
        <div class="form-inline pull-xs-left m-r-1">
            <select class="form-control" [value]="productsPerPage"
                    (change)="changePageSize($event.target.value)">
                <option value="3">3 per Page</option>
                <option value="4">4 per Page</option>
                <option value="6">6 per Page</option>
                <option value="8">8 per Page</option>
            </select>
        </div>
        <div class="btn-group pull-xs-right">
            <button *counter="let page of pageCount" (click)="changePage(page)"
                class="btn btn-outline-primary" [class.active]="page == selectedPage">
                    {{page}}
            </button>
        </div>
    </div>
```

The result is a button for each product that adds it to the cart, as shown in Figure 8-1. The full cart process isn't complete yet, but you can see the effect of each addition in the cart summary at the top of the page.

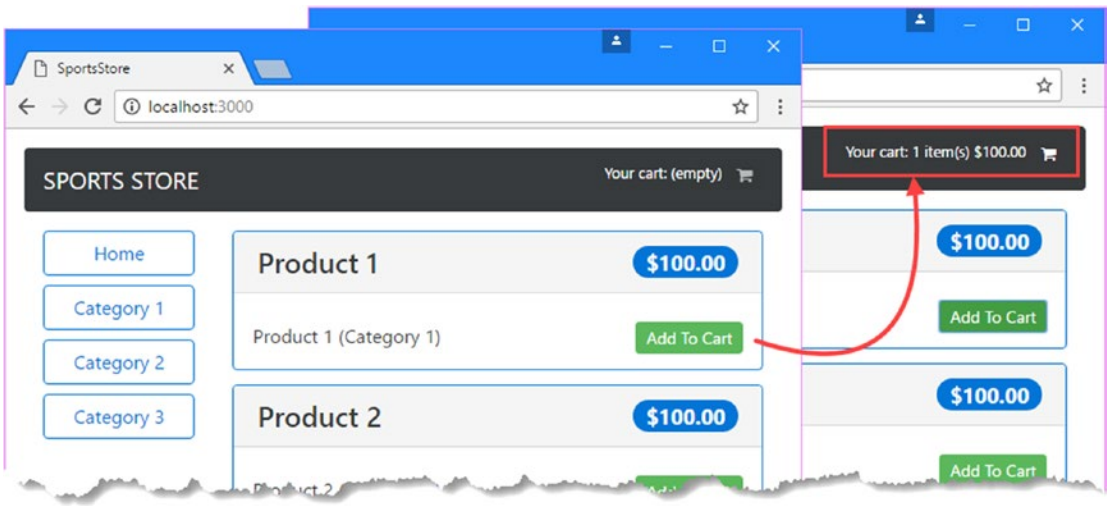


Figure 8-1. Adding cart support to the SportsStore application

Notice how clicking one of the Add To Cart buttons updates the summary component's content automatically. This happens because there is a single `Cart` object being shared between two components and changes made by one component are reflected when Angular evaluates the data binding expressions in the other component.

Adding URL Routing

Most applications need to show different content to the user at different times. In the case of the SportsStore application, when the user clicks one of the Add To Cart buttons, they should be shown a detailed view of their selected products and given the change to start the checkout process.

Angular supports a feature called URL routing, which uses the current URL displayed by the browser to select the components that are displayed to the user. This is an approach that makes it easy to create applications whose components are loosely coupled and easy to change without needing corresponding modifications elsewhere in the applications. URL routing also makes it easy to change the path that a user follows through an application.

For the SportsStore application, I am going to add support for three different URLs, which are described in Table 8-1. This is a simple configuration, but the routing system has a lot of features, which are described in detail in Chapters 25 to 27.

Table 8-1. *The URLs Supported by the SportsStore Application*

URL	Description
/store	This URL will display the list of products.
/cart	This URL will display the user's cart in detail.
/checkout	This URL will display the checkout process.

In the sections that follow, I create placeholder components for the SportsStore cart and order checkout stages and then integrate them into the application using URL routing. Once the URLs are implemented, I will return to the components and add more useful features.

Creating the Cart Detail and Checkout Components

Before adding URL routing to the application, I need to create the components that will be displayed by the `/cart` and `/checkout` URLs. I only need some basic placeholder content to get started at the moment, just so that it is obvious which component is being displayed. I started by adding a file called `cartDetail.component.ts` in the `SportsStore/app/store` folder and defined the component shown in Listing 8-8.

Listing 8-8. The Content of the cartDetail.component.ts File in the SportsStore/app/store Folder

```
import { Component } from "@angular/core";

@Component({
    template: `<div><h3 class="bg-info p-a-1">Cart Detail Component</h3></div>`
})
export class CartDetailComponent {}
```

Next, I added a file called `checkout.component.ts` in the `SportsStore/app/store` folder and defined the component shown in Listing 8-9.

Listing 8-9. The Contents of the checkout.component.ts File in the SportsStore/app/store Folder

```
import { Component } from "@angular/core";

@Component({
    template: `<div><h3 class="bg-info p-a-1">Checkout Component</h3></div>`
})
export class CheckoutComponent { }
```

This component follows the same pattern as the cart component and displays a placeholder message that makes it obvious which component is being displayed. Listing 8-10 registers the components in the store feature module and adds them to the `exports` property, which means they can be used elsewhere in the application.

Listing 8-10. Registering Components in the store.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { StoreComponent } from "./store.component";
import { CounterDirective } from "./counter.directive";
import { CartSummaryComponent } from "./cartsummary.component";
import { CartDetailComponent } from "./cartDetail.component";
import { CheckoutComponent } from "./checkout.component";

@NgModule({
    imports: [ModelModule, BrowserModule, FormsModule],
    declarations: [StoreComponent, CounterDirective, CartSummaryComponent,
        CartDetailComponent, CheckoutComponent],
    exports: [StoreComponent, CartDetailComponent, CheckoutComponent]
})
export class StoreModule { }
```

Creating and Applying the Routing Configuration

Now that I have a range of components to display, the next step is to create the routing configuration, which will tell Angular how to map URLs into components. Each mapping of a URL to a component is known as a *URL route*, or just a *route*. In Part 3, where I create more complex routing configurations, I define the routes in a separate, file but for this project, I am going to follow the alternate approach, which is to define the routes within the `@NgModule` decorator of the application's root module, as shown in Listing 8-11.

■ **Tip** The Angular routing feature requires a `base` element in the HTML document, which provides the base URL against which routes are applied. I added this element in Chapter 7 when I started the SportsStore project. If you omit the element, Angular will report an error and be unable to apply the routes.

Listing 8-11. Creating the Routing Configuration in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { AppComponent } from "./app.component";
import { StoreModule } from "./store/store.module";
import { StoreComponent } from "./store/store.component";
import { CheckoutComponent } from "./store/checkout.component";
import { CartDetailComponent } from "./store/cartDetail.component";
import { RouterModule } from "@angular/router";

@NgModule({
    imports: [BrowserModule, StoreModule,
        RouterModule.forRoot([
            { path: "store", component: StoreComponent },
            { path: "cart", component: CartDetailComponent },
            { path: "checkout", component: CheckoutComponent },
            { path: "**", redirectTo: "/store" }
        ])],
    declarations: [AppComponent],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

The `RouterModule.forRoot` method is passed a set of routes, each of which maps a URL to a component. The first three routes in the listing match the URLs from Table 8-1. The final route is a wildcard that redirects any other URL to `/store`, which will display `StoreComponent`.

When the routing feature is used, Angular looks for the `router-outlet` element, which defines the location in which the component that corresponds to the current URL should be displayed. Listing 8-12 replaces the `store` element in the root component's template with the `router-outlet` element.

Listing 8-12. Defining the Routing Target in the app.component.ts File

```
import { Component } from "@angular/core";

@Component({
    selector: "app",
    template: "<router-outlet></router-outlet>"
})
export class AppComponent { }
```

Angular will apply the routing configuration when you save the changes and the browser reloads the HTML document. The content displayed in the browser window hasn't changed, but if you examine the browser's URL bar, you will be able to see that the routing configuration has been applied, as shown in Figure 8-2.

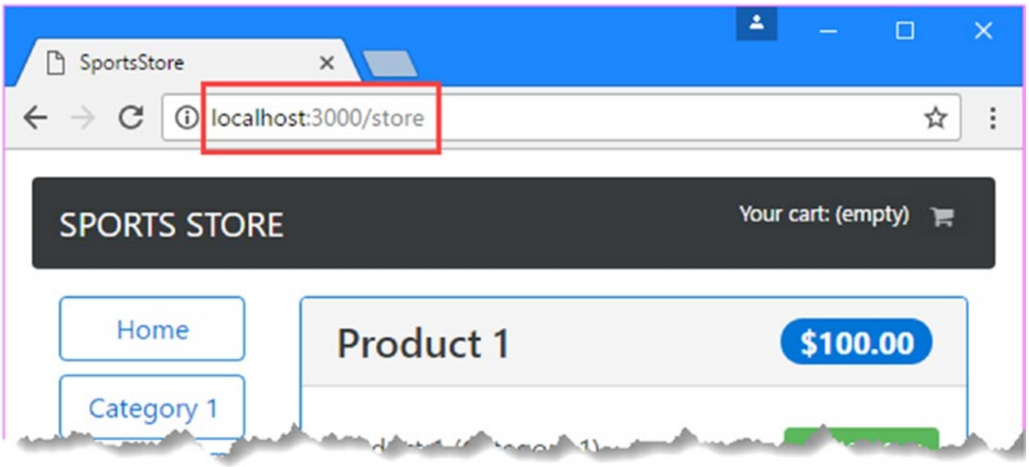


Figure 8-2. *The effect of URL routing*

Navigating through the Application

With the routing configuration in place, it is time to add support for navigating between components by changing the browser's URL. The URL routing feature relies on a JavaScript API provided by the browser, which means the user can't simply type the target URL into the browser's URL bar. Instead, the navigation has to be performed by the application, either by using JavaScript code in a component or other building block or by adding attributes to HTML elements in the template.

When the user clicks one of the Add To Cart buttons, the cart detail component should be shown, which means that the application should navigate to the `/cart` URL. Listing 8-13 adds navigation to the component method that is invoked when the user clicks the button.

Listing 8-13. Navigating Using JavaScript in the store.component.ts File

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { ProductRepository } from "../model/product.repository";
import { Cart } from "../model/cart.model";
import { Router } from "@angular/router";

@Component({
    selector: "store",
    moduleId: module.id,
    templateUrl: "store.component.html"
})
export class StoreComponent {
    public selectedCategory = null;
    public productsPerPage = 4;
    public selectedPage = 1;

    constructor(private repository: ProductRepository,
        private cart: Cart,
        private router: Router) { }
    get products(): Product[] {
        let pageIndex = (this.selectedPage - 1) * this.productsPerPage
        return this.repository.getProducts(this.selectedCategory)
            .slice(pageIndex, pageIndex + this.productsPerPage);
    }

    get categories(): string[] {
        return this.repository.getCategories();
    }

    changeCategory(newCategory?: string) {
        this.selectedCategory = newCategory;
    }

    changePage(newPage: number) {
        this.selectedPage = newPage;
    }

    changePageSize(newSize: number) {
        this.productsPerPage = Number(newSize);
        this.changePage(1);
    }

    get pageCount(): number {
        return Math.ceil(this.repository
            .getProducts(this.selectedCategory).length / this.productsPerPage)
    }

    addProductToCart(product: Product) {
        this.cart.addLine(product);
        this.router.navigateByUrl("/cart");
    }
}
```

The constructor has a `Router` parameter, which is provided by Angular through the dependency injection feature when a new instance of the component is created. In the `addProductToCart` method, the `Router.navigateByUrl` method is used to navigate to the `/cart` URL.

Navigation can also be done by adding the `routerLink` attribute to elements in the template. In Listing 8-14, the `routerLink` attribute has been applied to the cart button in the cart summary component's template.

Listing 8-14. Adding a Navigation Attribute in the cartSummary.component.html File

```
<div class="pull-xs-right">
    <small>
        Your cart:
        <span *ngIf="cart.itemCount > 0">
            {{ cart.itemCount }} item(s)
            {{ cart.cartPrice | currency:"USD":true:"2.2-2" }}
        </span>
        <span *ngIf="cart.itemCount == 0">
            (empty)
        </span>
    </small>
    <button class="btn btn-sm bg-inverse" [disabled]="cart.itemCount == 0"
            routerLink="/cart">
        <i class="fa fa-shopping-cart"></i>
    </button>
</div>
```

The value specified by the `routerLink` attribute is the URL that the application will navigate to when the `button` is clicked. This particular button is disabled when the cart is empty, so it will perform the navigation only when the user has added a product to the cart.

To add support for the `routerLink` attribute, the `RouterModule` module must be imported into the feature module, as shown in Listing 8-15.

Listing 8-15. Importing the Router Module in the store.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { StoreComponent } from "./store.component";
import { CounterDirective } from "./counter.directive";
import { CartSummaryComponent } from "./cartsummary.component";
import { CartDetailComponent } from "./cartDetail.component";
import { CheckoutComponent } from "./checkout.component";
import { RouterModule } from "@angular/router";

@NgModule({
    imports: [ModelModule, BrowserModule, FormsModule, RouterModule],
    declarations: [StoreComponent, CounterDirective, CartSummaryComponent,
        CartDetailComponent, CheckoutComponent],
    exports: [StoreComponent, CartDetailComponent, CheckoutComponent]
})
export class StoreModule { }
```

To see the effect of the navigation, save the changes of the files and, once the browser has reloaded the HTML document, click one of the Add To Cart buttons. The browser will navigate to the `/cart` URL, as shown in Figure 8-3.

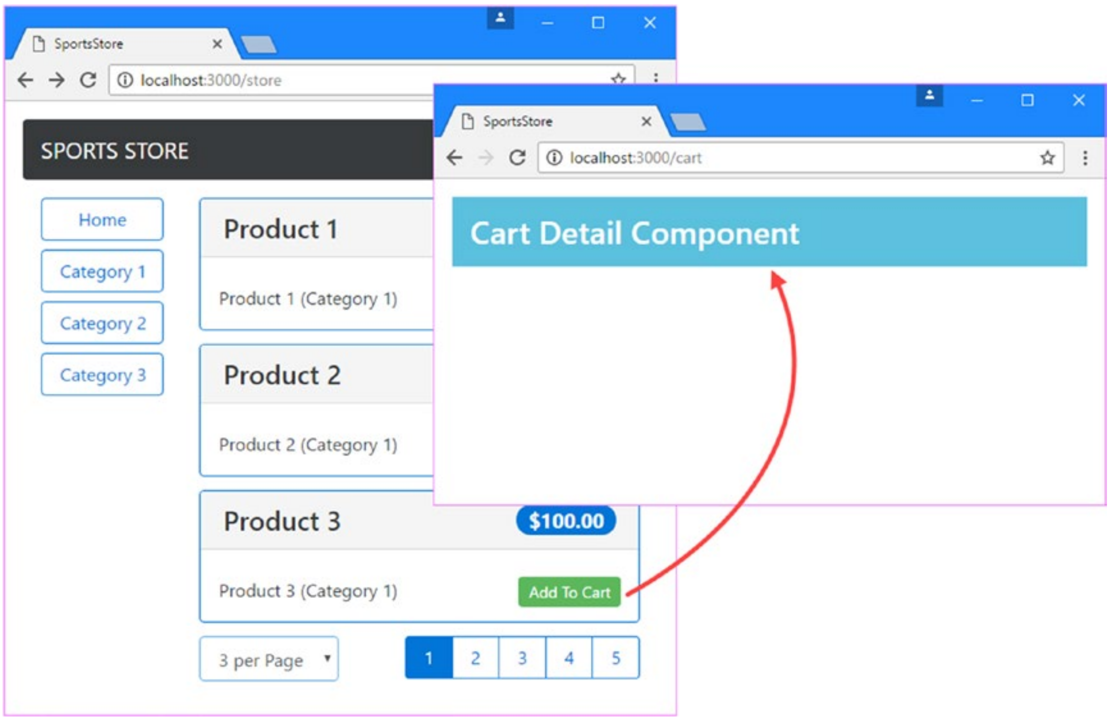


Figure 8-3. *Using URL routing*

Guarding the Routes

Remember that navigation can be performed only by the application. If you change the URL directly in the browser's URL bar, the browser will request the URL you enter from the web server. The `lite-server` package that is responding to HTTP requests will respond to any URL that doesn't correspond to a file by returning the contents of `index.html`. This is generally a useful behavior because it means you won't receive an HTTP error when the browser reload button is clicked.

But it can also cause problems if the application expects the user to navigate through the application following a specific path. As an example, if you click one of the Add To Cart buttons and then click the browser's reload button, the HTTP server will return the contents of the `index.html` file, and Angular will immediately jump to the cart detail component, skipping over the part of the application that allows the user to select products.

For some applications, being able to start using different URLs makes sense, but if that's not the case, then Angular supports route guards, which are used to govern the routing system.

To prevent the application from starting with the `/cart` or `/order` URL, I added a file called `storeFirst.guard.ts` in the `SportsStore/app` folder and defined the class shown in Listing 8-16.

Listing 8-16. The Contents of the storeFirst.guard.ts File in the SportsStore/app Folder

```
import { Injectable } from "@angular/core";
import {
    ActivatedRouteSnapshot, RouterStateSnapshot,
    Router
} from "@angular/router";
import { StoreComponent } from "./store/store.component";

@Injectable()
export class StoreFirstGuard {
    private firstNavigation = true;

    constructor(private router: Router) { }

    canActivate(route: ActivatedRouteSnapshot,
        state: RouterStateSnapshot): boolean {
        if (this.firstNavigation) {
            this.firstNavigation = false;
            if (route.component != StoreComponent) {
                this.router.navigateByUrl("/");
                return false;
            }
        }
        return true;
    }
}
```

There are different ways to guard routes, as described in Chapter 27, and this is an example of a guard that prevents a route from being activated, which is implemented as a class that defines a `canActivate` method. The implementation of this method uses the context objects that Angular provides that describe the route that is about to be navigated to and checks to see whether the target component is a `StoreComponent`. If this is the first time that the `canActivate` method has been called and a different component is about to be used, then the `Router.navigateByUrl` method is used to navigate to the root URL.

The `@Injectable` decorator has been applied in the listing because route guards are services. Listing 8-17 registers the guard as a service using the root module's `providers` property and guards each route using the `canActivate` property.

Listing 8-17. Guarding Routes in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { AppComponent } from "./app.component";
import { StoreModule } from "./store/store.module";
import { StoreComponent } from "./store/store.component";
import { CheckoutComponent } from "./store/checkout.component";
import { CartDetailComponent } from "./store/cartDetail.component";
import { RouterModule } from "@angular/router";
import { StoreFirstGuard } from "./storeFirst.guard";
```

```
@NgModule({
    imports: [BrowserModule, StoreModule,
        RouterModule.forRoot([
            {
                path: "store", component: StoreComponent,
                canActivate: [StoreFirstGuard]
            },
            {
                path: "cart", component: CartDetailComponent,
                canActivate: [StoreFirstGuard]
            },
            {
                path: "checkout", component: CheckoutComponent,
                canActivate: [StoreFirstGuard]
            },
            { path: "**", redirectTo: "/store" }
        ])],
    providers: [StoreFirstGuard],
    declarations: [AppComponent],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

If you reload the browser after clicking one of the Add To Cart buttons now, then you will see the browser is automatically directed back to safety, as shown in Figure 8-4.

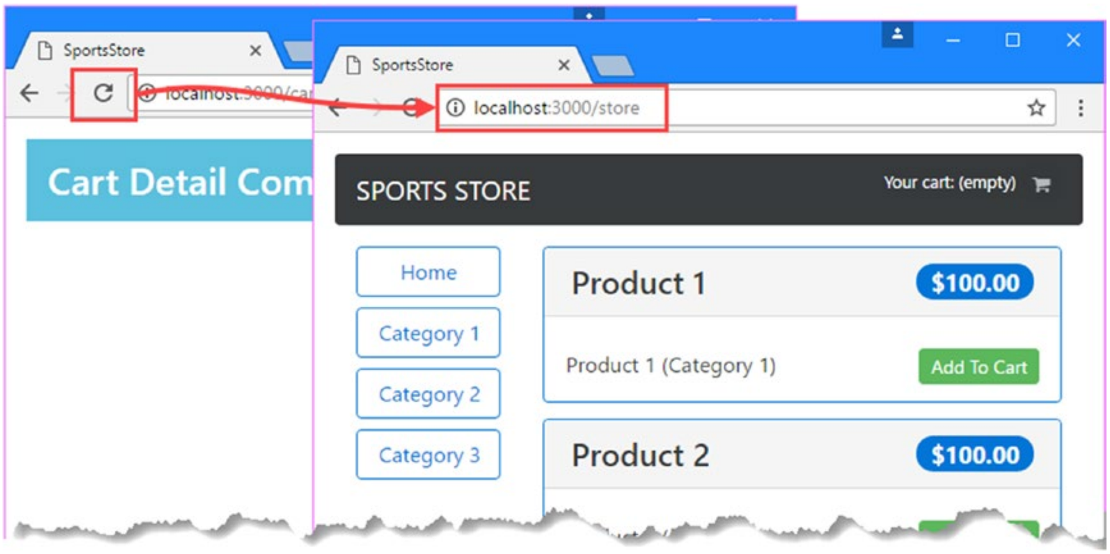


Figure 8-4. *Guarding routes*

Completing the Cart Detail Feature

The natural flow of development with Angular moves between setting up infrastructure, such as URL routing, and implementing features that are visible to the user. Now that the application has navigation support, it is time to complete the view that details the contents of the user's cart. Listing 8-18 removes the inline template from the cart detail component, specifies an external template in the same directory, and adds a `Cart` parameter to the constructor, which will be accessible in the template through a property called `cart`.

Listing 8-18. Changing the Template in the cartDetail.component.ts File

```
import { Component } from "@angular/core";
import { Cart } from "../model/cart.model";

@Component({
    moduleId: module.id,
    templateUrl: "cartDetail.component.html"
})
export class CartDetailComponent {

    constructor(public cart: Cart) { }
}
```

To complete the cart detail feature, I created an HTML file called `cartDetail.component.html` in the `SportsStore/app/store` folder and added the content shown in Listing 8-19.

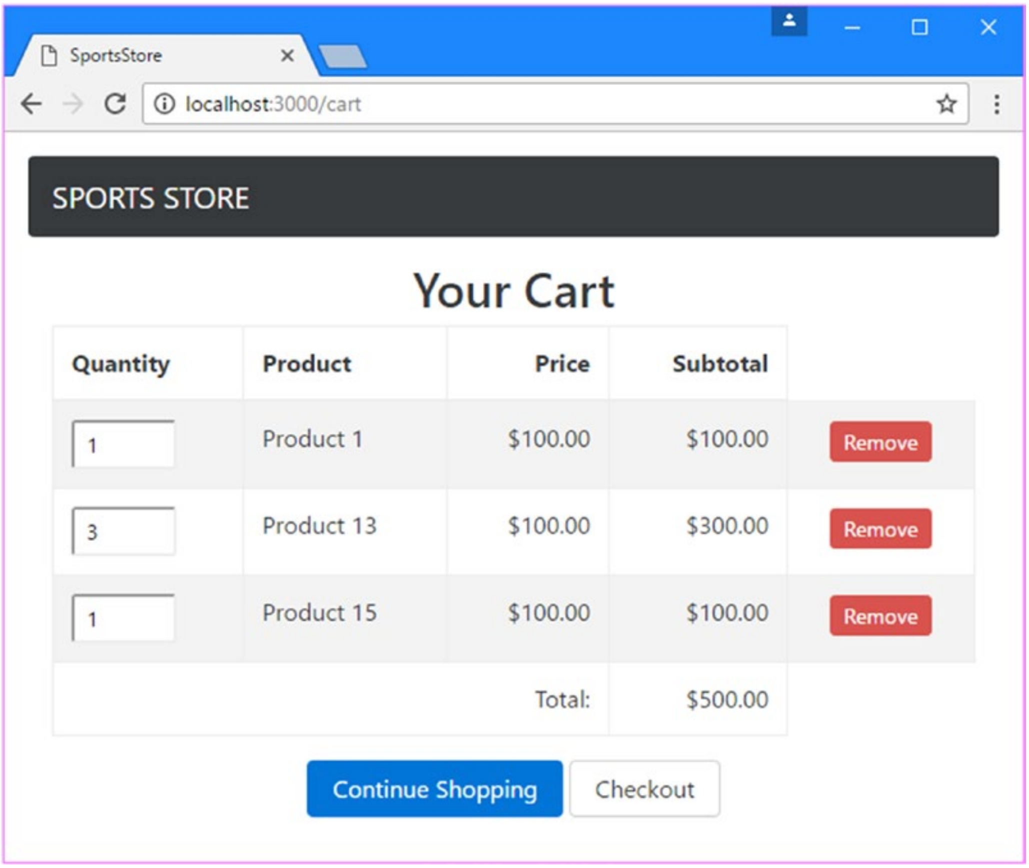
Listing 8-19. The Contents of the cartDetail.component.html File in the SportsStore/app/store Folder

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
</div>

<div class="m-a-1">
    <h2 class="text-xs-center">Your Cart</h2>
    <table class="table table-bordered table-striped p-a-1">
        <thead>
            <tr>
                <th>Quantity</th>
                <th>Product</th>
                <th class="text-xs-right">Price</th>
                <th class="text-xs-right">Subtotal</th>
            </tr>
        </thead>
        <tbody>
            <tr *ngIf="cart.lines.length == 0">
                <td colspan="4" class="text-xs-center">
                    Your cart is empty
                </td>
            </tr>
            <tr *ngFor="let line of cart.lines">
```

```
                <td>
                    <input type="number" class="form-control-sm"
                           style="width:5em"
                           [value]="line.quantity"
                           (change)="cart.updateQuantity(line.product,
                                $event.target.value)"/>
                </td>
                <td>{{line.product.name}}</td>
                <td class="text-xs-right">
                    {{line.product.price | currency:"USD":true:"2.2-2"}}
                </td>
                <td class="text-xs-right">
                    {{(line.lineTotal) | currency:"USD":true:"2.2-2" }}
                </td>
                <td class="text-xs-center">
                    <button class="btn btn-sm btn-danger"
                            (click)="cart.removeLine(line.product.id)">
                        Remove
                    </button>
                </td>
            </tr>
        </tbody>
        <tfoot>
            <tr>
                <td colspan="3" class="text-xs-right">Total:</td>
                <td class="text-xs-right">
                    {{cart.cartPrice | currency:"USD":true:"2.2-2"}}
                </td>
            </tr>
        </tfoot>
    </table>
</div>
<div class="text-xs-center">
    <button class="btn btn-primary" routerLink="/store">Continue Shopping</button>
    <button class="btn btn-secondary" routerLink="/checkout"
            [disabled]="cart.lines.length == 0">
        Checkout
    </button>
</div>
```

This template displays a table showing the user's product selections. For each product, there is an `input` element that can be used to change the quantity and a Remove button that deletes it from the cart. There are also two navigation buttons that allow the user to return to the list of products or continue to the checkout process, as shown in Figure 8-5. The combination of the Angular data bindings and the shared `Cart` object means that any changes made to the cart take immediate effect, recalculating the prices; and if you click the Continue Shopping button, the changes are reflected in the cart summary component shown above the list of products.



Quantity	Product	Price	Subtotal	
1	Product 1	$100.00	$100.00	Remove
3	Product 13	$100.00	$300.00	Remove
1	Product 15	$100.00	$100.00	Remove
		Total:	$500.00	

Figure 8-5. *Completing the cart detail feature*

Processing Orders

Being able to receive orders from customers is the most important aspect of an online store. In the sections that follow, I build on the application to add support for receiving the final details from the user and checking them out. To keep the process simple, I am going to avoid dealing with payment platforms, which are generally back-end services that are not specific to Angular applications.

Extending the Model

To describe orders placed by users, I added a file called `order.model.ts` in the `SportsStore/app/model` folder and defined the code shown in Listing 8-20.

Listing 8-20. The Contents of the order.model.ts File in the SportsStore/app/model Folder

```
import { Injectable } from "@angular/core";
import { Cart } from "./cart.model";

@Injectable()
export class Order {
    public id: number;
    public name: string;
    public address: string;
    public city: string;
    public state: string;
    public zip: string;
    public country: string;
    public shipped: boolean = false;

    constructor(public cart: Cart) { }

    clear() {
        this.id = null;
        this.name = this.address = this.city = null;
        this.state = this.zip = this.country = null;
        this.shipped = false;
        this.cart.clear();
    }
}
```

The Order class will be another service, which means that there will be one instance shared throughout the application. When Angular creates the Order object, it will detect the Cart constructor parameter and provide the same Cart object that is used elsewhere in the application.

Updating the Repository and Data Source

To handle orders in the application, I need to extend the repository and the data source so they can receive Order objects. Listing 8-21 adds a method to the data source that receives an order. Since this is still the dummy data source, the method simply produces a JSON string from the order and writes it to the JavaScript console. I'll do something more useful with the objects in the next section, when I create a data source that uses HTTP requests to communicate with the RESTful web service.

Listing 8-21. Handling Orders in the static.datasource.ts File

```
import { Injectable } from "@angular/core";
import { Product} from "./product.model";
import { Observable } from "rxjs/Observable";
import "rxjs/add/observable/from";
import { Order } from "./order.model";
```

```
@Injectable()
export class StaticDataSource {
    private products: Product[] = [

       // ...statements omitted for brevity...

    ];

    getProducts(): Observable<Product[]> {
        return Observable.from([this.products]);
    }

    saveOrder(order: Order): Observable<Order> {
        console.log(JSON.stringify(order));
        return Observable.from([order]);
    }
}
```

To manage orders, I added a file called `order.repository.ts` to the `SportsStore/app/model` folder and used it to define the class shown in Listing 8-22. There is only one method in the order repository at the moment, but I will add more functionality in Chapter 9 when I create the administration features.

■ **Tip** You don't have to use different repositories for each model type in the application, but I often do so because a single class responsible for multiple model types can become complex and difficult to maintain.

Listing 8-22. The Contents of the order.repository.ts File in the SportsStore/app/model Folder

```
import { Injectable } from "@angular/core";
import { Observable } from "rxjs/Observable";
import { Order } from "./order.model";
import { StaticDataSource } from "./static.datasource";

@Injectable()
export class OrderRepository {
    private orders: Order[] = [];

    constructor(private dataSource: StaticDataSource) {}

    getOrders(): Order[] {
        return this.orders;
    }

    saveOrder(order: Order): Observable<Order> {
        return this.dataSource.saveOrder(order);
    }
}
```

Updating the Feature Module

Listing 8-23 registers the Order class and the new repository as services using the providers property of the model feature module.

Listing 8-23. Registering Services in the model.module.ts File

```
import { NgModule } from "@angular/core";
import { ProductRepository } from "./product.repository";
import { StaticDataSource } from "./static.datasource";
import { Cart } from "./cart.model";
import { Order } from "./order.model";
import { OrderRepository } from "./order.repository";

@NgModule({
    providers: [ProductRepository, StaticDataSource, Cart,
                Order, OrderRepository]
})
export class ModelModule { }
```

Collecting the Order Details

The next step is to gather the details from the user required to complete the order. Angular includes built-in directives for working with HTML forms and validating their contents. Listing 8-24 prepares the checkout component, switching to an external template, receiving the Order object as a constructor parameter, and providing some additional support to help the template.

Listing 8-24. Preparing for a Form in the checkout.component.ts File

```
import { Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { OrderRepository } from "../model/order.repository";
import { Order } from "../model/order.model";

@Component({
    moduleId: module.id,
    templateUrl: "checkout.component.html",
    styleUrls: ["checkout.component.css"]
})
export class CheckoutComponent {
    orderSent: boolean = false;
    submitted: boolean = false;

    constructor(public repository: OrderRepository,
                public order: Order) {}

    submitOrder(form: NgForm) {
        this.submitted = true;
        if (form.valid) {
            this.repository.saveOrder(this.order).subscribe(order => {
                this.order.clear();
                this.orderSent = true;
                this.submitted = false;
            });
        }
    }
}
```

The submitOrder method will be invoked when the user submits a form, which is represented by an NgForm object. If the data that the form contains is valid, then the Order object will be passed to the repository's saveOrder method and the data in the cart and the order will be reset.

The @Component decorator's styleUrls property is used to specify one or more CSS stylesheets that should be applied to the content in the component's template. To provide validation feedback for the values that the user enters into the HTML form elements, I created a file called checkout.component.css in the SportsStore/app/store folder and defined the styles shown in Listing 8-25.

Listing 8-25. The Contents of the checkout.component.css File in the SportsStore/app/store Folder

```
input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
```

Angular adds elements to the ng-dirty, ng-valid, and ng-valid classes to indicate their validation status. The full set of validation classes is described in Chapter 14, but the effect of the styles in Listing 8-25 is to add a green border around input elements that are valid and a red border around those that are invalid.

The final piece of the puzzle is the template for the component, which presents the user with the form fields required to populate the properties of an Order object, as shown in Listing 8-26.

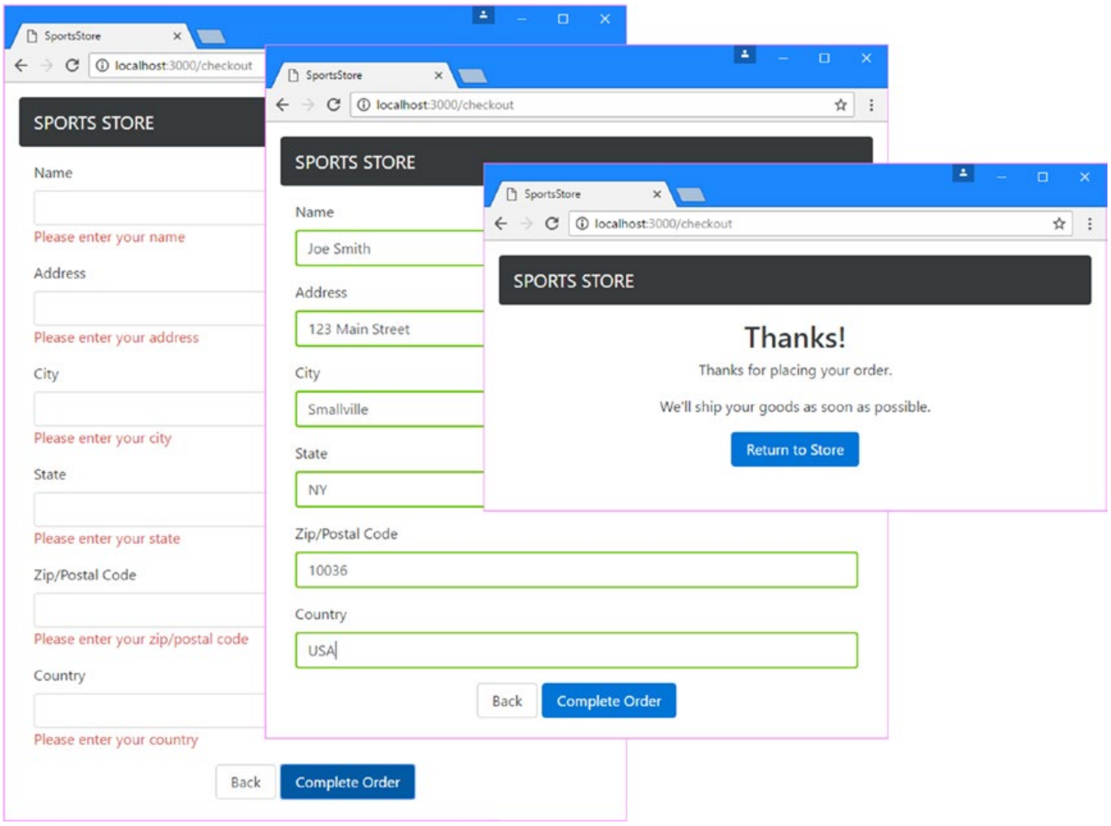
Listing 8-26. The Contents of the checkout.component.html File in the SportsStore/app/store Folder

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
</div>
<div *ngIf="orderSent" class="m-a-1 text-xs-center">
    <h2>Thanks!</h2>
    <p>Thanks for placing your order.</p>
    <p>We'll ship your goods as soon as possible.</p>
    <button class="btn btn-primary" routerLink="/store">Return to Store</button>
</div>
<form *ngIf="!orderSent" #form="ngForm" novalidate
      (ngSubmit)="submitOrder(form)" class="m-a-1">
    <div class="form-group">
        <label>Name</label>
        <input class="form-control" #name="ngModel" name="name"
               [(ngModel)]="order.name" required />
        <span  *ngIf="submitted && name.invalid" class="text-danger">
            Please enter your name
        </span>
    </div>
    <div class="form-group">
        <label>Address</label>
        <input class="form-control" #address="ngModel" name="address"
               [(ngModel)]="order.address" required />
        <span  *ngIf="submitted && address.invalid" class="text-danger">
            Please enter your address
        </span>
    </div>
    <div class="form-group">
        <label>City</label>
        <input class="form-control" #city="ngModel" name="city"
               [(ngModel)]="order.city" required />
        <span  *ngIf="submitted && city.invalid" class="text-danger">
            Please enter your city
        </span>
    </div>
    <div class="form-group">
        <label>State</label>
        <input class="form-control" #state="ngModel" name="state"
               [(ngModel)]="order.state" required />
        <span  *ngIf="submitted && state.invalid" class="text-danger">
            Please enter your state
        </span>
    </div>
    <div class="form-group">
        <label>Zip/Postal Code</label>
        <input class="form-control" #zip="ngModel" name="zip"
               [(ngModel)]="order.zip" required />
        <span  *ngIf="submitted && zip.invalid" class="text-danger">
            Please enter your zip/postal code
        </span>
    </div>
    <div class="form-group">
        <label>Country</label>
        <input class="form-control" #country="ngModel" name="country"
               [(ngModel)]="order.country" required />
        <span  *ngIf="submitted && country.invalid" class="text-danger">
            Please enter your country
        </span>
    </div>
    <div class="text-xs-center">
        <button class="btn btn-secondary" routerLink="/cart">Back</button>
        <button class="btn btn-primary" type="submit">Complete Order</button>
    </div>
</form>
```

The `form` and `input` elements in this template use Angular features to ensure that the user provides values for each field, and they provide visual feedback if the user clicks the `Complete Order` button without completing the form. Part of this feedback comes from applying the styles that were defined in Listing 8-25, and part comes from span elements that remain hidden until the user tries to submit an invalid form.

■ **Tip** Requiring values is only one of the ways that Angular can validate form fields, and as I explained in Chapter 14, you can easily add your own custom validation as well.

To see the process, start with the list of products and click one of the Add To Cart buttons to add a product to the cart. Click the Checkout button and you will see the HTML form shown in Figure 8-6. Click the Complete Order button without entering text into any of the `input` elements and you will see the validation feedback messages. Fill out the form and click the Complete Order button; you will see the confirmation message shown in the figure.


SportsStore
localhost:3000/checkout
SPORTS STORE
Name
Please enter your name
Address
Please enter your address
City
Please enter your city
State
Please enter your state
Zip/Postal Code
Please enter your zip/postal code
Country
Please enter your country
Back Complete Order

SportsStore
localhost:3000/checkout
SPORTS STORE
Name
Joe Smith
Address
123 Main Street
City
Smallville
State
NY
Zip/Postal Code
10036
Country
USA
Back Complete Order

SportsStore
localhost:3000/checkout
SPORTS STORE
Thanks!
Thanks for placing your order.
We'll ship your goods as soon as possible.
Return to Store

Figure 8-6. *Completing an order*

If you look in the browser's JavaScript console, you will see a JSON representation of the order like this:

```
{"cart":
    {"lines":[
        {"product":{"id":1,"name":"Product 1","category":"Category 1",
         "description":"Product 1 (Category 1)","price":100},"quantity":1}],
         "itemCount":1,"cartPrice":100},
    "shipped":false,
    "name":"Joe Smith","address":"123 Main Street",
    "city":"Smallville","state":"NY","zip":"10036","country":"USA"
}
```

Using the RESTful Web Service

Now that the basic SportsStore functionality is in place, it is time to replace the dummy data source with one that gets its data from the RESTful web service that was created during the project set up in Chapter 9.

To create the data source, I added a file called `rest.datasource.ts` in the `SportsStore/app/model` folder and added the code shown in Listing 8-27.

Listing 8-27. The Contents of the rest.datasource.ts File in the SportsStore/app/model Folder

```
import { Injectable } from "@angular/core";
import { Http, Request, RequestMethod } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import { Cart } from "./cart.model";
import { Order } from "./order.model";
import "rxjs/add/operator/map";

const PROTOCOL = "http";
const PORT = 3500;

@Injectable()
export class RestDataSource {
    baseUrl: string;

    constructor(private http: Http) {
        this.baseUrl = `${PROTOCOL}://${location.hostname}:${PORT}/`;
    }

    getProducts(): Observable<Product[]> {
        return this.sendRequest(RequestMethod.Get, "products");
    }

    saveOrder(order: Order): Observable<Order> {
        return this.sendRequest(RequestMethod.Post, "orders", order);
    }

    private sendRequest(verb: RequestMethod,
            url: string, body?: Product | Order): Observable<Product | Order> {
        return this.http.request(new Request({
            method: verb,
            url: this.baseUrl + url,
            body: body
        })).map(response => response.json());
    }
}
```

Angular provides a built-in service called `Http` that is used to make HTTP requests. The `RestDataSource` constructor receives the `Http` service and uses the global `location` object provided by the browser to determine the URL that the requests will be sent to, which is port 3500 on the same host that the application has been loaded from.

The methods defined by the RestDataSource class correspond to the ones defined by the static data source and are implemented by calling the sendRequest method, which uses the Http service, described in Chapter 24.

■ **Tip** When obtaining data via HTTP, it is possible that network congestion or server load will delay the request and leave the user looking at an application that has no data. In Chapter 27, I explain how to configure the routing system to prevent this problem.

Applying the Data Source

To complete this chapter, I am going to apply the RESTful data source by reconfiguring the application so that the switch from the dummy data to the REST data is done with changes to a single file. Listing 8-28 changes the behavior of the data source service in the model feature module.

Listing 8-28. Changing the Service Configuration in the model.module.ts File

```
import { NgModule } from "@angular/core";
import { ProductRepository } from "./product.repository";
import { StaticDataSource } from "./static.datasource";
import { Cart } from "./cart.model";
import { Order } from "./order.model";
import { OrderRepository } from "./order.repository";
import { RestDataSource } from "./rest.datasource";
import { HttpModule } from "@angular/http";

@NgModule({
    imports: [HttpModule],
    providers: [ProductRepository, Cart, Order, OrderRepository,
        { provide: StaticDataSource, useClass: RestDataSource }]
})
export class ModelModule { }
```

The imports property is used to declare a dependency on HttpModule feature module, which provides the Http service used in Listing 8-27. The change to the providers property tells Angular that when it needs to create an instance of a class with a StaticDataSource constructor parameter, it should use a RestDataSource instead. Since both objects define the same methods, the dynamic JavaScript type system means that the substitution is seamless. When all the changes have been saved and the browser reloads the application, you will see the dummy data has been replaced with the data obtained via HTTP, as shown in Figure 8-7.

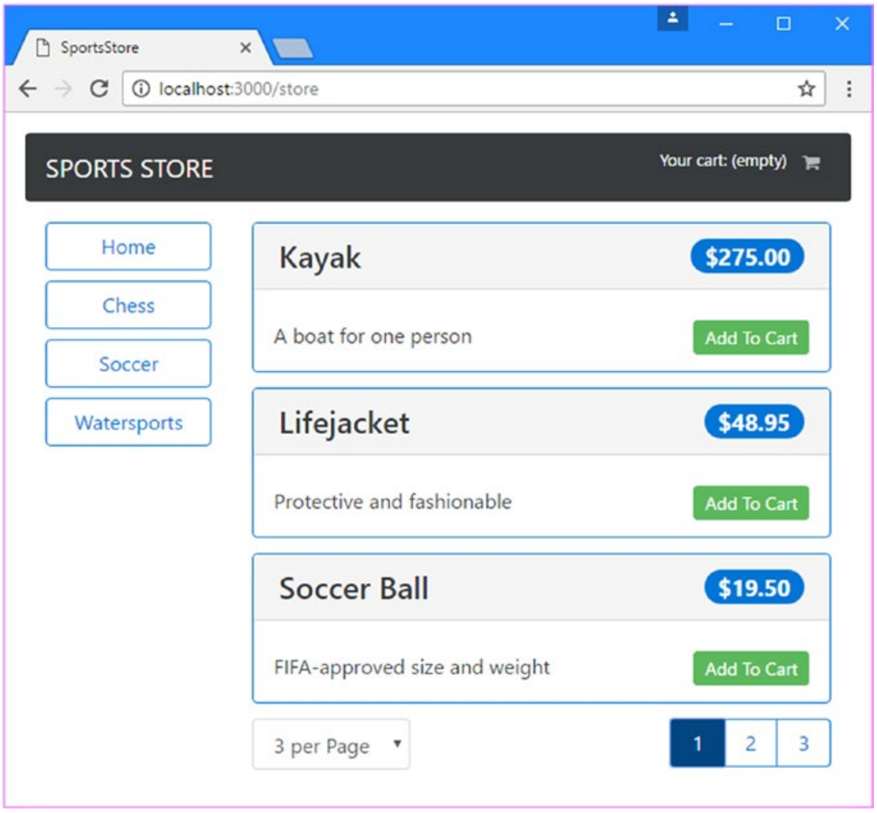


Figure 8-7. *Using the RESTful web service*

If you go through the process of selecting products and checking out, you can see that the data source has written the order to the web service by navigating to this URL:

```
http://localhost:3500/db
```

This will display the full contents of the database, including the collection of orders. You won't be able to request the `/orders` URL because it requires authentication, which I set up in the next chapter.

■ **Tip** Remember that the data provided by the RESTful web service is reset if you restart `npm`, resetting to the data defined in Chapter 7.

Summary

In this chapter, I continued adding features to the SportsStore application, adding support for a shopping cart into which the user can place products and a checkout process that completes the shopping process. To complete the chapter, I replaced the dummy data source with one that sends HTTP requests to the RESTful web service. In the next chapter, I create the administration features that allow the SportsStore data to be managed.

CHAPTER 9

SportsStore: Administration

In this chapter, I continue building the SportsStore application by adding administration features. Relatively few users will need to access the administration features, so it would be wasteful to force all users to download the administration code and content when it is unlikely to be used. Instead, I am going to put the administration features in a feature module that will be loaded only when administration is required. In this section, I prepare the application by creating the feature module, adding some initial content, and setting up the rest of the application so that the module can be loaded dynamically.

Preparing the Example Application

No preparation is required for this chapter, which continues using the SportsStore project from Chapter 8. Run the following command in the `SportsStore` folder to start the TypeScript compiler, the RESTful web service, and the development HTTP server:

```
npm start
```

Tip The free source code download from `apress.com` that accompanies this book contains the SportsStore project from each individual chapter if you don't want to have to start with the earlier chapters.

Creating the Module

The process for creating the feature module follows the same pattern for the rest of the application, except it is important that no other part of the application has dependencies on the module or the classes it contains, which would undermine the dynamic loading of the module and cause the JavaScript module to load the administration code, even if it is not used.

The starting point for the administration features will be to authenticate, so I created a file called `auth.component.ts` in the `SportsStore/app/admin` folder and used it to define the component shown in Listing 9-1.

Listing 9-1. The Content of the auth.component.ts File in the SportsStore/app/admin Folder

```
import { Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Router } from "@angular/router";
```

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```
@Component({
    moduleId: module.id,
    templateUrl: "auth.component.html"
})
export class AuthComponent {
    public username: string;
    public password: string;
    public errorMessage: string;

    constructor(private router: Router) {}

    authenticate(form: NgForm) {
        if (form.valid) {
            // perform authentication
            this.router.navigateByUrl("/admin/main");
        } else {
            this.errorMessage = "Form Data Invalid";
        }
    }
}
```

The component defines properties for the username and password that will be used to authenticate the user, an `errorMessage` property that will be used to display messages to the user when there are problems, and an `authenticate` method that will perform the authentication process (but that does nothing at the moment).

To provide the component with a template, I created a file called `auth.component.html` in the `SportsStore/app/admin` folder and added the content shown in Listing 9-2.

Listing 9-2. The Content of the auth.component.html File in the SportsStore/app/admin Folder

```
<div class="bg-info p-a-1 text-xs-center">
    <h3>SportsStore Admin</h3>
</div>
<div class="bg-danger m-t-1 p-a-1 text-xs-center"
        *ngIf="errorMessage != null">
    {{errorMessage}}
</div>
<div class="p-a-1">
    <form novalidate #form="ngForm" (ngSubmit)="authenticate(form)">
        <div class="form-group">
            <label>Name</label>
            <input class="form-control" name="username"
                [(ngModel)]="username" required />
        </div>
        <div class="form-group">
            <label>Password</label>
            <input class="form-control" type="password" name="password"
                [(ngModel)]="password" required />
        </div>
        <div class="text-xs-center">
            <button class="btn btn-secondary" routerLink="/">Go back</button>
            <button class="btn btn-primary" type="submit">Log In</button>
        </div>
    </form>
</div>
```

The template contains an HTML form that uses two-way data binding expressions for the component's properties. There is a button that will submit the form, a button that navigates back to the root URL, and a div element that is visible only when there is an error message to display.

To create a placeholder for the administration features, I added a file called admin.component.ts in the SportsStore/app/admin folder and defined the component shown in Listing 9-3.

Listing 9-3. The Contents of the admin.component.ts File in the SportsStore/app/admin Folder

```
import { Component } from "@angular/core";

@Component({
    moduleId: module.id,
    templateUrl: "admin.component.html"
})
export class AdminComponent {}
```

The component doesn't contain any functionality at the moment. To provide a template for the component, I added a file called admin.component.html to the SportsStore/app/admin folder and the placeholder content shown in Listing 9-4.

Listing 9-4. The Contents of the admin.component.html File in the SportsStore/app/admin Folder

```
<div class="bg-info p-a-1">
    <h3>Placeholder for Admin Features</h3>
</div>
```

To define the feature module, I added a file called admin.module.ts in the SportsStore/app/admin folder and added the code shown in Listing 9-5.

Listing 9-5. The Contents of the admin.module.ts File in the SportsStore/app/admin Folder

```
import { NgModule } from "@angular/core";
import { CommonModule } from "@angular/common";
import { FormsModule } from "@angular/forms";
import { RouterModule } from "@angular/router";
import { AuthComponent } from "./auth.component";
import { AdminComponent } from "./admin.component";

let routing = RouterModule.forChild([
    { path: "auth", component: AuthComponent },
    { path: "main", component: AdminComponent },
    { path: "**", redirectTo: "auth" }
]);

@NgModule({
    imports: [CommonModule, FormsModule, routing],
    declarations: [AuthComponent, AdminComponent]
})
export class AdminModule { }
```

The main difference when creating a dynamically loaded module is that the feature module must be self-contained and include all the information that Angular requires, including the routing URLs that are supported and the components they display.

The `RouterModule.forChild` method is used to define the routing configuration for the feature module, which is then included in the module's `imports` property.

The prohibition on exporting classes from a dynamically loaded module doesn't apply to imports. This module relies on the functionality in the model feature module, which has been added to the module's `imports` so that components can access the model classes and the repositories.

Configuring the URL Routing System

Dynamically loaded modules are managed through the routing configuration, which triggers the loading process when the application navigates to a specific URL. Listing 9-6 extends the routing configuration of the application so that the `/admin` URL will load the administration feature module.

Listing 9-6. Configuring a Dynamically Loaded Module in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { AppComponent } from "./app.component";
import { StoreModule } from "./store/store.module";
import { StoreComponent } from "./store/store.component";
import { CheckoutComponent } from "./store/checkout.component";
import { CartDetailComponent } from "./store/cartDetail.component";
import { RouterModule } from "@angular/router";
import { StoreFirstGuard } from "./storeFirst.guard";

@NgModule({
    imports: [BrowserModule, StoreModule,
        RouterModule.forRoot([
            {
                path: "store", component: StoreComponent,
                canActivate: [StoreFirstGuard]
            },
            {
                path: "cart", component: CartDetailComponent,
                canActivate: [StoreFirstGuard]
            },
            {
                path: "checkout", component: CheckoutComponent,
                canActivate: [StoreFirstGuard]
            },
            {
                path: "admin",
                loadChildren: "app/admin/admin.module#AdminModule",
                canActivate: [StoreFirstGuard]
            },
            { path: "**", redirectTo: "/store" }
        ])],
    providers: [StoreFirstGuard],
    declarations: [AppComponent],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

The new route tells Angular that when the application navigates to the `/admin` URL, it should load a feature module defined by a class called `AdminModule` from the `/app/admin/admin.module.ts` file. When Angular processes the admin module, it will incorporate the routing information it contains into the overall set of routes and complete the navigation.

Navigating to the Administration URL

The final preparatory step is to provide the user with the ability to navigate to the `/admin` URL so that the administration feature module will be loaded and its component displayed to the user. Listing 9-7 adds a button to the store component's template that will perform the navigation.

Listing 9-7. Adding a Navigation Button in the store.component.html File

```
<div class="navbar navbar-inverse bg-inverse">
    <a class="navbar-brand">SPORTS STORE</a>
    <cart-summary></cart-summary>
</div>
<div class="col-xs-3 p-a-1">
    <button class="btn btn-block btn-outline-primary"
            (click)="changeCategory()">
        Home
    </button>
    <button *ngFor="let cat of categories"
            class="btn btn-outline-primary btn-block"
            [class.active]="cat == selectedCategory"
            (click)="changeCategory(cat)">
        {{cat}}
    </button>
    <button class="btn btn-block btn-danger m-t-3" routerLink="/admin">
        Admin
    </button>
</div>
<div class="col-xs-9 p-a-1">

    <!-- ...elements omitted for brevity... -->

</div>
```

To see the result, use the browser's F12 developer tools to see the network requests made by the browser as the application is loaded. The files for the administration module will not be loaded until you click the Admin button, at which point Angular will request the files and display the login page shown in Figure 9-1.

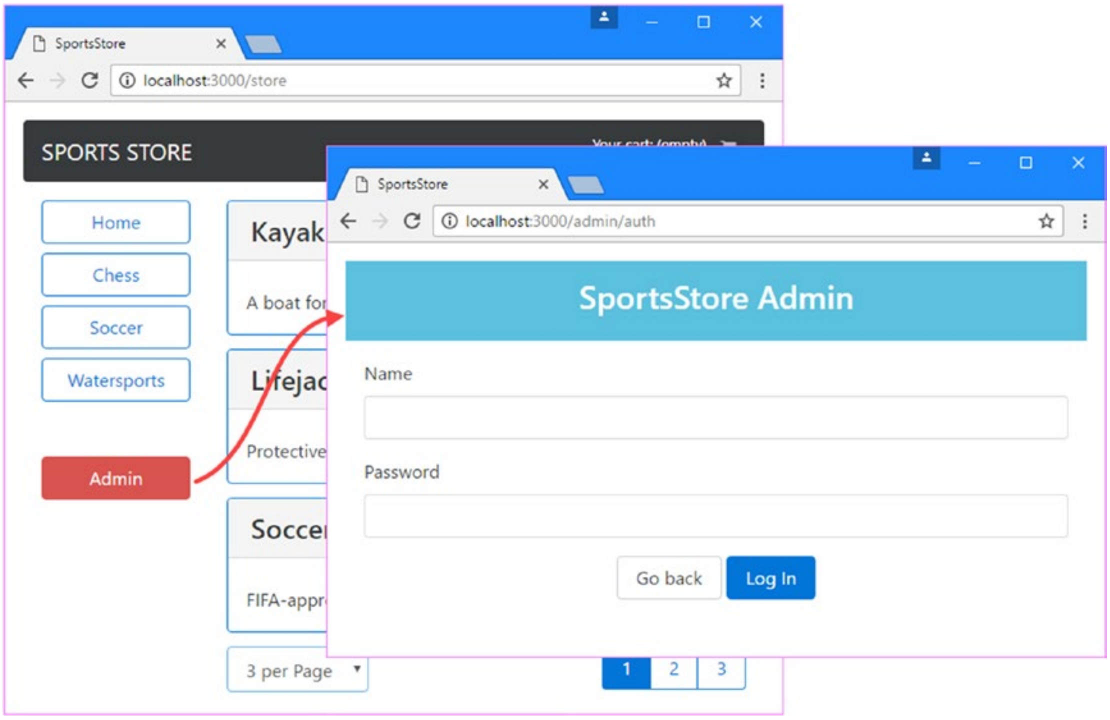


Figure 9-1. *Using a dynamically loaded module*

Enter any name and password into the form fields and click the Log In button to see the placeholder content, as shown in Figure 9-2. If you leave either of the form fields empty, a warning message will be displayed.

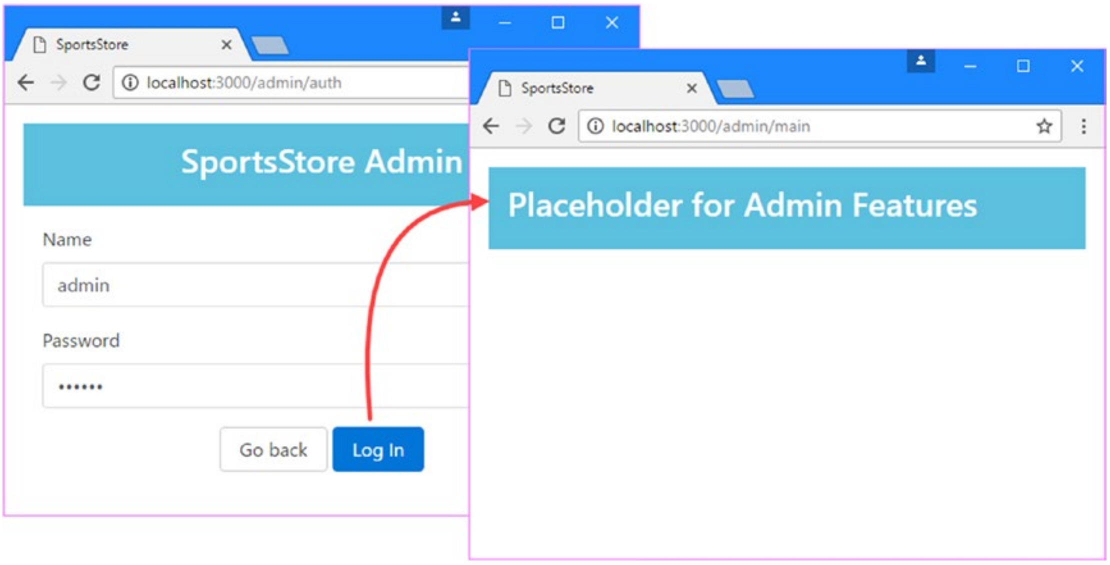

SportsStore
localhost:3000/admin/auth
SportsStore Admin
Name
admin
Password
••••••
Go back
Log In
SportsStore
localhost:3000/admin/main
Placeholder for Admin Features

Figure 9-2. *The placeholder administration features*

Implementing Authentication

The RESTful web service has been configured so that it requires authentication for the requests that the administration feature will require. In the sections that follow, I extend the data model to support authenticated HTTP requests and integrate them into the administration module.

Understanding the Authentication System

The result of authentication with the RESTful web service is a JSON Web Token (JWT), which is returned by the server and must be included in any subsequent requests to show that the application is authorized to perform protected operations. You can read the JWT specification at https://tools.ietf.org/html/rfc7519, but for the purposes of the SportsStore application it is enough to know that the Angular application can authenticate the user by sending a POST request to the /login URL, including a JSON-formatted object in the request body that contains name and password properties. There is only one set of valid credentials in the authentication code used in Chapter 7, which is shown in Table 9-1.

Table 9-1. *The Authentication Credentials Supported by the RESTful Web Service*

Username	Password
admin	secret

As I noted in Chapter 7, you should not hard-code credentials in real projects, but this is the username and password that you will need for the SportsStore application.

If the correct credentials are sent to the /login URL, then the response from the RESTful web service will contain a JSON object like this:

```
{
  "success": true,
  "token":"eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJkYXRhIjoiYWRtaW4iLCJleHBpcmVz
           SW4iOiIxaCIsImlhdCI6MTQ3ODk1NjI1Mn0.lJaDDrSu-bHBtdWrz0312p_DG5tKypGv6cA
           NgOyzlg8"
}
```

The success property describes the outcome of the authentication operation, and the token property contains the JWT, which should be included in subsequent requests using the Authorization HTTP header in this format:

```
Authorization: Bearer<eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJkYXRhIjoiYWRtaW4iLC
                     JleHBpcmVzSW4iOiIxaCIsImlhdCI6MTQ3ODk1NjI1Mn0.lJaDDrSu-bHBtd
                     Wrz0312p_DG5tKypGv6cANgOyzlg8>
```

I configured the JWT tokens returned by the server so they expire after one hour.

If the wrong credentials are sent to the server, then the JSON object returned in the response will just contain a success property set to false, like this:

```
{
  "success": false
}
```

Extending the Data Source

The RESTful data source is the class that will do most of the work because it is responsible for sending the authentication request to the `/login` URL and including the JWT in later requests. Listing 9-8 adds authentication to the `RestDataSource` class and extends the `sendRequest` method so that it can include the JWT in requests.

Listing 9-8. Adding Authentication in the rest.datasource.ts File

```
import { Injectable } from "@angular/core";
import { Http, Request, RequestMethod } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import { Cart } from "./cart.model";
import { Order } from "./order.model";
import "rxjs/add/operator/map";

const PROTOCOL = "http";
const PORT = 3500;

@Injectable()
export class RestDataSource {
    baseUrl: string;
    auth_token: string;

    constructor(private http: Http) {
        this.baseUrl = `${PROTOCOL}://${location.hostname}:${PORT}/`;
    }

    authenticate(user: string, pass: string): Observable<boolean> {
        return this.http.request(new Request({
            method: RequestMethod.Post,
            url: this.baseUrl + "login",
            body: { name: user, password: pass }
        })).map(response => {
            let r = response.json();
            this.auth_token = r.success ? r.token : null;
            return r.success;
        });
    }

    getProducts(): Observable<Product[]> {
        return this.sendRequest(RequestMethod.Get, "products");
    }

    saveOrder(order: Order): Observable<Order> {
        return this.sendRequest(RequestMethod.Post,
            "orders", order);
    }
    private sendRequest(verb: RequestMethod,
            url: string, body?: Product | Order, auth: boolean = false)
                : Observable<Product | Product[] | Order | Order[]> {

        let request = new Request({
            method: verb,
            url: this.baseUrl + url,
            body: body
        });
        if (auth && this.auth_token != null) {
            request.headers.set("Authorization", `Bearer<${this.auth_token}>`);
        }
        return this.http.request(request).map(response => response.json());
    }
}
```

Creating the Authentication Service

Rather than expose the data source directly to the rest of the application, I am going to create a service that can be used to perform authentication and determine whether the application has been authenticated. I added a file called `auth.service.ts` in the `SportsStore/app/model` folder and defined the class shown in Listing 9-9.

Listing 9-9. The Contents of the auth.service.ts File in the SportsStore/app/model Folder

```
import { Injectable } from "@angular/core";
import { Observable } from "rxjs/Observable";
import { RestDataSource } from "./rest.datasource";
import "rxjs/add/operator/map";

@Injectable()
export class AuthService {

    constructor(private datasource: RestDataSource) {}

    authenticate(username: string, password: string): Observable<boolean> {
        return this.datasource.authenticate(username, password);
    }

    get authenticated(): boolean {
        return this.datasource.auth_token != null;
    }

    clear() {
        this.datasource.auth_token = null;
    }
}
```

The `authenticate` method receives the user's credentials and passes them on to the data source `authenticate` method, returning an `Observable` that will yield `true` if the authentication process has succeeded and `false` otherwise. The `authenticated` property is a getter-only property that returns `true` if the data source has obtained an authentication token. The `clear` method removes the token from the data source.

Listing 9-10 registers the new service with the model feature module. It also adds a `providers` entry for the `RestDataSource` class, which has been used only as a substitute for the `StaticDataSource` class in earlier chapters. Since the `AuthService` class has a `RestDataSource` constructor parameter, it needs its own entry in the module.

Listing 9-10. Configuring the Services in the model.module.ts File

```
import { NgModule } from "@angular/core";
import { ProductRepository } from "./product.repository";
import { StaticDataSource } from "./static.datasource";
import { Cart } from "./cart.model";
import { Order } from "./order.model";
import { OrderRepository } from "./order.repository";
import { RestDataSource } from "./rest.datasource";
import { HttpModule } from "@angular/http";
import { AuthService } from "./auth.service";

@NgModule({
    imports: [HttpModule],
    providers: [ProductRepository, Cart, Order, OrderRepository,
        { provide: StaticDataSource, useClass: RestDataSource },
        RestDataSource, AuthService]
})
export class ModelModule { }
```

Enabling Authentication

The next step is to wire up the component that obtains the credentials from the user so that it will perform authentication through the new service, as shown in Listing 9-11.

Listing 9-11. Enabling Authentication in the auth.component.ts File

```
import { Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Router } from "@angular/router";
import { AuthService } from "../model/auth.service";

@Component({
    moduleId: module.id,
    templateUrl: "auth.component.html"
})
export class AuthComponent {
    public username: string;
    public password: string;
    public errorMessage: string;
    constructor(private router: Router,
                private auth: AuthService) { }

    authenticate(form: NgForm) {
        if (form.valid) {
            this.auth.authenticate(this.username, this.password)
                .subscribe(response => {
                    if (response) {
                        this.router.navigateByUrl("/admin/main");
                    }
                    this.errorMessage = "Authentication Failed";
                })
        } else {
            this.errorMessage = "Form Data Invalid";
        }
    }
}
```

To prevent the application from navigating directly to the administration features, which will lead to HTTP requests being sent without a token, I added a file called `auth.guard.ts` in the `SportsStore/app/admin` folder and defined the route guard shown in Listing 9-12.

Listing 9-12. The Contents of the auth.guard.ts File in the SportsStore/app/admin Folder

```
import { Injectable } from "@angular/core";
import { ActivatedRouteSnapshot, RouterStateSnapshot,
            Router } from "@angular/router";
import { AuthService } from "../model/auth.service";

@Injectable()
export class AuthGuard {

    constructor(private router: Router,
                private auth: AuthService) { }

    canActivate(route: ActivatedRouteSnapshot,
        state: RouterStateSnapshot): boolean {

        if (!this.auth.authenticated) {
            this.router.navigateByUrl("/admin/auth");
            return false;
        }
        return true;
    }
}
```

Listing 9-13 applies the route guard to one of the routes defined by the administration feature module.

Listing 9-13. Guarding a Route in the admin.module.ts File

```
import { NgModule } from "@angular/core";
import { CommonModule } from "@angular/common";
import { FormsModule } from "@angular/forms";
import { RouterModule } from "@angular/router";
import { AuthComponent } from "./auth.component";
import { AdminComponent } from "./admin.component";
import { AuthGuard } from "./auth.guard";

let routing = RouterModule.forChild([
    { path: "auth", component: AuthComponent },
    { path: "main", component: AdminComponent, canActivate: [AuthGuard] },
    { path: "**", redirectTo: "auth" }
]);

@NgModule({
    imports: [CommonModule, FormsModule, routing],
    providers: [AuthGuard],
    declarations: [AuthComponent, AdminComponent]
})
export class AdminModule {}
```

To test the authentication system, click the Admin button, enter some credentials, and click the Log In button. If the credentials are the ones from Table 9-1, then you will see the placeholder for the administration features. If you enter other credentials, you will see an error message. Both outcomes are illustrated in Figure 9-3.

■ **Tip** The token isn't stored persistently, so if you can, reload the application in the browser to start again and try a different set of credentials.

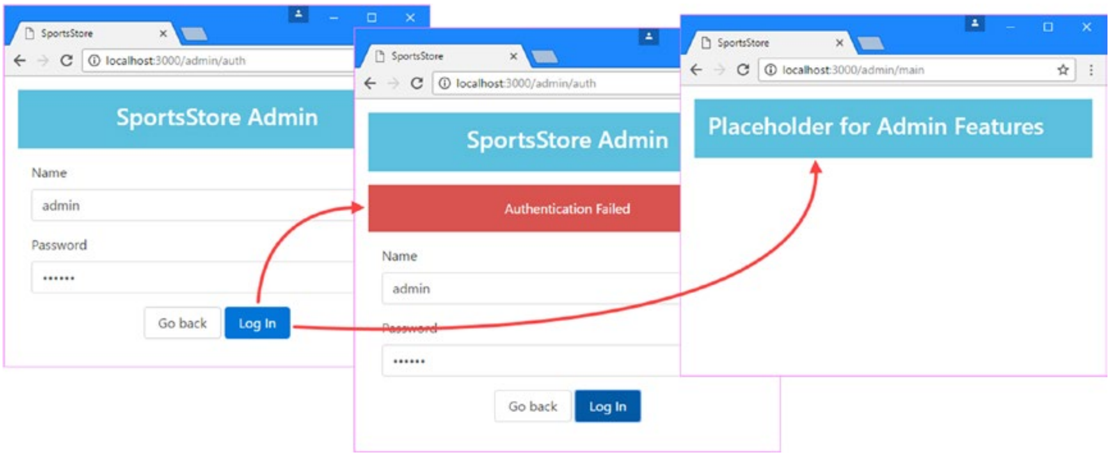


Figure 9-3. *Testing the authentication feature*

Extending the Data Source and Repositories

With the authentication system in place, the next step is to extend the data source so that it can send authenticated requests and to expose those features through the order and product repository classes. Listing 9-14 adds methods to the data source that include the authentication token.

Listing 9-14. Adding New Operations in the rest.datasource.ts File

```
import { Injectable } from "@angular/core";
import { Http, Request, RequestMethod } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import { Cart } from "./cart.model";
import { Order } from "./order.model";
import "rxjs/add/operator/map";

const PROTOCOL = "http";
const PORT = 3500;

@Injectable()
export class RestDataSource {
    baseUrl: string;
    auth_token: string;

    constructor(private http: Http) {
        this.baseUrl = `${PROTOCOL}://${location.hostname}:${PORT}/`;
    }

    authenticate(user: string, pass: string): Observable<boolean> {
        return this.http.request(new Request({
            method: RequestMethod.Post,
            url: this.baseUrl + "login",
            body: { name: user, password: pass }
        })).map(response => {
            let r = response.json();
            this.auth_token = r.success ? r.token : null;
            return r.success;
        });
    }

    getProducts(): Observable<Product[]> {
        return this.sendRequest(RequestMethod.Get, "products");
    }

    saveProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Post, "products",
            product, true);
    }
    updateProduct(product): Observable<Product> {
        return this.sendRequest(RequestMethod.Put,
            `products/${product.id}`, product, true);
    }

    deleteProduct(id: number): Observable<Product> {
        return this.sendRequest(RequestMethod.Delete,
            `products/${id}`, null, true);
    }

    getOrders(): Observable<Order[]> {
        return this.sendRequest(RequestMethod.Get,
            "orders", null, true);
    }

    deleteOrder(id: number): Observable<Order> {
        return this.sendRequest(RequestMethod.Delete,
            `orders/${id}`, null, true);
    }

    updateOrder(order: Order): Observable<Order> {
        return this.sendRequest(RequestMethod.Put,
            `orders/${order.id}`, order, true);
    }

    saveOrder(order: Order): Observable<Order> {
        return this.sendRequest(RequestMethod.Post,
            "orders", order);
    }

    private sendRequest(verb: RequestMethod,
            url: string, body?: Product | Order, auth: boolean = false)
                : Observable<Product | Product[] | Order | Order[]> {

        let request = new Request({
            method: verb,
            url: this.baseUrl + url,
            body: body
        });
        if (auth && this.auth_token != null) {
            request.headers.set("Authorization", `Bearer<${this.auth_token}>`);
        }
        return this.http.request(request).map(response => response.json());
    }
}
```

Listing 9-15 adds new methods to the product repository class that allow products to be created, updated, or deleted. The saveProduct method is responsible for creating and updating products, which is an approach that works well when using a single object managed by a component, which you will see demonstrated later in this chapter. The listing also changes the type of the constructor argument to RestDataSource.

Listing 9-15. Adding New Operations in the product.repository.ts File

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";
import { RestDataSource } from "./rest.datasource";

@Injectable()
export class ProductRepository {
    private products: Product[] = [];
    private categories: string[] = [];

    constructor(private dataSource: RestDataSource) {
        dataSource.getProducts().subscribe(data => {
            this.products = data;
            this.categories = data.map(p => p.category)
                .filter((c, index, array) => array.indexOf(c) == index).sort();
        });
    }

    getProducts(category: string = null): Product[] {
        return this.products
            .filter(p => category == null || category == p.category);
    }

    getProduct(id: number): Product {
        return this.products.find(p => p.id == id);
    }

    getCategories(): string[] {
        return this.categories;
    }

    saveProduct(product: Product) {
        if (product.id == null || product.id == 0) {
            this.dataSource.saveProduct(product)
                .subscribe(p => this.products.push(p));
        } else {
            this.dataSource.updateProduct(product)
                .subscribe(p => {
                    this.products.splice(this.products.
                        findIndex(p => p.id == product.id), 1, product);
                });
        }
    }

    deleteProduct(id: number) {
        this.dataSource.deleteProduct(id).subscribe(p => {
            this.products.splice(this.products.
                findIndex(p => p.id == id), 1);
        })
    }
}
```

Listing 9-16 makes the corresponding changes to the order repository, adding methods that allow orders to be modified and deleted.

Listing 9-16. Adding New Operations in the order.repository.ts File

```
import { Injectable } from "@angular/core";
import { Observable } from "rxjs/Observable";
import { Order } from "./order.model";
import { RestDataSource } from "./rest.datasource";

@Injectable()
export class OrderRepository {
    private orders: Order[] = [];
    private loaded: boolean = false;

    constructor(private dataSource: RestDataSource) {}

    loadOrders() {
        this.loaded = true;
        this.dataSource.getOrders()
            .subscribe(orders => this.orders = orders);
    }

    getOrders(): Order[] {
        if (!this.loaded) {
            this.loadOrders();
        }
        return this.orders;
    }

    saveOrder(order: Order): Observable<Order> {
        return this.dataSource.saveOrder(order);
    }

    updateOrder(order: Order) {
        this.dataSource.updateOrder(order).subscribe(order => {
            this.orders.splice(this.orders.
                findIndex(o => o.id == order.id), 1, order);
        });
    }

    deleteOrder(id: number) {
        this.dataSource.deleteOrder(id).subscribe(order => {
            this.orders.splice(this.orders.findIndex(o => id == o.id));
        });
    }
}
```

The order repository defines a `loadOrders` method that gets the orders from the repository and that is used to ensure that the request isn't sent to the RESTful web service until authentication has been performed.

Creating the Administration Feature Structure

Now that the authentication system is in place and the repositories provide the full range of operations, I can create the structure that will display the administration features, which I am going to create by building on the existing URL routing configuration. Table 9-2 lists the URLs that I am going to support and the functionality that each will present to the user.

Table 9-2. *The URLs for Administration Features*

Name	Description
`/admin/main/products`	Navigating to this URL will display all the products in a table, along with buttons that allow an existing product to be edited or deleted and a new product to be created.
`/admin/main/products/create`	Navigating to this URL will present the user with an empty editor for creating a new product.
`/admin/main/products/edit/1`	Navigating to this URL will present the user with a populated editor for editing an existing product.
`/admin/main/orders`	Navigating to this URL will present the user with all the orders in a table, along with buttons to mark an order shipped and to cancel an order by deleting it.

Creating the Placeholder Components

I find that the easiest way to add features to an Angular project is to define components that have placeholder content and build the structure of the application around them. Once the structure is in place, then I return to the components and implement the features in detail. For the administration features, I started by adding a file called `productTable.component.ts` to the `SportsStore/app/admin` folder and defined the component shown in Listing 9-17. This component will be responsible for showing a list of products, along with buttons required to edit and delete them or to create a new product.

Listing 9-17. The Contents of the productTable.component.ts File in the SportsStore/app/admin Folder

```
import { Component } from "@angular/core";

@Component({
    template: `<div class="bg-info p-a-1">
                  <h3>Product Table Placeholder</h3>
               </div>`
})
export class ProductTableComponent {}
```

I added a file called `productEditor.component.ts` in the `SportsStore/app/admin` folder and used it to define the component shown in Listing 9-18, which will be used to allow the user to enter the details required to create or edit a component.

Listing 9-18. The Contents of the productEditor.component.ts File in the SportsStore/app/admin Folder

```
import { Component } from "@angular/core";

@Component({
    template: `<div class="bg-warning p-a-1">
                <h3>Product Editor Placeholder</h3>
              </div>`
})
export class ProductEditorComponent { }
```

To create the component that will be responsible for managing customer orders, I added a file called `orderTable.component.ts` to the `SportsStore/app/admin` folder and added the code shown in Listing 9-19.

Listing 9-19. The Contents of the orderTable.component.ts File in the SportsStore/app/admin Folder

```
import { Component } from "@angular/core";

@Component({
    template: `<div class="bg-primary p-a-1">
                <h3>Order Table Placeholder</h3>
              </div>`
})
export class OrderTableComponent { }
```

Preparing the Common Content and the Feature Module

The components created in the previous section will be responsible for specific features. To bring those features together and allow the user to navigate between them, I need to modify the template of the placeholder component that I have been using to demonstrate the result of a successful authentication attempt. I replaced the placeholder content with the elements shown in Listing 9-20.

Listing 9-20. Replacing the Content in the admin.component.html File

```
<div class="navbar navbar-inverse bg-info">
    <a class="navbar-brand">SPORTS STORE Admin</a>
</div>
<div class="m-t-1">
    <div class="col-xs-3">
        <button class="btn btn-outline-info btn-block"
                routerLink="/admin/main/products"
                routerLinkActive="active">
            Products
        </button>
        <button class="btn btn-outline-info btn-block"
                routerLink="/admin/main/orders"
                routerLinkActive="active">
            Orders
        </button>
        <button class="btn btn-outline-danger btn-block" (click)="logout()">
            Logout
        </button>
    </div>
    <div class="col-xs-9">
        <router-outlet></router-outlet>
    </div>
</div>
```

This template contains a `router-outlet` element that will be used to display the components from the previous section. There are also buttons that will navigate the application to the `/admin/main/products` and `/admin/main/orders` URLs, which will select the products or orders features. These buttons use the `routerLinkActive` attribute, which is used to add the element to a CSS class when the route specified by the `routerLink` attribute is active.

The template also contains a `Logout` button that has an event binding that targets a method called `logout`. Listing 9-21 adds this method to the component, which uses the authentication service to remove the bearer token and navigates the application to the default URL.

Listing 9-21. Implementing the Logout Method in the admin.component.ts File

```
import { Component } from "@angular/core";
import { Router } from "@angular/router";
import { AuthService } from "../model/auth.service";

@Component({
    moduleId: module.id,
    templateUrl: "admin.component.html"
})
export class AdminComponent {

    constructor(private auth: AuthService,
                private router: Router) { }

    logout() {
        this.auth.clear();
        this.router.navigateByUrl("/");
    }
}
```

Listing 9-22 enables the placeholder components that will be used for each administration feature and extends the URL routing configuration to implement the URLs from Table 9-2.

Listing 9-22. Configuring the Feature Module in the admin.module.ts File

```
import { NgModule } from "@angular/core";
import { CommonModule } from "@angular/common";
import { FormsModule } from "@angular/forms";
import { RouterModule } from "@angular/router";
import { AuthComponent } from "./auth.component";
import { AdminComponent } from "./admin.component";
import { AuthGuard } from "./auth.guard";
import { ProductTableComponent } from "./productTable.component";
import { ProductEditorComponent } from "./productEditor.component";
import { OrderTableComponent } from "./orderTable.component";
```

```
let routing = RouterModule.forChild([
    { path: "auth", component: AuthComponent },
    {
        path: "main", component: AdminComponent, canActivate: [AuthGuard],
        children: [
            { path: "products/:mode/:id", component: ProductEditorComponent },
            { path: "products/:mode", component: ProductEditorComponent },
            { path: "products", component: ProductTableComponent },
            { path: "orders", component: OrderTableComponent },
            { path: "**", redirectTo: "products" }
        ]
    },
    { path: "**", redirectTo: "auth" }
]);

@NgModule({
    imports: [CommonModule, FormsModule, routing],
    providers: [AuthGuard],
    declarations: [AuthComponent, AdminComponent,
        ProductTableComponent, ProductEditorComponent, OrderTableComponent]
})
export class AdminModule {}
```

Individual routes can be extended using the children property, which is used to define routes that will target a nested router-outlet element, which I describe in Chapter 25. As you will see shortly, components can get details of the active route from Angular so they can adapt their behavior. Routes can include route parameters, such as :mode or :id, that match any URL segment and that can be used to provide information to components that can be used to change their behavior.

When all the changes have been saved, click the Admin button and authenticate as admin with the password secret. You will see the new layout, as shown in Figure 9-4. Clicking the Products and Orders buttons will change the component displayed by the router-outlet element from Listing 9-20, and clicking the Logout button will exit the administration area.

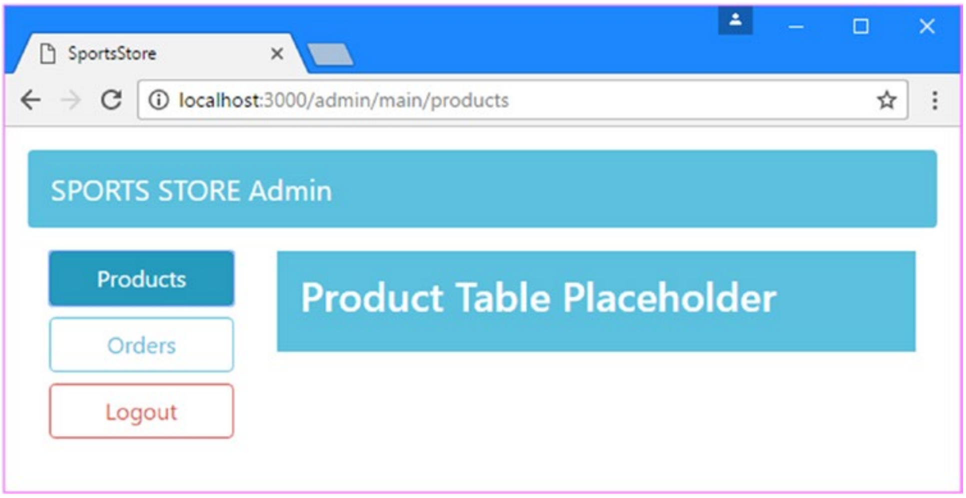


Figure 9-4. *The administration layout structure*

Implementing the Product Feature

The initial administration feature presented to the user will be a list of products, with the ability to create a new product and delete or edit an existing one. Listing 9-23 removes the placeholder content from the product table component and adds the logic required to implement this feature.

Listing 9-23. Replacing the Placeholder Content in the productTable.component.ts File

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { ProductRepository } from "../model/product.repository";

@Component({
    moduleId: module.id,
    templateUrl: "productTable.component.html"
})
export class ProductTableComponent {

    constructor(private repository: ProductRepository) { }

    getProducts(): Product[] {
        return this.repository.getProducts();
    }

    deleteProduct(id: number) {
        this.repository.deleteProduct(id);
    }
}
```

The component methods provide access to the products in the repository and allow products to be deleted. The other operations will be handled by the editor component, which will be activated using routing URLs in the component's template. To provide the template, I added a file called `productTable.component.html` in the `SportsStore/app/admin` folder and added the markup shown in Listing 9-24.

Listing 9-24. The productTable.component.html File in the SportsStore/app/admin Folder

```
<table class="table table-sm table-striped">
    <thead>
        <tr>
            <th>ID</th><th>Name</th><th>Category</th><th>Price</th>
            <th></th>
        </tr>
    </thead>
    <tbody>
        <tr *ngFor="let p of getProducts()">
            <td>{{p.id}}</td>
            <td>{{p.name}}</td>
            <td>{{p.category}}</td>
            <td>{{p.price | currency:"USD":true:"2.2-2"}}</td>
            <td>
                <button class="btn btn-sm btn-warning"
                        [routerLink]="['/admin/main/products/edit', p.id]">
```

```
                    Edit
                </button>
                <button class="btn btn-sm btn-danger" (click)="deleteProduct(p.id)">
                    Delete
                </button>
            </td>
        </tr>
    </tbody>
</table>
<button class="btn btn-primary" routerLink="/admin/main/products/create">
    Create New Product
</button>
```

The template contains a table that uses the `ngFor` directive to generate a row for each product returned by the component's `getProducts` method. Each row contains a Delete button that invokes the component's `delete` method and an `Edit` button that navigates to a URL that targets the editor component. The editor component is also the target of the `Create New Product`, although a different URL is used.

Implementing the Product Editor

Components can receive information about the current routing URL and adapt their behavior accordingly. The editor component needs to use this feature to differentiate between requests to create a new component and edit an existing one. Listing 9-25 adds the functionality to the editor component required to create or edit products.

Listing 9-25. Adding Functionality in the productEditor.component.ts File

```
import { Component } from "@angular/core";
import { Router, ActivatedRoute } from "@angular/router";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { ProductRepository } from "../model/product.repository";

@Component({
    moduleId: module.id,
    templateUrl: "productEditor.component.html"
})
export class ProductEditorComponent {
    editing: boolean = false;
    product: Product = new Product();

    constructor(private repository: ProductRepository,
                private router: Router,
                activeRoute: ActivatedRoute) {

        this.editing = activeRoute.snapshot.params["mode"] == "edit";
        if (this.editing) {
            Object.assign(this.product,
                repository.getProduct(activeRoute.snapshot.params["id"]));
        }
    }
    save(form: NgForm) {
        this.repository.saveProduct(this.product);
        this.router.navigateByUrl("/admin/main/products");
    }
}
```

Angular will provide an `ActivatedRoute` object as a constructor argument when it creates a new instance of the component class and that can be used to inspect the activated route. In this case, the component works out whether it should be editing or creating a product and, if editing, retrieves the current details from the repository. There is also a `save` method, which uses the repository to save changes that the user has made.

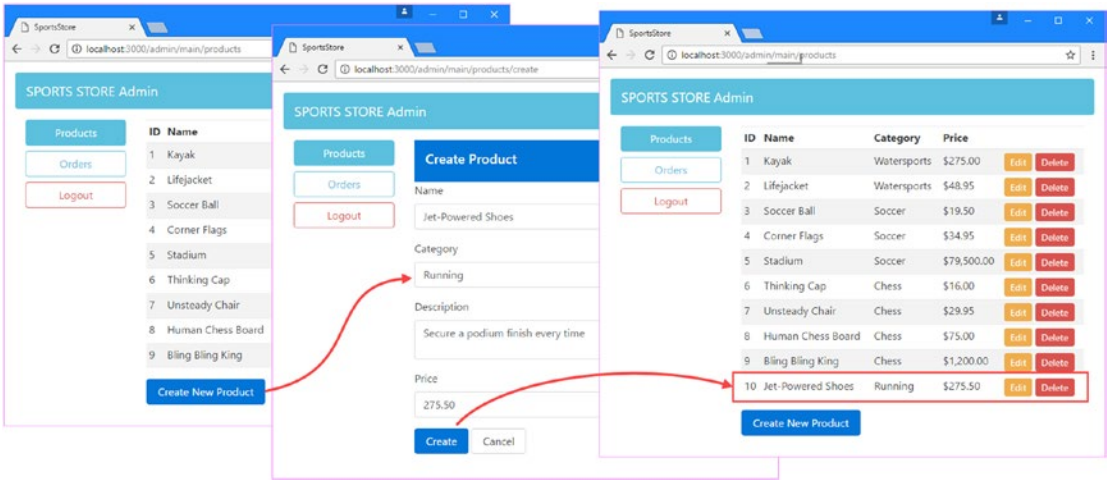
To provide the component with a template, I added a file called `productEditor.component.html` in the `SportsStore/app/admin` folder and added the markup shown in Listing 9-26.

Listing 9-26. The productEditor.component.html File in the SportsStore/app/admin Folder

```
<div class="bg-primary p-a-1" [class.bg-warning]="editing">
    <h5>{{editing  ? "Edit" : "Create"}} Product</h5>
</div>
<form novalidate #form="ngForm" (ngSubmit)="save(form)" >
    <div class="form-group">
        <label>Name</label>
        <input class="form-control" name="name" [(ngModel)]="product.name" />
    </div>
    <div class="form-group">
        <label>Category</label>
        <input class="form-control" name="category" [(ngModel)]="product.category" />
    </div>
    <div class="form-group">
        <label>Description</label>
        <textarea class="form-control" name="description"
                  [(ngModel)]="product.description">
        </textarea>
    </div>
    <div class="form-group">
        <label>Price</label>
        <input class="form-control" name="price" [(ngModel)]="product.price" />
    </div>
    <button type="submit" class="btn btn-primary" [class.btn-warning]="editing">
        {{editing ? "Save" : "Create"}}
    </button>
    <button type="reset" class="btn btn-secondary" routerLink="/admin/main/products">
        Cancel
    </button>
</form>
```

The template contains a form with fields for the properties defined by the `Product` model class, with the exception of the `id` property, which is assigned automatically by the RESTful web service.

The elements in the form adapt their appearance to differentiate between the editing and creating features. To see how the component works, authenticate to access the Admin features and click the Create New Product button that appears under the table of products. Fill out the form, click the Create button, and the new product will be sent to the RESTful web service where it will be assigned an ID property and displayed in the product table, as shown in Figure 9-5.



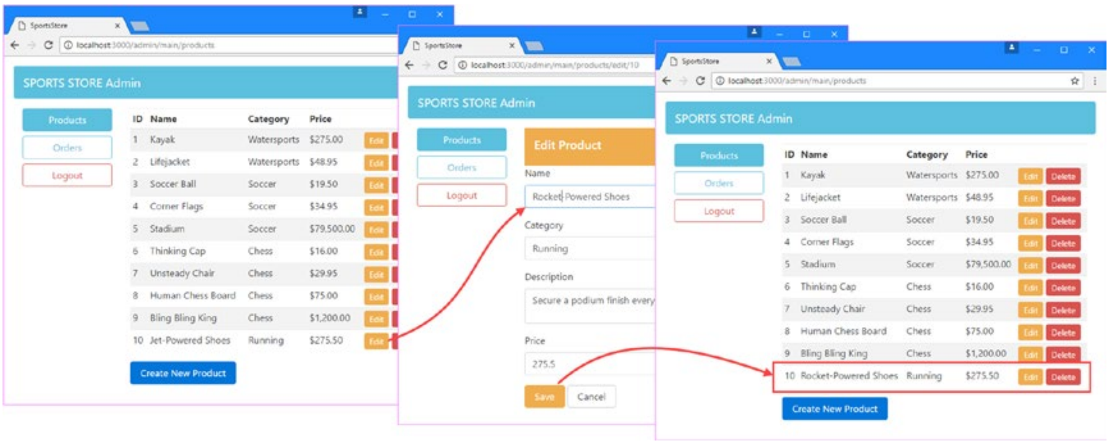
ID	Name
1	Kayak
2	Lifejacket
3	Soccer Ball
4	Corner Flags
5	Stadium
6	Thinking Cap
7	Unsteady Chair
8	Human Chess Board
9	Bling Bling King

Name: Jet-Powered Shoes
Category: Running
Description: Secure a podium finish every time
Price: 275.50

ID	Name	Category	Price		
1	Kayak	Watersports	$275.00	Edit	Delete
2	Lifejacket	Watersports	$48.95	Edit	Delete
3	Soccer Ball	Soccer	$19.50	Edit	Delete
4	Corner Flags	Soccer	$34.95	Edit	Delete
5	Stadium	Soccer	$79,500.00	Edit	Delete
6	Thinking Cap	Chess	$16.00	Edit	Delete
7	Unsteady Chair	Chess	$29.95	Edit	Delete
8	Human Chess Board	Chess	$75.00	Edit	Delete
9	Bling Bling King	Chess	$1,200.00	Edit	Delete
10	Jet-Powered Shoes	Running	$275.50	Edit	Delete

Figure 9-5. *Creating a new product*

The editing process works in a similar way. Click one of the Edit buttons to see the current details, edit them using the form fields, and click the Save button to save the changes, as shown in Figure 9-6.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Edit
2	Lifejacket	Watersports	$48.95	Edit
3	Soccer Ball	Soccer	$19.50	Edit
4	Corner Flags	Soccer	$34.95	Edit
5	Stadium	Soccer	$79,500.00	Edit
6	Thinking Cap	Chess	$16.00	Edit
7	Unsteady Chair	Chess	$29.95	Edit
8	Human Chess Board	Chess	$75.00	Edit
9	Bling Bling King	Chess	$1,200.00	Edit
10	Jet-Powered Shoes	Running	$275.50	Edit

Name: Rocket-Powered Shoes
Category: Running
Description: Secure a podium finish every
Price: 275.5

ID	Name	Category	Price		
1	Kayak	Watersports	$275.00	Edit	Delete
2	Lifejacket	Watersports	$48.95	Edit	Delete
3	Soccer Ball	Soccer	$19.50	Edit	Delete
4	Corner Flags	Soccer	$34.95	Edit	Delete
5	Stadium	Soccer	$79,500.00	Edit	Delete
6	Thinking Cap	Chess	$16.00	Edit	Delete
7	Unsteady Chair	Chess	$29.95	Edit	Delete
8	Human Chess Board	Chess	$75.00	Edit	Delete
9	Bling Bling King	Chess	$1,200.00	Edit	Delete
10	Rocket-Powered Shoes	Running	$275.50	Edit	Delete

Figure 9-6. *Editing an existing product*

Implementing the Orders Feature

The order management feature is nice and simple. It requires a table that lists the set of orders, along with buttons that will set the shipped property to `true` or delete an order entirely. Listing 9-27 replaces the placeholder content in the component with the logic required to support these operations.

Listing 9-27. Adding Operations in the orderTable.component.ts File

```
import { Component } from "@angular/core";
import { Order } from "../model/order.model";
import { OrderRepository } from "../model/order.repository";
```

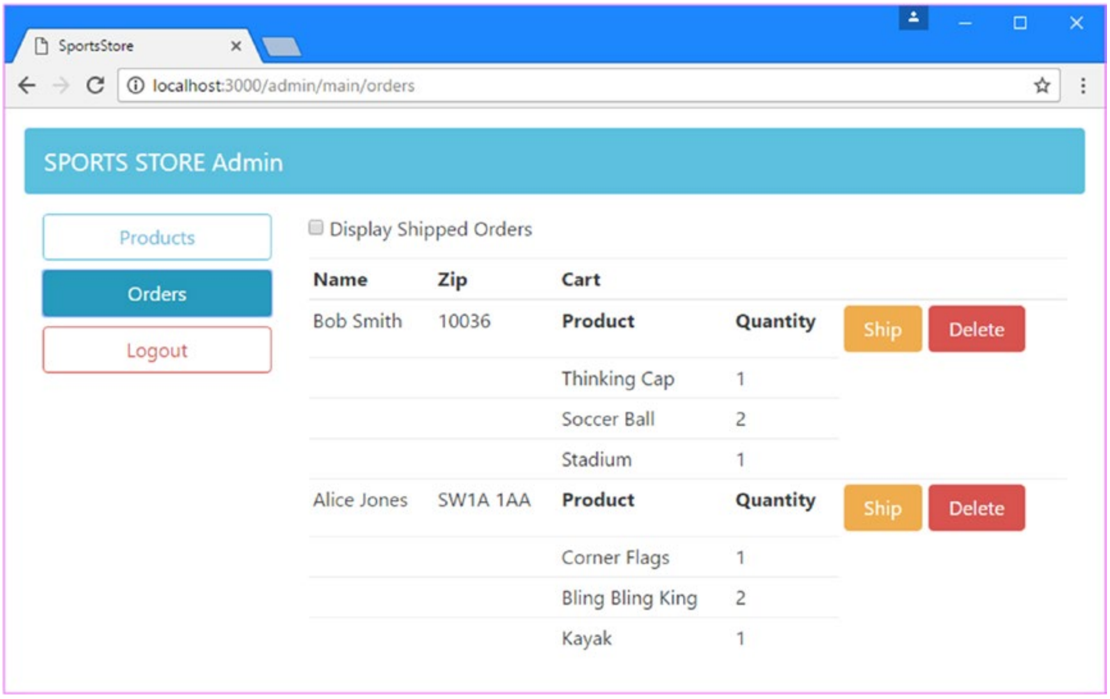
```
@Component({
    moduleId: module.id,
    templateUrl: "orderTable.component.html"
})
export class OrderTableComponent {
    includeShipped = false;

    constructor(private repository: OrderRepository) {}

    getOrders(): Order[] {
        return this.repository.getOrders()
            .filter(o => this.includeShipped || !o.shipped);
    }

    markShipped(order: Order) {
        order.shipped = true;
        this.repository.updateOrder(order);
    }

    delete(id: number) {
        this.repository.deleteOrder(id);
    }
}
```

In addition to providing methods for marking orders as shipped and deleting orders, the component defines a `getOrders` method that allows shipped orders to be included or excluded based on the value of a property called `includeShipped`. This property is used in the template, which I created by adding a file called `orderTable.component.html` to the `SportsStore/app/admin` folder with the markup shown in Listing 9-28.

Listing 9-28. The Contents of the orderTable.component.html in the SportsStore/app/admin Folder

```
<div class="form-check">
    <label class="form-check-label">
    <input type="checkbox" class="form-check-input" [(ngModel)]="includeShipped"/>
        Display Shipped Orders
    </label>
</div>
<table class="table table-sm">
    <thead>
        <tr><th>Name</th><th>Zip</th><th colspan="2">Cart</th><th></th></tr>
    </thead>
    <tbody>
        <tr *ngIf="getOrders().length == 0">
            <td colspan="5">There are no orders</td>
        </tr>
        <template ngFor let-o [ngForOf]="getOrders()">
            <tr>
                <td>{{o.name}}</td><td>{{o.zip}}</td>
                <th>Product</th><th>Quantity</th>
                <td>
                    <button class="btn btn-warning" (click)="markShipped(o)">
                        Ship
                    </button>
                    <button class="btn btn-danger" (click)="delete(o.id)">
                        Delete
                    </button>
                </td>
            </tr>
            <tr *ngFor="let line of o.cart.lines">
                <td colspan="2"></td>
                <td>{{line.product.name}}</td>
                <td>{{line.quantity}}</td>
            </tr>
        </template>
    </tbody>
</table>
```

Remember that the data presented by the RESTful web service is reset each time the process is started, which means you will have to use the shopping cart and checkout to create orders. Once that's done, you can inspect and manage them using the Orders section of the administration tool, as shown in Figure 9-7.



Name	Zip	Cart	
Bob Smith	10036	**Product**	**Quantity**
		Thinking Cap	1
		Soccer Ball	2
		Stadium	1
Alice Jones	SW1A 1AA	**Product**	**Quantity**
		Corner Flags	1
		Bling Bling King	2
		Kayak	1

Figure 9-7. *Managing orders*

Summary

In this chapter, I created a dynamically loaded Angular feature module that contains the administration tools required to manage the catalog of products and process orders. In the next chapter, I prepare the SportsStore application for deployment into production.

CHAPTER 10

SportsStore: Deployment

In this chapter, I prepare the SportsStore application for deployment by incorporating all of the application content and the Angular framework into a single file and "containerizing" the application using Docker.

Stopping the TypeScript Compiler

For this chapter, it is important that you stop the TypeScript compiler, which is started with the `npm start` command. The TypeScript compiler conflicts with the special compiler that is used to prepare Angular applications for deployment.

Working Around a Compiler Bug

The process that I follow to prepare SportsStore for deployment packages all of the resources required by the application into a single file. This process relies on a special compiler provided by the Angular team that has, at least at the time of writing, a problem dealing with dynamically loaded modules.

This is a problem that I expect to be fixed in later releases of Angular, but at the time of writing, the only options are to remove the administration module from the application or to change the module so that it isn't loaded dynamically. I want to deploy all of the SportsStore functionality, so I am going to include the administration module in the deployed application, even though it is the kind of functionality that won't be required by most users.

Note I expect this problem to be a temporary one, and later versions of Angular should allow dynamically loaded modules to be deployed in the same way that I deploy the application in this chapter.

In Listing 10-1, I have updated the application's root module so that it imports the administration modules and includes the administration routes.

Listing 10-1. Integrating the Administration Module in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { AppComponent } from "./app.component";
import { StoreModule } from "./store/store.module";
import { StoreComponent } from "./store/store.component";
import { CheckoutComponent } from "./store/checkout.component";
```

A. Freeman, *Pro Angular*, DOI 10.1007/978-1-4842-2307-9_10

```
import { CartDetailComponent } from "./store/cartDetail.component";
import { RouterModule } from "@angular/router";
import { StoreFirstGuard } from "./storeFirst.guard";
import { AdminModule } from "./admin/admin.module";
import { AuthComponent } from "./admin/auth.component";
import { AdminComponent } from "./admin/admin.component";
import { AuthGuard } from "./admin/auth.guard";
import { ProductTableComponent } from "./admin/productTable.component";
import { ProductEditorComponent } from "./admin/productEditor.component";
import { OrderTableComponent } from "./admin/orderTable.component";

@NgModule({
    imports: [BrowserModule, StoreModule, AdminModule,
        RouterModule.forRoot([
            {
                path: "store", component: StoreComponent,
                canActivate: [StoreFirstGuard]
            },
            {
                path: "cart", component: CartDetailComponent,
                canActivate: [StoreFirstGuard]
            },
            {
                path: "checkout", component: CheckoutComponent,
                canActivate: [StoreFirstGuard]
            },
            {
                path: "admin",
                children: [
                    { path: "auth", component: AuthComponent },
                    {
                        path: "main", component: AdminComponent,
                            canActivate: [AuthGuard],
                        children: [
                            { path: "products/:mode/:id",
                                  component: ProductEditorComponent },
                            { path: "products/:mode",
                                  component: ProductEditorComponent },
                            { path: "products", component: ProductTableComponent },
                            { path: "orders", component: OrderTableComponent },
                            { path: "**", redirectTo: "products" }
                        ]
                    },
                    { path: "**", redirectTo: "auth" }
                ],
                //loadChildren: "app/admin/admin.module#AdminModule",
                canActivate: [StoreFirstGuard]
            },
            { path: "**", redirectTo: "/store" }
        ])],
    providers: [StoreFirstGuard],
    declarations: [AppComponent],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

Listing 10-2 shows the corresponding changes to the administration feature module.

Listing 10-2. Removing Routes from the admin.module.ts File

```
import { NgModule } from "@angular/core";
import { CommonModule } from "@angular/common";
import { FormsModule } from "@angular/forms";
import { RouterModule } from "@angular/router";
import { AuthComponent } from "./auth.component";
import { AdminComponent } from "./admin.component";
import { AuthGuard } from "./auth.guard";
import { ProductTableComponent } from "./productTable.component";
import { ProductEditorComponent } from "./productEditor.component";
import { OrderTableComponent } from "./orderTable.component";

//let routing = RouterModule.forChild([
//    { path: "auth", component: AuthComponent },
//    {
//        path: "main", component: AdminComponent, canActivate: [AuthGuard],
//        children: [
//            { path: "products/:mode/:id", component: ProductEditorComponent },
//            { path: "products/:mode", component: ProductEditorComponent },
//            { path: "products", component: ProductTableComponent },
//            { path: "orders", component: OrderTableComponent },
//            { path: "**", redirectTo: "products" }
//        ]
//    },
//    { path: "**", redirectTo: "auth" }
//]);

@NgModule({
    imports: [CommonModule, FormsModule, RouterModule],
    providers: [AuthGuard],
    declarations: [AuthComponent, AdminComponent,
        ProductTableComponent, ProductEditorComponent, OrderTableComponent]
})
export class AdminModule { }
```

Using the Ahead-of-Time Compiler

The first step to prepare the application is to use the Ahead-of-Time (AoT) compiler. At the moment, the SportsStore project relies on the Angular Just-In-Time compiler, which is loaded by the browser as part of the Angular modules and is used to compile the building blocks of the application, such as components and directives. This compilation step is in addition to the process of converting TypeScript to JavaScript and is required to create factory classes that combine the application's code and its templates and CSS stylesheets.

The AoT compiler creates the factory classes so that the browser doesn't have to perform this step, which can reduce the amount of time it takes for a browser to display the application.

Installing and Configuring the AoT Compiler

The AoT compiler is provided in an NPM package. In Listing 10-3, I added the package to the `devDependencies` section of the `package.json` file.

Listing 10-3. Configuring the Application in the package.json File

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/forms": "2.2.0",
    "@angular/http": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/router": "3.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4",
    "font-awesome": "4.7.0",
    "intl": "1.2.5",
    "html5-history-api": "4.2.7"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.2",
    "typings": "1.3.2",
    "concurrently": "2.2.0",
    "systemjs-builder": "0.15.32",
    "json-server": "0.8.21",
    "jsonwebtoken": "7.1.9",
    "@angular/compiler-cli": "2.2.0",
    "rollup": "0.36.3",
    "rollup-plugin-node-resolve": "2.0.0",
    "rollup-plugin-commonjs": "5.0.5",
    "rollup-plugin-uglify": "1.0.1",
    "rollup-plugin-alias": "1.2.0"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" \"npm run json\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "json": "json-server data.js -p 3500 -m authMiddleware.js",
    "typings": "typings",
    "postinstall": "typings install",
    "ngc": "ngc -p tsconfig-aot.json",
    "roll": "rollup -c rollup-config.js",
    "startbundle": "concurrently \"npm run lite\" \"npm run json\" "
  }
}
```

One of the additions in the devDependencies section is the `@angular/compiler-cli` package, which installs the ngc tool that does the AoT compilation. The `scripts` section defines an ngc entry that will be used to run the compiler and that specifies a configuration file with the compiler settings.

The AoT compiler requires its own configuration file, separate from the one used for regular TypeScript compilation. I created a file called `tsconfig-aot.json` in the SportsStore folder and added the configuration properties shown in Listing 10-4. The name of the file corresponds to the ngc entry in the scripts section of `package.json`.

■ **Tip** The AoT compiler is a wrapper around the standard TypeScript compiler and supports the same configuration options.

Listing 10-4. The Contents of the tsconfig-aot.json File in the SportsStore Folder

```
{
  "compilerOptions": {
    "target": "es5",
    "module": "es2015",
    "moduleResolution": "node",
    "emitDecoratorMetadata": true,
    "experimentalDecorators": true
  },
  "files": [
    "app/app.module.ts",
    "app/main.ts"
  ],
  "angularCompilerOptions": {
    "genDir": "aot",
    "skipMetadataEmit": true
  }
}
```

The listing highlights the differences from the original `tsconfig.json` file that I created in Chapter 7. While most of the configuration settings are the same, the value of the `module` property has been changed to `es2015`, which will allow me to use a package recommended by Google to prepare the application for its final deployment, as described in the “Shaking the Tree” section.

Run the following command in the SportsStore folder to download and install the AoT compiler package:

```
npm install
```

Configuring the Application Bootstrap

The SportsStore bootstrap file must be changed so that it no longer uses the dynamic compiler. In Listing 10-5, I have commented out the statement that has been responsible for starting the application during development and replaced it with one that will use the files generated by the AoT compiler.

Listing 10-5. Configuring the Application Startup in the main.ts File

```
///<reference path="../typings/globals/core-js/index.d.ts"/>
///<reference path="../typings/globals/node/index.d.ts"/>

//import { platformBrowserDynamic } from "@angular/platform-browser-dynamic";
//import { AppModule } from "./app.module";
import { platformBrowser } from "@angular/platform-browser";
import { enableProdMode } from "@angular/core";
import { AppModuleNgFactory } from "../aot/app/app.module.ngfactory";

enableProdMode();

//platformBrowserDynamic().bootstrapModule(AppModule);
platformBrowser().bootstrapModuleFactory(AppModuleNgFactory);
```

The first two statements add references to the TypeScript type information that was downloaded and installed when the SportsStore project was created in Chapter 7 and that prevent the AoT compiler from reporting type annotation errors.

The `platformBrowser` method replaces `platformBrowserDynamic` when starting the application, and its `bootstrapModuleFactory` is passed the `AppModuleNgFactory` class, which has been generated by the `npm` compiler in the `aot/app` folder. Using the `bootstrapModuleFactory` method tells Angular that it is dealing with compiled files.

The listing also calls the `enableProdMode` function, which is used to disable the development mode and disable some checks that Angular performs to make sure that there are no side effects in data bindings (as described in Chapter 13).

Compiling the Application

The next step is to compile the application using the AoT compiler. Run the following command in the `SportsStore` folder:

```
npm run ngc
```

The compiler can take a while to run. When it has finished, there will be a `SportsStore/aot` folder that contains the compiled files. For each module, component, and directive in the `app` folder, there will be corresponding files in the `aot` folder, with names that include `factory` and that contain any template content compiled into the JavaScript code.

Don't edit any of the files in the aot folder because changes are lost the next time you run the ngc compiler and a new set of AoT files are generated.

■ **Tip** You may see warning messages about inaccessible properties and methods. This is caused by templates that rely on component properties and methods to which the `private` keyword has been applied. This doesn't cause a problem during development because the browser processes the template using the JavaScript files, which have no concept of access controls, but it causes problems when using the AoT compiler because the template is processed using TypeScript. To correct the problem, remove the `private` keyword or replace it with `public` (which has the same effect).

Shaking the Tree

The phrase *shaking the tree* refers to the process of inspecting all the dependencies in an application in order to ensure that only the files that are required to run the application are sent to the browser. In this section, I use a package called `rollup`, which is well-suited to working with Angular applications. (There are plenty of alternatives if you don't like rollup, including the popular `webpack`.)

The result of this process will be a single file that contains all the code required to run the application, including the parts of the Angular and RxJS packages that the application depends on. To configure the process of creating the file, known as the *bundle*, I added a file called `rollup-config.js` to the `SportsStore` folder and added the configuration settings shown in Listing 10-6.

Listing 10-6. The Contents of the rollup-config.js File in the SportsStore Folder

```
import rollup      from "rollup";
import nodeResolve from "rollup-plugin-node-resolve";
import commonjs    from "rollup-plugin-commonjs";
import uglify      from "rollup-plugin-uglify";
import alias from 'rollup-plugin-alias';

export default {
    entry: "app/main.js",
    dest: "sportsstore.min.js",
    sourceMap: false,
    format: "umd",
    plugins: [
    nodeResolve({jsnext: true, module: true}),
    commonjs({
        include: "node_modules/rxjs/**",
    }),
    uglify()]
}
```

To shake the tree and generate the bundle, run the following command in the SportsStore folder:

```
npm run roll
```

You will see a lot of warnings about the `this` keyword, which can be ignored. When the rollup process has completed, there will be a file called `sportsstore.min.js` in the SportsStore folder, which contains all of the code required by the SportsStore application.

Testing the Application

Now that the application has been bundled into a single file, some changes are required to the `index.html` file, as shown in Listing 10-7.

Listing 10-7. Using a Single Application Bundle in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <base href="/" />
    <title>SportsStore</title>
    <meta charset="utf-8" />
    <script src="node_modules/html5-history-api/history.min.js"></script>
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/intl/dist/Intl.complete.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script>window.module = "";</script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
    <link href="node_modules/font-awesome/css/font-awesome.min.css"
          rel="stylesheet"/>
</head>
<body class="m-a-1">
    <app>SportsStore Will Go Here</app>
    <script src="sportsstore.min.js"></script>
</body>
</html>
```

This listing removes the `script` elements for the `reflect-metadata` and `SystemJS` packages, which are not required when using a single application bundle. The bundle file is loaded using a `script` element that must appear after the element in which the application will be displayed, which is the `app` element for the SportsStore application and is the reason that the `script` element for the `sportsstore.min.js` file appears at the end of the body section of the HTML document.

The final change is a fragment of JavaScript code that defines a global `module` property and assigns it the value `aot`. This is a workaround to support relative paths for templates and CSS files when using the `@Component` directive. It doesn't matter what value is assigned to `window.module`, just as long as it is defined.

To test the application, run the following command from the SportsStore folder:

```
npm run startbundle
```

I added the `startbundle` command to the `package.json` file in Listing 10-3, and it starts the RESTful web server and the development HTTP server. It does not start the TypeScript compiler, which is no longer required since changes to the TypeScript files have no impact on the content of the application bundle.

A new browser window or tab will open, and the SportsStore application will load. If you use the browser's F12 development tools, you will see that most of the individual HTTP requests for JavaScript files have been replaced by a single request for the `sportsstore.min.js` file.

Containerizing the SportsStore Application

To complete this chapter, I am going to create a container for the SportsStore application that replaces the development tools I have been using in previous chapters and shows the transition from development to deployment. In the sections that follow, I will create a Docker container. At the time of writing, Docker is the most popular way to create containers, which is a pared-down version of Linux with just enough functionality to run the application. Most cloud platforms or hosting engines have support for Docker, and its tools run on the most popular operating systems.

Installing Docker

The first step is to download and install the Docker tools on your development machine, which is available from `www.docker.com/products/docker`. There are versions for macOS, Windows, and Linux, and there are some specialized versions to work with the Amazon and Microsoft cloud platforms.

■ **Caution** One drawback of using Docker is that the company that produces the software has gained a reputation for making breaking changes. This may mean that the example that follows may not work as intended with later versions. The version I used for the examples in this chapter is 1.12.3. If you have problems, check the repository for this book for updates (details are on the `apress.com` page for this book) or contact me at `adam@adam-freeman.com`.

Preparing the Application

The first step is to create a staging directory that will contain the files required to configure and run the application. I created a folder called `deploy` within the `SportsStore` folder and added a `package.json` file with the content shown in Listing 10-8.

Listing 10-8. The Contents of the package.json File in the SportsStore/deploy Folder

```
{
  "dependencies": {
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "bootstrap": "4.0.0-alpha.4",
    "font-awesome": "4.7.0",
    "intl": "1.2.5",
    "html5-history-api": "4.2.7"
  },

  "devDependencies": {
    "express": "4.14.0",
    "concurrently": "2.2.0",
    "json-server": "0.8.21",
    "jsonwebtoken": "7.1.9"
  },

  "scripts": {
    "start": "concurrently \"npm run express\" \"npm run json\" ",
    "express": "node server.js",
    "json": "json-server data.js -m authMiddleware.js -p 3500"
  }
}
```

The dependencies section omits the Angular and RxJS libraries, which have been included in the bundle file. The remaining packages are polyfills to support older browsers and the Bootstrap and Font Awesome packages used to style content.

The devDependencies and scripts sections include a different set of tools from the ones used in development, as described in the sections that follow.

Configuring the HTTP Server

One of the packages in Listing 10-8 is express, which is the package that the development HTTP server and the RESTful web server packages rely on. I don't want BrowserSync to add JavaScript code to every response when the application is in production, so I am using express directly in this part of the chapter.

■ **Note** The express package is an excellent server (and provides many more features than I am using here), but there are plenty of other choices, and any web server will do. I chose express because it is so similar to the development tools used in earlier chapters and because it is easy to use in a Docker container.

To configure express to run the application, I created a file called server.js in the SportsStore/deploy folder and added the code shown in Listing 10-9.

Listing 10-9. The Contents of the server.js File in the SportsStore/deploy Folder

```
var express = require("express");

var app = express();

app.use("/node_modules",
    express.static("/usr/src/sportsstore/node_modules"));
app.use("/", express.static("/usr/src/sportsstore/app"));

app.listen(3000, function () {
    console.log("HTTP Server running on port 3000");
});
```

The name of the file corresponds to the express command in the scripts section of the package.json file in Listing 10-8. The code creates an HTTP server on port 3000, serving the files in a folder called app, as well as the node_modules folder.

Creating the Container

To create the container, I added a file called `Dockerfile` (with no extension) to the `SportsStore/deploy` folder and added the comments shown in Listing 10-10.

Listing 10-10. The Contents of the Dockerfile File in the SportsStore/deploy Folder

```
FROM node:6.9.1

RUN mkdir -p /usr/src/sportsstore/app
WORKDIR /usr/src/sportsstore

COPY sportsstore.min.js /usr/src/sportsstore/app/
COPY index.html /usr/src/sportsstore/app/
COPY authMiddleware.js /usr/src/sportsstore/
COPY data.js /usr/src/sportsstore/
COPY deploy/server.js /usr/src/sportsstore/

COPY deploy/package.json /usr/src/sportsstore/
RUN npm install

EXPOSE 3000
EXPOSE 3500

CMD ["npm", "start"]
```

The contents of the Dockerfile use a base image that has been configured with Node.js and copies the files required to run the application, including the bundle file containing the application and the `package.json` file that will be used to install the packages required to run the application in deployment.

To build the Docker container, run the following command in the `SportsStore` folder (and not the `deploy` folder):

```
docker build -t sportsstore . -f .\deploy\Dockerfile
```

Docker will download and install the packages required for the container, which can take a while.

Running the Application

Once the container has been created, start it using the following command:

```
docker run -p 3000:3000 -p3500:3500 sportsstore
```

You can test the application by opening `http://localhost:3000` in the browser, which will display the response provided by the web server running in the container, as shown in Figure 10-1.

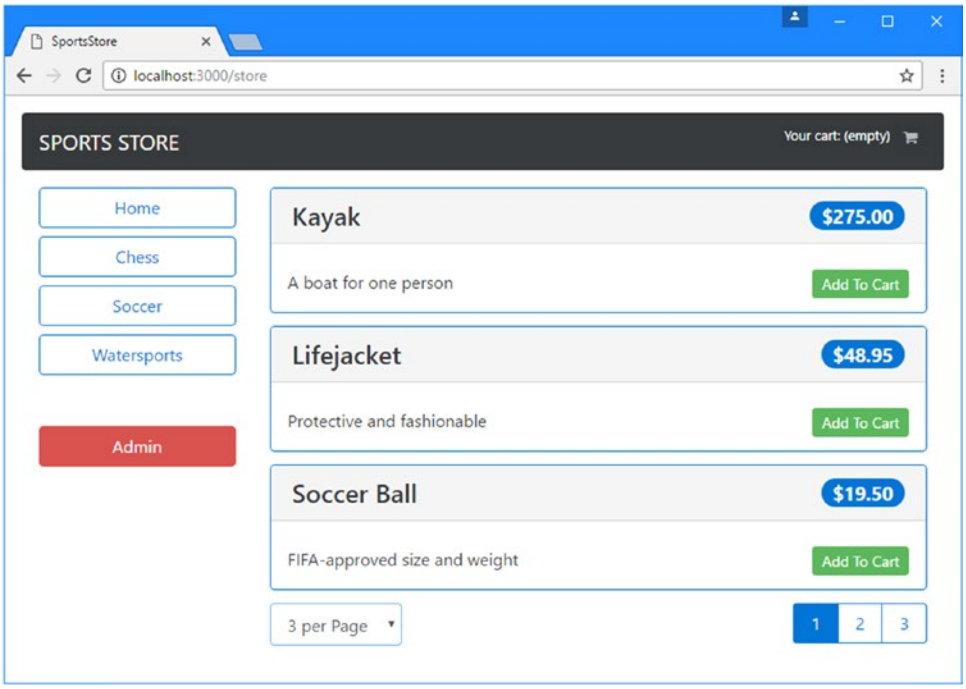


Figure 10-1. *Running the containerized SportsStore application*

To stop the container, run the following command:

```
docker ps
```

You will see a list of running containers, like this (I have omitted some fields for brevity):

```
CONTAINER ID        IMAGE               COMMAND             CREATED
ecc84f7245d6        sportsstore         "npm start"         33 seconds ago
```

Using the container ID, run the following command:

```
docker stop ecc84f7245d6
```

Summary

This chapter completes the SportsStore application, showing how an Angular application can be prepared for deployment and how easy it is to put an Angular application into a container such as Docker.

That's the end of this part of the book. In Part 2, I begin the process of digging into the details and show you how the features I used to create the SportsStore application work in depth.

CHAPTER 11

Creating an Angular Project

In this chapter, I explain the process of starting a new Angular project and creating an application in detail. I explain the purpose of every software package, every configuration file, and every code file that is created. The result is a simple Angular application that, admittedly, does little. However, by the end of the chapter, you will understand how the parts of a project fit together and have a foundation on which to apply the more advanced features that are described in the chapters that follow. Table 11-1 summarizes the chapter.

Table 11-1. *Chapter Summary*

Problem	Solution	Listing
Prepare an HTML document for an Angular application	Add a custom element, conventionally called `app`	1
Add the packages required by the application and the development process	Create a `package.json` file and use the `npm install` command	2, 3
Provide the TypeScript compiler with type annotations	Use the `typings` command to download and install the type data	4
Configure the TypeScript compiler	Create a filed called `tsconfig.json`	5–7
Ensure that the browser reloads the HTML document when there is a change to the project	Use a package such as `lite-server` as the development HTTP server	8, 9
Create a simple Angular application	Create a data model, a root component, a root module and a bootstrap file	10–16
Ensure that the module dependencies in the application can be resolved	Configure the JavaScript module loader	17, 18

Preparing a TypeScript Angular Development Project

Beginning a new Angular project starts with setting up the development process. In previous chapters, I just told you to add files with specific content, but in this chapter, I am going to walk through the process step-by-step and explain what is required in detail.

Before you start, you need to have selected a code editor, installed a recent browser, and have a recent version of Node.js installed. See Chapter 2 for setup instructions if you have not yet performed these tasks.

■ **Tip** You don't have to follow every step in this chapter just to create the example project. The free source code download that accompanies this book at `apress.com` contains a complete project for every chapter and includes the project that I create in this chapter.

Creating the Project Folder Structure

The simplest structure for an Angular project consists of two folders. The top-level folder contains all the project files, as well as an `app` folder that contains the Angular code files. For this chapter, I created a folder called `example` as the top-level folder and created the `app` folder within it. For quick reference, these folders are described in Table 11-2.

Table 11-2. *The Folders Required for the Example Project*

Name	Description
`example`	This is the root folder, and it contains all the project files, including static content (such as HTML files and images) and the configuration files that are described later in this chapter.
`example/app`	This folder contains the Angular code files.

Creating and Serving the HTML Document

Angular relies on an HTML document that provides the browser with the JavaScript files needed to load and start the application. When you begin a new Angular project, one of the first steps is to create the HTML file and set up a mechanism for delivering it to the browser, which means installing a web server.

The default name for the HTML document is `index.html`, and it is created in the root folder of the project. I created the HTML file and added the content shown in Listing 11-1.

Listing 11-1. The Contents of the index.html File in the example Folder

```
<!DOCTYPE html>
<html>
<head>
    <title>Angular</title>
    <meta charset="utf-8" />
</head>
<body>
    <app>This is static content</app>
</body>
</html>
```

Once all the application building blocks and development tools are in place, the `app` element will be used to display dynamic content. But, for the moment, there is only a static placeholder.

Preparing the Project Configuration

Angular projects rely on a number of software packages, and the easiest way to download and install them is to use the Node Package Manager (NPM) , which is described in Chapter 2. In preparation for the packages that I add later in the chapter, I created a file called `package.json` in the `example` folder and added the content shown in Listing 11-2.

Listing 11-2. The Contents of the package.json File in the example Folder

```
{
  "dependencies": {
  },

  "devDependencies": {
  },

  "scripts": {
  }
}
```

The name `package.json` is used by NPM for its configuration file. There are three sections to the file shown in Listing 11-2, which will be populated as the project is set up and configured. Each of the sections is described in Table 11-3.

Table 11-3. *The Sections in the package.json File*

Name	Description
`dependencies`	This section is used to specify the packages that the application relies on, including Angular itself.
`devDependencies`	This section is used to specify the packages that are used in development, such compilers and test frameworks.
`scripts`	This section is used to define commands that are used to compile, test, or run the application.

Adding Packages

The next step is to add the packages that are required to support development and run the application, as shown in Listing 11-3. The name of each package is specified, along with the version that is required.

■ **Caution** It is important that you use the exact version numbers shown in the listing (and throughout the book) in order to get the right results from the examples. Even if you are using later releases for your own projects, you should still use the packages specified in Listing 11-3 for the book examples.

Listing 11-3. Adding Packages to the package.json File

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4"
  },

  "devDependencies": {
      "lite-server": "2.2.2",
      "typescript": "2.0.2",
      "typings": "1.3.2",
      "concurrently": "2.2.0"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

The individual packages are described in the following sections, but they provide the core functionality required to get started in an Angular development project. Once you have edited the `package.json` file, run the following command in the `example` folder:

```
npm install
```

NPM will download the packages specified in Listing 11-3 and install them in a folder called `node_modules`. This process can take a while because each of the packages depends on other packages, many of which have their own dependencies. When the process is finished, NPM will display a list of the packages that have been installed. You will see some error messages and warnings during the installation process, in part because NPM is a verbose tool and in part because the configuration in Listing 11-3 relies on some features that I set up later in this chapter. As long as you see the lengthy list of installed packages, you will be fine.

WHY USE NPM

I use NPM because it is the standard mechanism for managing JavaScript packages. The world of JavaScript development has fragmented into an incredible number of small and focused packages that are woven together to create rich and fluid functionality. Manually downloading the packages required for a project means working through a long list of dependencies, each of which has to be downloaded, installed, and inspected for its own dependencies. Even a simple configuration like the one in Listing 11-3 results in a dependency graph of more than 400 packages. Managing the packages by hand is a difficult process and makes NPM a worthwhile tool.

The main problem with NPM is that it exposes your project to a large set of dependencies. Dependencies between packages can be specified loosely, allowing NPM some flexibility in the version it selects. This can cause problems when package creators publish updated packages that contain bugs. When you update your installed packages or move a project to a new machine, you receive a slightly different set of packages, which can break your application. This happened to me while writing this book—what appeared to be a sudden break in one of the example applications was really caused by an update to a package buried deep in the dependency tree. Package developers fix these problems pretty quickly, but it can still disrupt the development process (and be difficult to figure out).

If you have problems with the examples, try using the projects in the free `apress.com` source code download that accompanies this book. I have used the `npm shrinkwrap` command to generate a file that lists all the versions of the packages that I used to write this book, which means you should get the same versions when you download the projects and run the `npm install` command.

Understanding the Dependencies Packages

The entries in the `dependencies` section in Listing 11-3 add Angular to the project, along with the packages it depends on and some additional packages that are useful in most web applications, as described in Table 11-4.

■ **Tip** Some of the packages used in this book are in a pre-release state. In most cases, such as the `rxjs` package, this is because the pre-release version is specified by the Angular team and has been used for their pre-release testing. The exception is the `bootstrap` package, which I have selected to style the content in the application. As noted in the previous section, you should use the same pre-release versions in order to get the expected results from the examples, even if you choose to use subsequent releases in your own projects.

Table 11-4. *The dependencies Packages*

Name	Description
`@angular/*`	These packages provide the Angular functionality, which is split into separate modules. Each module provides a different set of features, and the modules in Listnig 11-3 are a good foundation for new web applications. I add other modules in later chapters to support specific features, such as working with HTML forms.
`reflect-metadata`	This package implements a reflection API that is used to inspect decorators on classes.
`rxjs`	This is the Reactive Extensions package, which is used to implement the Angular change-detection system that is used in data bindings, as described in Chapters 12–17, and used directly for some Angular features, as described in Chapter 23–27.
`zone.js`	This is the Zone.js package, which provides an execution context for asynchronous tasks and is used to evaluate template expressions.
`core-js`	The Core-JS package provides support for new JavaScript features for browsers that don't implement them. See `https://github.com/zloirock/core-js` for details.
`classlist.js`	This package provides missing features required for IE9.
`systemjs`	This package is the module loader, which is described in the "Configuring the JavaScript Module Loader" section.
`bootstrap`	Bootstrap is the CSS framework that I use to style HTML content throughout this book. See `http://getbootstrap.com` for details.

Understanding the Development Dependencies Packages

The packages in the `devDependencies` section are the development tools that will be used to create Angular applications, as described in Table 11-5. Most of these packages require configuration files, which I describe in the sections that follow the table.

Table 11-5. *The devDependencies Packages*

Name	Description
`lite-server`	This is the package that provides the development HTTP server used throughout this book. See the "Configuring the Development HTTP Server" section for details.
`typescript`	This is the package that provides TypeScript language support, including the compiler. See the "Setting Up TypeScript" section for details.
`typings`	This is the package that provides type information for popular JavaScript packages so they can be used more conveniently with TypeScript. See the "Setting Up TypeScript" section for details.
`concurrently`	This package allows multiple commands to be run by `npm` at the same time. See the "Starting the Watch Processes" section for details.

Setting Up TypeScript

TypeScript uses type definition files to make it easier to work with JavaScript libraries that have been written in plain JavaScript. The type definitions are collected at `http://definitelytyped.org` and are managed using the `typings` package that I added to the `package.json` file in Listing 11-3. Run the following commands in the `example` folder to download and install the typing definitions that will be required for this part of the book:

```
npm run typings -- install dt~core-js --save --global
npm run typings -- install dt~node --save --global
```

These commands correspond to the `typings` entry in the `scripts` section of the `package.json` file and use the `typings` package to get the type definitions from the Definitively Typed repository (`http://definitelytyped.org`) for the `core-js` and `node` packages. The `--global` argument tells the `typings` tool that the type definitions apply to the entire project, and the `--save` argument creates a configuration file that can be used to easily install the type information again, which is useful when a new developer checks the project out of version control. Once the command has completed, the `example` folder will contain the `typings/globals/core-js` and `typings/global/node` folders that contain the type definitions and a `typings.json` file that contains details of the type information that was downloaded, as shown in Listing 11-4. You may see different version numbers in your `typings.json` file.

Listing 11-4. The Contents of the typings.json File in the example Folder

```
{
  "globalDependencies": {
    "core-js": "registry:dt/core-js#0.0.0+20160914114559",
    "node": "registry:dt/node#6.0.0+20161110151007"
  }
}
```

WORKING WITH TYPE DEFINITIONS

If you need a type definition for a package, you can take a look at the list available at `definitelytyped.org` or use the `typings` tool to see what is available. As an example, the following command searches for a type definition for the `core-js` package:

```
npm run typings -- search core-js
```

The two hyphens (`--`) tell `npm` to pass on any following arguments to the `typings` tool. The `search` argument tells `typings` that you are looking for type information, and the `core-js` argument specifies the name of the package. This command produces a result like this one:

```
NAME         SOURCE HOMEPAGE                             DESCRIPTION VERSIONS
core-js dt   https://github.com/zloirock/core-js/        1
```

To download and install a type definition, the `SOURCE` value is combined with the `NAME`, separated with a tilde (the ~ character), like this:

```
npm run typings -- install dt~core-js --save --global
```

The `--save` argument creates a `typings.json` file that allows type information, which means you can download and install the same type definition in the future using the following command:

```
npm run typings install
```

The `postinstall` entry in the `scripts` section of the `package.json` file ensures that the type information specified in the `typings.json` file is downloaded and installed after the `npm install` command is run.

Configuring the TypeScript Compiler

The TypeScript compiler requires a configuration file to prepare it for use in an Angular project. I created a file called `tsconfig.json` in the example folder and added the content shown in Listing 11-5.

Listing 11-5. The Contents of the tsconfig.json File in the example Folder

```
{
  "compilerOptions": {
    "target": "es5",
    "module": "commonjs",
    "moduleResolution": "node",
    "emitDecoratorMetadata": true,
    "experimentalDecorators": true
  },
  "exclude": [ "node_modules" ]
}
```

There are many configuration options available to control the way that TypeScript code is compiled, and the ones show in the listing are the basic set required for an Angular application, as described in Table 11-6.

Table 11-6. *The TypeScript Compiler Options for Angular Applications*

Name	Description
`target`	This setting specifies the JavaScript version that the compiler will target. The compiler will translate TypeScript features into plain JavaScript code uses only the features of the specified version. The `es5` setting corresponds to the ES5 standard, which is supported by most browsers, including legacy versions, and covers most of the browsers supported by Angular.
`module`	This setting specifies the format used to create JavaScript modules, and it should correspond to the loader used for the project. The listing specified `commonjs`, which creates modules that can be used with a wide range of JavaScript module loaders, including SystemJS, which is introduced in the "Configuring the JavaScript Module Loader" section.
`moduleResolution`	This setting specifies how the compiler deals with `import` statements. The `node` value looks for package in the `node_modules` folder, which is where they are placed by NPM.
`emitDecoratorMetadata`	When `true`, the compiler includes information about the decorator that can be accessed using the `reflect-metadata` package. This is required for Angular applications.
`experimentalDecorators`	This setting is required by the `emitDecoratorMetadata` setting.
`exclude`	This setting tells the compiler which directories should be ignored.

To test the compiler, I added a file called `compilertest.ts` to the `example` folder and added the code shown in Listing 11-6.

Listing 11-6. The Contents of the compilertest.ts File in the example Folder

```
export class Test {

    constructor(public message: string) {}
}
```

This listing defines a simple class with a single constructor-defined property, which is called `message`. To test the compiler, run the following command in the `example` folder:

```
npm run tsc
```

This command corresponds to the `tsc` entry in the `scripts` section. The compiler will locate all the TypeScript files in the project and compile them and, if required, report any errors it encounters. In this case, the test class should compile without problems and produce a file called `compilertest.js` in the `example` folder, with the content shown in Listing 11-7.

Listing 11-7. The Contents of the compilertest.js File in the example Folder

```
"use strict";
var Test = (function () {
    function Test(message) {
        this.message = message;
    }
    return Test;
}());
exports.Test = Test;
```

TypeScript has converted the class into plain JavaScript and packaged it in the module format specified by the `module` configuration settings from Listing 11-5.

Configuring the Development HTTP Server

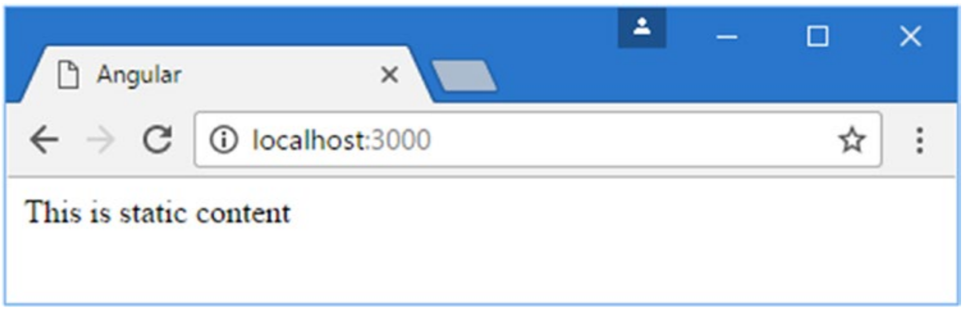
Angular applications are delivered to the browser by a web server. The server package that I use throughout this book is called `lite-server`, which is based on the popular `BrowserSync` package and provides a simple HTTP server that incorporates file change detection and browser reloading.

■ **Caution** Do not use `lite-server` in production. There are many web servers suitable for production environments, including the `express` server that lite-server is based on and that I used in Chapter 10 to prepare the SportsStore application for deployment. See `en.wikipedia.org/wiki/Web_server#Market_share` for the most popular options.

Start the HTTP server by running the following command in the `example` folder:

```
npm run lite
```

This command uses the `lite` entry defined in the `scripts` section in Listing 11-3, which starts the HTTP server. A new browser window or tab will open, as shown in Figure 11-1, and connect to `http://localhost:3000`, which is the default URL.



This is static content

Figure 11-1. *The initial project contents*

If you right-click in the browser window and select View Source or View HTML, you will see that a `script` element has been added to the HTML document, like this:

```
<!DOCTYPE html>
<html>
<head>
    <title>Angular</title>
    <meta charset="utf-8" />
</head>
<body>
    <script id="__bs_script__">//<![CDATA[
        document.write("<script async src='/browser-sync/browser-sync-
        client.2.16.0.js'><\/script>".replace("HOST", location.hostname));//]]>
    </script>
    <app>This is static content</app>
</body>
</html>
```

The `script` element is added by the BrowserSync package, and it keeps a connection open to the server. When there is a change to any of the files in the project, the server sends a signal that causes the browser to reload. To see the effect, make the changes to the `index.html` file shown in Listing 11-8.

Listing 11-8. Adding Content to the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title>Angular</title>
    <meta charset="utf-8" />
</head>
<body>
    <app>
        This is static content
        <input />
    </app>
</body>
</html>
```

The browser will reload the HTML document as soon as you save the changes. BrowserSync doesn't just reload the content when it changes; it also keeps multiple browsers synchronized so that scrolling the document or clicking a control in one browser causes the same action to be applied to any other browser displaying the same document.

To see how this works, open another browser window or start another browser and navigate to `http://localhost:3000`, which is the default URL. Any text you type into the textbox in one browser is also shown in the second browser, as illustrated by Figure 11-2.

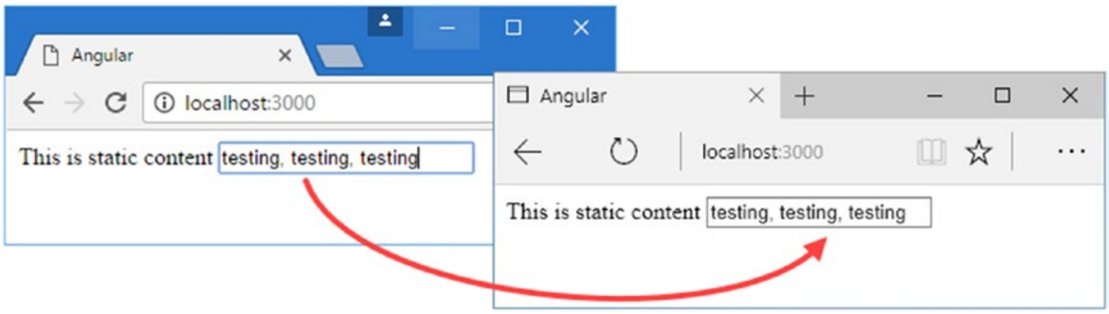


Figure 11-2. *Synchronizing multiple browser windows*

This feature is clever, but it can cause problems with Angular applications, which don't always respond as expected when BrowserSync generates events to represent user interaction from other windows. To change the configuration, I created a file called `bs-config.js` in the `example` folder and added the configuration statements shown in Listing 11-9.

Listing 11-9. The Contents of the bs-config.js File in the example Folder

```
module.exports = {
    ghostMode: false,
    reloadDelay: 1000,
    reloadDebounce: 1000,
    injectChanges: false,
    minify: false
}
```

Table 11-7 describes these configuration properties.

■ **Tip** BrowserSync has a wide range of features that can be configured and tweaked in the `bs-config.js` file. See `https://www.browsersync.io/docs/options` for details.

Table 11-7. *The BrowserSync Configuration Options for Angular Applications*

Name	Description
`ghostMode`	This option controls the event synchronization between browsers shown in Figure 11-2 The value `false` disables this feature.
`reloadDelay`	This option delays the update message being sent to browsers after a file change is detected. This is useful to prevent repeated reloads when the TypeScript compiler writes multiple JavaScript files.
`reloadDebounce`	This option prevents BrowserSync from sending reload messages to the browsers until after the specified period has passed.
`injectChanges`	Setting this option to false prevents BrowserSync from trying to inject some changes into the existing document rather than performing a reload.
`minify`	Setting this option to false prevents BrowserSync from minifying JavaScript files.

Starting the Watch Processes

The reason I added the `concurrently` package to the project is so that NPM can run multiple tools at the same time. To create a smooth workflow, I want the TypeScript compiler to detect changes to the code files and compile and then the development server to detect the new JavaScript files and reload the browser. This is the purpose of the `start` entry in the `scripts` section of the `package.json` file. Terminate any running processes from earlier sections and run the following command in the `example` folder:

```
npm start
```

The TypeScript compiler is started in watch mode so that it will compile any new or changed TypeScript files. The files that it generates will trigger the BrowserSync change detection and cause the browser to reload the HTML file.

■ **Tip** Although it is convenient to have both the TypeScript compiler and the HTTP server running in a single process, it does mean that TypeScript compiler errors can be hard to spot among the stream of file request messages from the HTTP server. You can also open two command prompts and run these tools separately, using the `npm run tscwatch` command in one terminal to run the compiler and the `npm run lite` command in the other terminal for the web server.

Starting Angular Development with TypeScript

The structure of an Angular application can be confusing, especially when you are first starting out. To help illustrate how everything fits together, Figure 11-3 shows the building blocks that you will find in an Angular application.

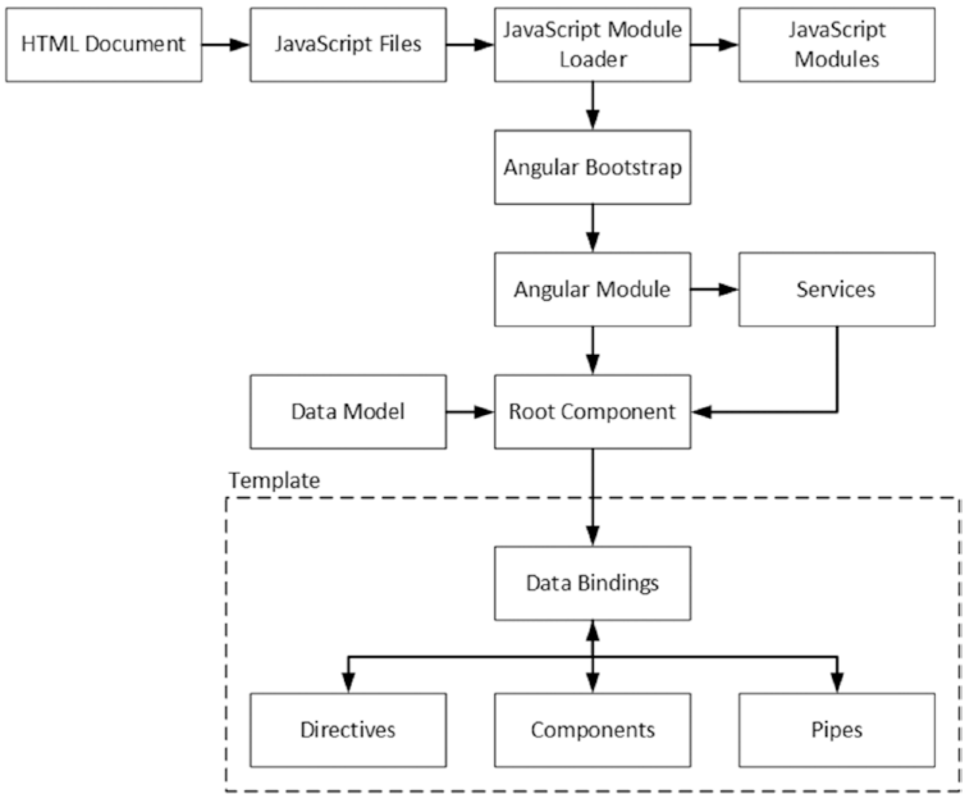


Figure 11-3. *The building blocks in a basic Angular application*

The number of building blocks might be alarming at first, but you will soon understand what each of them does and how they fit together. In the sections that follow, I add some of the fundamental building blocks to the project and explain what they are and what they do. In the chapters that follow, I dig into the detail as well as cover the building blocks that are not used to get the project started. To help provide some context, Table 11-8 briefly describes each of the building blocks in Figure 11-3.

■ **Tip** Don't worry if the descriptions in the table don't make sense right away, because understanding the role and interaction between these building blocks is a big part of learning Angular. You will have a general sense of how Angular applications fit together by the end of this chapter and understand the detail behind how everything works by the end of the book.

Table 11-8. *The Building Blocks in an Angular Application*

Name	Description
HTML Document	This is the HTML document that is requested by the browser and that contains all the content required to load and start the Angular application. I created the HTML document for the project in Listing 11-1.
JavaScript Files	These are regular JavaScript files that are added to the HTML document using `script` elements. The JavaScript files are used to add missing features required by Angular that are not supported by the browser and for the JavaScript module loader. See the "Updating the HTML Document" section for the list of JavaScript files that are required.
Module Loader	This is a JavaScript component that is responsible for loading the Angular modules and the other application building blocks. See the "Configuring the JavaScript Module Loader" and "Applying the JavaScript Module Loader" sections for more details.
JavaScript Modules	These are JavaScript files that are packaged into a specific format that allows dependencies between packages to be managed by the module loader to ensure that the JavaScript code in the application is loaded correctly and executed in the right order. The Angular framework is delivered as a set of JavaScript modules, as are some of the required support libraries.
Angular Bootstrap	This is a TypeScript file that configures Angular and specifies the Angular module, which is loaded to start the application. See the "Bootstrapping the Application" section for details.
Angular Module	All Angular projects have a root module that describes the application and can contain additional modules to group related features together and make the project more manageable. See the "Creating the Angular Module" section for the basic module used in the chapter and Chapter 21 for full details of how modules work.
Data Model	The model provides the data in the application and the logic required to access it. See the "Creating the Model" section for details.
Root Component	The root component is the entry point into the application and is responsible for generating the dynamic content that is displayed to the user. See the "Creating the Template and Root Component" section for details. Components are described in depth in Chapter 17.
Template	The template is the HTML content that is displayed by the root component. See the "Creating the Template and Root Component" section for details.
Data Bindings	Data bindings are annotations in the template that tell Angular how to insert dynamic content, such as data values, and how to respond to user interactions. Data bindings are described in Chapter 12.
Directives	Directives are classes that transform HTML elements to generate dynamic content. See Chapter 13 for details.
Components	Components add content to the application to provide application features, as described in Chapter 17.
Pipes	Pipes are classes that are used to format data values for display to the user, as described in Chapter 18.

It can be hard to keep track of the files in an Angular project, so Table 11-9 lists the files and folders that will be created in the sections that follow and explains which of the building blocks from Table 11-8 they relate to. I add further files in the chapters that follow to demonstrate how each of the building blocks works in details.

Table 11-9. *The Files and Folders in the Example Project*

Name	Description
`example/app/main.ts`	This file contains the bootstrap code, which provides Angular with the name of the Angular module. See the "Bootstrapping the Application" section.
`example/app/app.module.ts`	This file contains the Angular module, which provides the name of the root component. See the "Creating the Angular Module" section.
`example/app/product.model.ts`	This file is part of the data model. See the "Creating the Data Model" section.
`example/app/datasource.model.ts`	This file is part of the data model. See the "Creating the Data Model" section.
`example/app/repository.model.ts`	This file is part of the data model. See the "Creating the Data Model" section.
`example/app/template.html`	This file contains the template, which is a mix of HTML elements and dynamic content. See the "Creating the Template and Root Component" section.
`example/app/component.ts`	This file contains the root—and only—component, which provides data and logic to support the template. See the "Creating the Template and Root Component" section.
`example/index.html`	This file contains the HTML document. See the "Updating the HTML Document" section.
`example/package.json`	This file contains a list of the packages that are used by the application and that support the development process. It also contains the commands that can be run from the command line.
`example/typings.json`	This file provides the list of typing information that will be added to the project for the TypeScript compiler. See the "Setting Up TypeScript" section.
`example/tsconfig.json`	This file provides the configuration for the TypeScript compiler. See the "Setting Up TypeScript" section.
`example/bs-config.js`	This file contains the configuration for the development HTTP server. See the "Configuring the Development HTTP Server" section.
`example/systemjs.config.js`	This file contains the configuration for the JavaScript module loader. See the "Configuring the JavaScript Module Loader" section.
`example/typings`	This folder contains the type information for the TypeScript compiler.
`example/node_modules`	This folder is where the packages specified in the `package.json` file are stored.

Creating the Data Model

The data model in an Angular application provides access to the data in the application and the means to manipulate it. Of all the building blocks in an application, the model is the one for which Angular is the least prescriptive. Elsewhere in the application, Angular requires specific decorators to be applied or parts of the API to be used, but the only requirement for the model is that it provides access to the data that the application requires; the details of how this is done and what that data looks like is left to the developer.

This can feel a little odd, and it can be difficult to know how to begin, but, at its heart, the model can be broken into three different parts.

- A class that describes the data in the model
- A data source that loads and saves data, typically to a server
- A repository that allows the data in the model to be manipulated

In the following sections, I create a simple model, which provides the functionality that I need to describe Angular features in the chapters that follow.

Creating the Descriptive Model Class

Descriptive classes, as the name suggests, describe the data in the application. In a real project, there will generally be a lot of classes to fully describe the data that the application operates on, but to get started for this chapter, I am going to create a single, simple class. I added a file called `product.model.ts` to the app folder and defined the class shown in Listing 11-10.

Listing 11-10. The Contents of the product.model.ts File in the app Folder

```
export class Product {

    constructor(public id?: number,
                public name?: string,
                public category?: string,
                public price?: number) {}
}
```

The `Product` class defines properties for a product identifier, the name of the product, the category, and its price. The properties are defined as optional constructor arguments, which will be useful when it comes to creating a `Product` object using an HTML form, which I demonstrate in Chapter 14.

Creating the Data Source

The data source provides the application with the data. The most common type of data source uses HTTP to request data from a server, which I describe in Chapter 24. For this chapter, I need something simpler and something that will reset to a known state each time the application starts to ensure that you get the expected result in the examples. I added a file called `datasource.model.ts` to the app folder and added the code shown in Listing 11-11.

Listing 11-11. The Contents of the datasource.model.ts file in the example app Folder

```
import {Product} from "./product.model";

export class SimpleDataSource {
    private data:Product[];
    constructor() {
        this.data = new Array<Product>(
        new Product(1, "Kayak", "Watersports", 275),
        new Product(2, "Lifejacket", "Watersports", 48.95),
        new Product(3, "Soccer Ball", "Soccer", 19.50),
        new Product(4, "Corner Flags", "Soccer", 34.95),
        new Product(5, "Thinking Cap", "Chess", 16));
    }

    getData(): Product[] {
        return this.data;
    }
}
```

The data in this class is hardwired, which means that any changes that are made in the application will be lost when the browser is reloaded. This is far from useful in a real application, but it is ideal for book examples.

Creating the Model Repository

The final step to complete the simple model is to define a repository that will provide access to the data from the data source and allow it to be manipulated in the application. I added a file called `repository.model.ts` in the app folder and defined the class shown in Listing 11-12.

Listing 11-12. The Contents of the repository.model.ts File in the app Folder

```
import { Product } from "./product.model";
import { SimpleDataSource } from "./datasource.model";

export class Model {
    private dataSource: SimpleDataSource;
    private products: Product[];
    private locator = (p:Product, id:number) => p.id == id;

    constructor() {
        this.dataSource = new SimpleDataSource();
        this.products = new Array<Product>();
        this.dataSource.getData().forEach(p => this.products.push(p));
    }

    getProducts(): Product[] {
        return this.products;
    }

    getProduct(id: number) : Product {
        return this.products.find(p => this.locator(p, id));
    }

    saveProduct(product: Product) {
        if (product.id == 0 || product.id == null) {
            product.id = this.generateID();
            this.products.push(product);
        } else {
            let index = this.products
                .findIndex(p => this.locator(p, product.id));
            this.products.splice(index, 1, product);
        }
    }

    deleteProduct(id: number) {
        let index = this.products.findIndex(p => this.locator(p, id));
        if (index > -1) {
            this.products.splice(index, 1);
        }
    }

    private generateID(): number {
        let candidate = 100;
        while (this.getProduct(candidate) != null) {
            candidate++;
        }
        return candidate;
    }
}
```

The Model class defines a constructor that gets the initial data from the data source class and provides access to it through a set of methods. These methods are typical of those defined by a repository and are described in Table 11-10.

Table 11-10. *The Types of Web Forms Code Nuggets*

Name	Description
getProducts	This method returns an array containing all of the Product objects in the model.
getProduct	This method returns a single Product object based on its ID.
saveProduct	This method updates an existing Product object or adds a new one to the model.
deleteProduct	This method removes a Product object from the model based on its ID.

The implementation of the repository may seem odd because the data objects are stored in a standard JavaScript array but the methods defined by the Model class present the data as though it were a collection of Product objects indexed by the id property. There are two main considerations when writing a repository for model data. The first is that is should present the data that will be displayed as efficiently as possible. For the example application, this means presenting all of the data in the model in a form that can be iterated, such as an array. This is important because the iteration can happen often, as explained in Chapter 16. The other operations of the Model class are inefficient, but they will be used less often.

The second consideration is being able to present unchanged data for Angular to work with. I explain why this is important in Chapter 13, but in terms of implementing the repository, it means that the getProducts method should return the same object when it is called multiple times, unless one of the other methods or another part of the application has made a change to the data that the getProducts method provides. If a method returns a different object each time it is returned, even if they are different arrays containing the same objects, then Angular will report an error. This can cause some unexpected problems.

As an example, the ES6 specification includes a `Map` class that allows objects to be stored by key and that would make the implantation of the `getProduct`, `saveProduct`, and `deleteProduct` methods more efficient than the code in Listing 11-12, but it generates a new sequence of objects when it is asked for its contents, which causes problems for Angular. Taking both of these points into account means that the best way to implement the repository is to store the data in an array and accept the inefficiencies that creates for some operations.

Creating the Template and Root Component

A template is a fragment of HTML that will be displayed to the user. Templates can range from the simple to the complex, covering everything from a single HTML element through to a complex block of content. To create the template, I added a file called `template.html` to the `app` folder and added the HTML elements shown in Listing 11-13.

Listing 11-13. The Contents of the template.html File in the app Folder

```
<div class="bg-info p-a-1">
    There are {{model.getProducts().length}} products in the model
</div>
```

Most of this template is standard HTML, but the part between the double brace characters (the `{{` and `}}` in the `div` element) is an example of a data binding. When the template is displayed, Angular will process the content it contains and discover the binding. Bindings contain expressions that are evaluated and whose results are displayed in the HTML document.

The logic and data required to support the template is provided by its component, which is a TypeScript class to which the `@Component` decorator has been applied. To provide a component for the template in Listing 11-13, I added a file called `component.ts` to the `app` folder and defined the class shown in Listing 11-14.

Listing 11-14. The Contents of the component.ts File in the app Folder

```
import { Component } from "@angular/core";
import { Model } from "./repository.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();
}
```

The `@Component` decorator configures the component. The `selector` property specifies the HTML element that the directive will be applied to, which corresponds to the `app` element in the HTML document, created in Listing 11-1 (and modified in Listing 11-8).

```
...
<body>
    <app>This is static content <input /></app>
</body>
...
```

The templateUrl property in the @Component directive specifies the content that will be used to replace the app element, and, for this example, this property specifies the template.html file.

The component class, which is called ProductComponent for this example, is responsible for providing the template with the data and logic that is needed for its bindings. In this case, the ProductComponent class defines a single property, called model, which provides access to a Model object.

Creating the Angular Module

Every project has a root module, which is responsible for describing the application to Angular. I added a file called app.module.ts, which is the conventional name to use for the root module, in the app folder and added the code shown in Listing 11-15.

Listing 11-15. The Contents of the app.module.ts File in the app Folder

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";

@NgModule({
    imports: [BrowserModule],
    declarations: [ProductComponent],
    bootstrap: [ProductComponent]
})
export class AppModule {}
```

It is the metadata expressed in the @NgModule decorator that describes the application and provides some essential application features. The imports property is used to specify the dependencies the application has and the BrowserModule specified in Listing 11-15 sets up the built-in template features, such as the {{ and }} sequences that I included in the template.html file and that you will see working later in this chapter.

The declarations property describes the features that the application exposes publicly. This is a useful feature when creating libraries of Angular functionality for use in other applications—as described in Chapter 21—but for simpler applications the declaration property is used only to register the root component, such as the ProductComponent class from Listing 11-14.

The bootstrap property tells Angular that the ProductComponent class is the entry point into the application. When the application starts, Angular will use the metadata from the @Component decorator applied to the ProductComponent class to start the application off, as described in the "Running the Application" section later in this chapter.

Bootstrapping the Application

The bootstrap process tells Angular about the component created in the previous section and creates the bridge between the functionality provided by the Angular framework and the custom code in the application. Bootstrapping is done by defining a TypeScript class, which I have done in a file called main.ts in the app folder, as shown in Listing 11-16.

Listing 11-16. The Contents of the main.ts File in the app Folder

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { AppModule } from './app.module';

platformBrowserDynamic().bootstrapModule(AppModule);
```

Angular is capable of running applications on a range of different platforms, each of which provides a runtime environment for loading and running applications. The `platformBrowserDynamic` class provides the runtime for browsers, and the `bootstrapModule` method is used to tell Angular which module describes the application.

■ **Tip** Notice that the argument to the `bootstrapModule` method is the name of the class and not a new instance of that class. Or, put another way, you call `bootstrapModule(AppModule)` and not `bootstrapModule(new AppModule())` or `bootstrapModule("AppModule")`.

The `platformBrowserDynamic` class enables the Angular Just-in-Time compiler, which means that the browser has to process the JavaScript files it receives each time the application is loaded. In Chapter 10, I demonstrated the use of the Ahead-of-Time compiler, which performs this step before an application is deployed and which requires changes to the bootstrap file so that a different platform is used to start the application.

Configuring the JavaScript Module Loader

The term *module* is shorthand for referring to two different things in an Angular application. An *Angular module* is a TypeScript class whose metadata describes an application.

As described in Chapter 6, a *JavaScript module* is a file that contains JavaScript code. JavaScript modules range from small files that contain a single class, such as the ones created so far in the example project, right through to large files containing lots of classes that have been bundled together (using the kind of process that I demonstrated in Chapter 10 to prepare the SportsStore application for production).

The JavaScript module loader is responsible for loading all of the JavaScript module files that the browser needs to run an application and executing them in the right order. This may seem like a trivial task, but loading JavaScript files correctly can be a difficult job, because the dependencies can be complex, especially in a large Angular application.

The TypeScript compiler comes with built-in support for working with JavaScript module loaders. When you use an `import` statement in a TypeScript file, the compiler declares a dependency in the plain JavaScript file that tells the module loader that the applicaion relies on another JavaScript module. Here are the import statements from the `component.ts` file:

```
...
import { Component } from "@angular/core";
import { Model } from "./repository.model";
...
```

When the TypeScript compiler processes the `component.ts` file, it uses the `import` statements to provide the module loader with information about the dependencies, which are then included in the plain JavaScript file, like this:

```
...
var core_1 = require("@angular/core");
var repository_model_1 = require("./repository.model");
...
```

The TypeScript compiler has used the `require` method to resolve the dependencies because I specified `commonjs` for the `module` property in the `tsconfig.json` file in Listing 11-5. There are different module formats available, but using `commonjs` makes it possible to take advantage of a useful Angular feature for components, which I describe in Chapter 21.

■ **Note** It is important that the value of the `module` setting in the `tsconfig.json` file matches the module loader you are using. I specified `commonjs`, which means that TypeScript will generate JavaScript code in modules that work with a wide range of module loaders, including the SystemJS package. If you switch to a different module loader, then you must ensure that the TypeScript creates JavaScript modules that match.

Module loaders have to be configured so they can resolve the dependencies that are declared in the files they load. To configure SystemJS, I created a file called `systemjs.config.js` in the example folder and added the code shown in Listing 11-17.

Listing 11-17. The Contents of the systemjs.config.js File in the example Folder

```
(function(global) {

    var paths = {
        "rxjs/*": "node_modules/rxjs/bundles/Rx.min.js",
        "@angular/*": "node_modules/@angular/*"
    }

    var packages = { "app":  {} };

    var angularModules = ["common", "compiler",
     "core", "platform-browser", "platform-browser-dynamic"];

    angularModules.forEach(function(pkg) {
        packages["@angular/" + pkg] = {
            main: "/bundles/" + pkg + ".umd.min.js"
        };
    });

    System.config({ paths: paths, packages: packages });

})(this);
```

This configuration file is written in JavaScript code (as opposed to being just static JSON data) and contains three different ways of resolving JavaScript module dependencies, which are applied to three different parts of the application, as described in the sections that follow. This kind of approach is typical of most complex applications, regardless of whether they are written in Angular, because important JavaScript packages are delivered in a range of ways that have to be handled differently.

Resolving the RxJS Modules

The first package that is configured in 17 is `rxjs`, which was added to the `package.json` file in Listing 11-3. This is the Reactive Extensions (RxJS) package development by Microsoft that is used by Angular to distribute notifications throughout an application when the data model changes.

The Reactive Extensions package is delivered as a file called `Rx.min.js`, within a folder called `node_modules/rxjs/bundles`. This file contains multiple modules, and in order to resolve all dependencies for all of them in a single file, I have used the SystemJS paths feature, like this:

```
...
var paths = {
    "rxjs/*": "node_modules/rxjs/bundles/Rx.min.js",
    "@angular/*": "node_modules/@angular/*"
}
...
```

Whenever the module loader encounters a dependency on a module that starts with `rxjs/`, such as `rxjs/Subject`, it will be resolved using the code in the `Rx.min.js` file.

■ **Tip** If you are working directly with RxJS features, which you will need to do in more complex applications, then you will have to create a custom RxJS module for your project. I demonstrate this process in Chapter 22.

Resolving the Custom Application Modules

The TypeScript compiler creates a new module for every TypeScript file it processes, which means that there are modules for each of the model classes and the component in the example application.

The module loader is configured to resolve dependencies on the custom modules in the app folder, like this:

```
...
var packages = { "app":  {} };
...
```

The `packages` object is used to register the packages whose modules the loader will handle. The reason for defining this setting is to take advantage of the defaults that SystemJS uses so that dependencies on modules such as `app/component` will be resolved by loading the `app/component.js` file from the server.

Resolving the Angular Modules

The Angular framework is distributed as a set of JavaScript modules. When there is a dependency on a module such as `@angular/core`, it must be handled by loading a file such as `node_modules/@angular/core/bundles/core.umd.min.js`. The paths feature that I used to deal with the `RxJS` package can't be used on its own in this situation because the name of the module appears twice in the path name, which the paths feature doesn't support.

Two different configuration steps are required to configure the module loader to handle the Angular JavaScript modules. The first step is to tell the module loader about each of the Angular modules that the application requires.

```
...
var angularModules = ["common", "compiler",
    "core", "platform-browser", "platform-browser-dynamic"];
```

```
angularModules.forEach(function(pkg) {
    packages["@angular/" + pkg] = {
        main: "/bundles/" + pkg + ".umd.min.js"
    };
});
...
```

I have started with five modules, which are the ones that are required for a basic Angular application. (I add others in later chapters.) For each of the Angular JavaScript modules, a new property is defined on the packages object that looks like this:

```
packages["@angular/core"] = {main: "/bundles/core.umd.min.js"}
```

The main property that is defined is used to specify a file in a package that should be used by default. In this case, when there is a dependency on the @angular/core module, the loader will resolve it by loading the @angular/core/bundles/core.umd.min.js file.

The second step is to configure a path setting that correctly targets the files in the node_modules folder, like this:

```
...
var paths = {
    "rxjs/*": "node_modules/rxjs/bundles/Rx.umd.min.js",
    "@angular/*": "node_modules/@angular/*"
}
...
```

Combined with the packages setting, the module loader will correctly handle dependencies on an Angular module.

Applying the Configuration Options

The final step is to pass both the paths and packages objects to the System.config method, which provides the module loader with its configuration details.

```
...
System.config({ paths: paths, packages: packages });
...
```

TRIAL AND ERROR: CONFIGURING THE MODULE LOADER

Working out the required configuration can require some trial and error, using the browser's F12 developer tools to see what files are requested and then adjusting the module loader's settings so it knows how to find those files in the project. Not all packages are as awkward to deal with as Angular, but many have quirks in the way they are packaged or distributed. The popular module loaders provide configuration options that are flexible enough to deal with most packages. I used two of the features offered by SystemJS in this section, and you can see the full range of options at http://github.com/systemjs/systemjs.

It is important to check to see which files are being requested whenever you add a new package to a project because it is easy to end up with a production application that requests more files than it requires or that requests the uncompressed versions that are intended for debugging.

Updating the HTML Document

The final step is to update the HTML document so that it includes the packages that are not delivered as modules and the module loader. Listing 11-18 shows the changes that are required for the example application.

Listing 11-18. Adding JavaScript Packages and the Module Loader in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title></title>
    <meta charset="utf-8" />
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
</head>
<body class="m-a-1">
    <app></app>
</body>
</html>
```

Not all of the JavaScript packages required by Angular are delivered or loaded as JavaScript modules. The first four `script` elements in the listing are for the classList.js, Core-JS, Zone.js, and Reflect-Metadata packages, which the browser will load and execute in order.

■ **Tip** The most reliable way to find out which file should be loaded from a package is to look at the project's homepage. For example, the homepage for Core-JS is `https://github.com/zloirock/core-js`, and it describes the different ways that the package can be used, including using the `client/shim.min.js` file.

Applying the JavaScript Module Loader

The SystemJS module loader requires three separate `script` elements. The first `script` element loads the `SystemJS` library.

```
...
<script src="node_modules/systemjs/dist/system.src.js"></script>
...
```

The next step is to load the configuration file. Since this file is JavaScript—rather than JSON—it can be loaded and executed using a `script` element.

```
...
<script src="systemjs.config.js"></script>
...
```

The final `script` element loads the plain JavaScript file that the TypeScript compiler created from the Angular bootstrap file, which was shown in Listing 11-18.

```
...
<script>
    System.import("app/main").catch(function(err){ console.error(err); });
</script>
...
```

The `System.import` method loads the file and starts the process of resolving its dependencies. In the listing, the argument to the `import` method is `app/main`, which the configuration in the `systemjs.config.js` file maps to the `app/main.js` file. Any errors will be written to the browser's JavaScript console.

Styling the Content

The `link` element in Listing 11-18 loads the Bootstrap CSS package, which I use throughout this book to style the HTML content in the examples. Bootstrap is not directly related to Angular but can be used to style both the static content in the HTML document and the dynamic content created from templates. The HTML document contains a simple Bootstrap style, applied to the `body` element.

```
...
<body class="m-a-1">
...
```

Assigning an element to the `m-a-1` class adds a margin to all four edges, creating space between the element and the content that surrounds it. There are also Bootstrap styles in the `template.html` file shown in Listing 11-13, applied to a `div` element.

```
...
<div class="bg-info p-a-1">
...
```

Assigning an element to the `bg-info` class applies a background color to the element, where `info` refers to one of a set of standardized colors (`info`, `danger`, `success`, and so on). Assigning an element to the `p-a-1` class adds padding to all four edges of an element, creating space between its content and the element's edges.

Running the Application

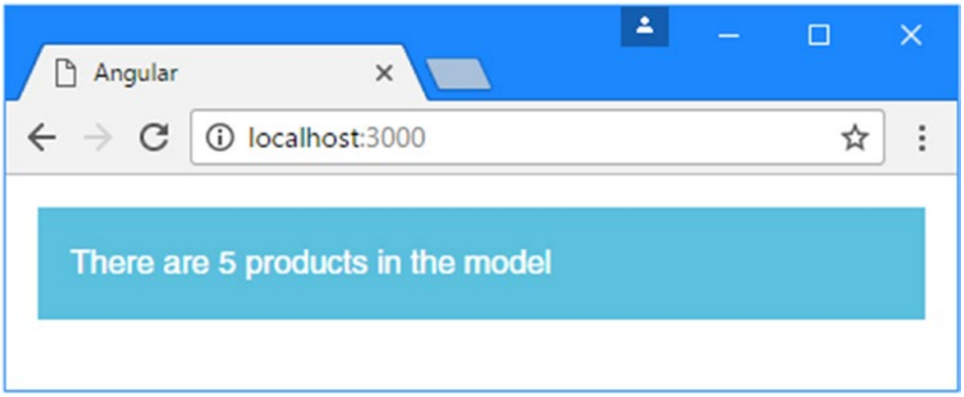
When you save the changes to the `index.html` file in Listing 11-18, all of the building blocks are in place and the application can run. The browser loads the HTML document and processes its contents, including the `script` elements for the module loader.

The module loader loads the `app/main.js` file and starts resolving its dependencies, which are the root module for the application and one of the Angular framework's JavaScript modules files. Each of these has its own dependencies, and the module loader works its way through the entire chain, loading the corresponding files from the server using the settings in its configuration files.

Once all the files have been loaded, the module loader executes the `main.js` file, which bootstraps the Angular application. The bootstrap file tells Angular that the root module for the application is the `AppModule` class, and the properties in its `@NgModule` decorator specify that the root component for the application is the `ProductComponent` class. Angular inspects the `@Component` decorator of the `ProductComponent` class and looks for the element in the HTML document that corresponds to the component's `selector` configuration property. It inserts the content specified by its `templateUrl` property, which is contained in the `app/template.html` file, into the HTML document as the content of the `selector` element. As the template is processed, Angular encounters the `{{` and `}}` characters that denote a data binding and evaluate the expression they contain.

```
...
<div class="bg-info p-a-1">
    There are {{model.getProducts().length}} products in the model
</div>
...
```

The value of the `model` property is provided by the component, which created a new `Model` object. Angular calls the `getProducts` method on the `Model` object and inserts the value of the `length` property of the result into the HTML document, producing the result shown in Figure 11-4.



There are 5 products in the model

Figure 11-4. *Running the example application*

Right-click the content in the browser's window and select Inspect or Inspect Element from the pop-up menu (the exact working differs between browsers and may not be shown until the F12 Developer Tools window is open). If you examine the browser's Document Object Model (DOM), which is the dynamic representation of the HTML document, you will see how the building blocks in the application have come together, like this:

```
<html>
<head>
    <title></title>
    <meta charset="utf-8">
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css" rel="stylesheet">
</head>
<body class="m-a-1"><script id="__bs_script__">//<![CDATA[
    document.write("<script async src='/browser-sync/browser-sync-
    client.js?v=2.16.0'><\/script>".replace("HOST", location.hostname));
    //]]></script><script async="" src="/browser-sync/browser-sync-
    client.js?v=2.16.0"></script>

    <app>
        <div class="bg-info p-a-1">
            There are 5 products in the model
       </div>
    </app>
</body>
</html>
```

The bootloader, the Angular module, the root component, the template, the data binding, the data model, and the Angular framework itself have all worked together to generate the content shown in the browser window. That may not seem like such an impressive feat since it has led to such a simple outcome, but creating the project has laid the foundation for the more advanced—and interesting—features that are described in the chapters that follow.

Summary

In this chapter, I created an Angular development project and used it to introduce some of the building blocks for a simple application and the process by which they are created, compiled, and delivered to the client. In the next chapter, I start digging into the detail, starting with Angular data bindings.

CHAPTER 12

Using Data Bindings

The example application in the previous chapter contains a simple template that was displayed to the user and that contained a data binding that showed how many objects were in the data model. In this chapter, I describe the basic data bindings that Angular provides and demonstrate how they can be used to produce dynamic content. In later chapters, I describe more advanced data bindings and explain how to extend the Angular binding system with custom features. Table 12-1 puts data bindings in context.

Table 12-1. *Putting Data Bindings in Context*

Question	Answer
What are they?	Data bindings are expressions embedded into templates and are evaluated to produce dynamic content in the HTML document.
Why are they useful?	Data bindings provide the link between the HTML elements in the HTML document and in template files with the data and code in the application.
How are they used?	Data bindings are applied as attributes on HTML elements or as special sequences of characters in strings.
Are there any pitfalls or limitations?	Data bindings contain simple JavaScript expressions that are evaluated to generate content. The main pitfall is including too much logic in a binding because such logic cannot be properly tested or used elsewhere in the application. Data binding expressions should be as simple as possible and rely on components (and other Angular features such pipes) to provide complex application logic.
Are there any alternatives?	No. Data bindings are an essential part of Angular development.

Table 12-2 summarizes the chapter.

Table 12-2. *Chapter Summary*

Problem	Solution	Listing
Display data dynamically in the HTML document	Define a data binding	1–4
Configure an HTML element	Use a standard property or attribute binding	5, 8
Set the contents of an element	Use a string interpolation binding	6, 7
Configure the classes to which an element is assigned	Use a class binding	9–13
Configure the individual styles applied to an element	Use a style binding	14–17
Manually trigger a data model update	Use the browser's JavaScript console	18, 19

Preparing the Example Project

For this chapter, I continue using the `example` project from Chapter 11. To prepare for this chapter, I added a method to the component class, as shown in Listing 12-1.

■ **Note** You can download the example projects for this book from `apress.com` if you don't want to create the project from scratch.

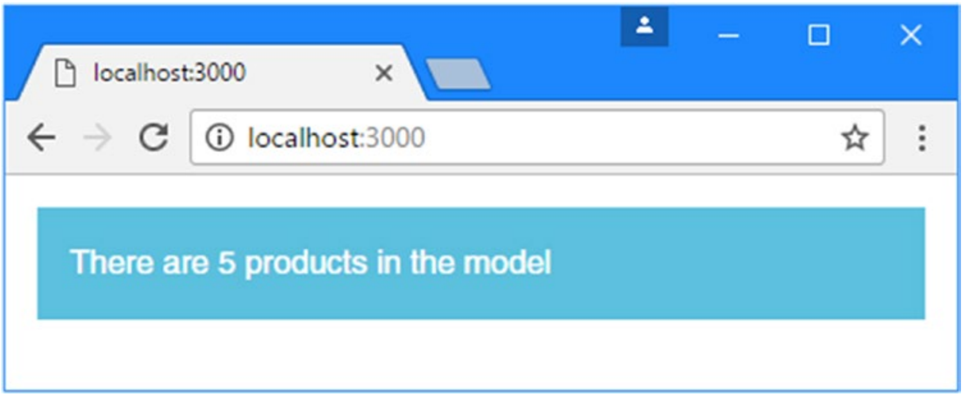
Listing 12-1. Adding a Method in the component.ts File

```
import { Component } from "@angular/core";
import { Model } from "./repository.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getClasses(): string {
        return this.model.getProducts().length == 5 ? "bg-success" : "bg-warning";
    }
}
```

You can start the development HTTP server by running the following command in the `example` folder:

```
npm start
```

A new browser window will open, and the content shown in Figure 12-1 will be displayed.



There are 5 products in the model

Figure 12-1. *Running the example application*

Understanding One-Way Data Bindings

One-way data bindings are used to generate content for the user and are the basic building block for Angular templates. The term *one-way* refers to the fact that the data flows in one direction, which, in the case of the bindings that I describe in this chapter, means that data flows from the data model to the component and, finally, into the data binding so that it can be displayed in a template.

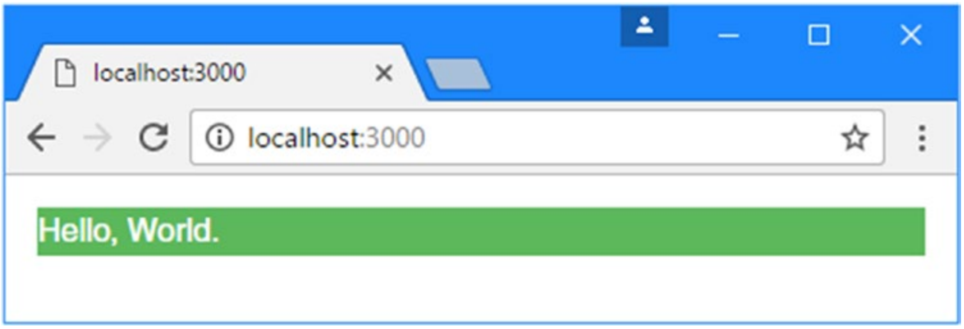
There are other types of Angular data binding, which I describe in later chapters. Event bindings flow in the other direction, from the elements in the template into the rest of the application, and allow user interaction. *Two-way bindings* allow data to flow in both directions and are most commonly used in forms. See Chapters 13 and 14 for details of other bindings.

To get started with one-way data bindings, I have replaced the content of the template, as shown in Listing 12-2.

Listing 12-2. The Contents of the template.html File

```
<div [ngClass]="getClasses()" >
    Hello, World.
</div>
```

When you save the changes to the template, the development server will trigger a browser reload and display the output shown in Figure 12-2.



Hello, World.

Figure 12-2. *Using a one-way data binding*

This is a simple example, but it shows the basic structure of a data binding, which is illustrated in Figure 12-3.

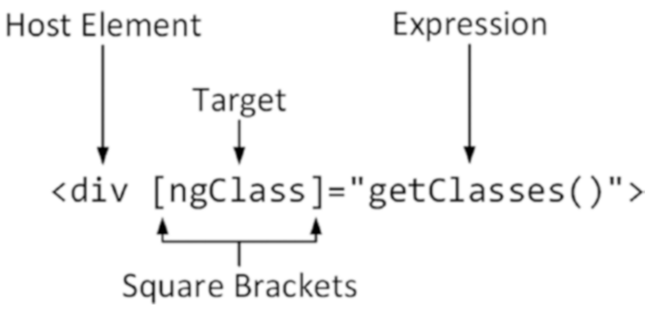


Figure 12-3. *The anatomy of a data binding*

A data binding has these four parts:

- The *host element* is the HTML element that the binding will affect, by changing its appearance, content, or behavior.
- The *square brackets* tell Angular that this is a one-way data binding. When Angular sees square brackets in a data binding, it will evaluate the expression and pass the result to the binding's *target* so that it can modify the host element.
- The *target* specifies what the binding will do. There are two different types of target: a *directive* or a *property binding*.
- The *expression* is a fragment of JavaScript that is evaluated using the template's component to provide context, meaning that the component's property and methods can be included in the expression, like the `getClasses` method in the example binding.

Looking at the binding in Listing 12-2, you can see that the host element is a `div` element, meaning that's the element that the binding is intended to modify. The expression invokes the component's `getClasses` method, which was defined at the start of the chapter. This method returns a string containing a Bootstrap CSS class based on the number of objects in the data model.

```
...
getClasses(): string {
    return this.model.getProducts().length == 5 ? "bg-success" : "bg-warning";
}
...
```

If there are five objects in the data model, then the method returns `bg-success`, which is a Bootstrap class that applies a green background. Otherwise, the method returns `bg-warning`, which is a Bootstrap class that applies an amber background.

The target for the data binding in Listing 12-2 is a directive, which is a class that is specifically written to support a data binding. Angular comes with some useful built-in directives, and you can create your own to provide custom functionality. The names of the built-in directives start with `ng`, which tells you that the `ngClass` target is one of the built-in directives. The target usually gives an indication of what the directive does, and, as its name suggests, the `ngClass` directive will add or remove the host element from the class or classes whose names are returned when the expression is evaluated.

Putting it all together, the data binding in Listing 12-2 will add the `div` element to the `bg-success` or `bg-warning` classes based on the number of items in the data model.

Since there are five objects in the model when the application starts (because the initial data is hard-coded into the `SimpleDataSource` class created in Chapter 12), the `getClasses` method returns `bg-success` and produces the result shown in Figure 12-3, adding a green background to the `div` element.

Understanding the Binding Target

When Angular processes the target of a data binding, it starts by checking to see whether it matches a directive. Most applications will rely on a mix of the built-in directives provided by Angular and custom directives that provide application-specific features. You can usually tell when a directive is the target of a data binding because the name will be distinctive and give some indication of what the directive is for. The built-in directives can be recognized by the `ng` prefix. The binding in Listing 12-2 gives you a hint that the target is a built-in directive that is related to the class membership of the host element. For quick reference, Table 12-3 describes the basic built-in Angular directives and where they are described in this book. (There are other directives described in later chapters, but these are the simplest and most commonly used.)

Table 12-3. *The Basic Built-in Angular Directives*

Name	Description
`ngClass`	This directive is used to assign host elements to classes, as described in the "Setting Classes and Styles" section.
`ngStyle`	This directive is used to set individual styles, as described in the "Setting Classes and Styles" section.
`ngIf`	This directive is used to insert content in the HTML document when its expression evaluates as `true`, as described in Chapter 13.
`ngFor`	This directive inserts the same content into the HTML document for each item in a data source, as described in Chapter 13.
`ngSwitch ngSwitchCase ngSwitchDefault`	These directives are used to choose between blocks of content to insert into the HTML document based on the value of the expression, as described in Chapter 13.
`ngTemplateOutlet`	This directive is used to repeat a block of content, as described in Chapter 13.

Understanding Property Bindings

If the binding target doesn't correspond to a directive, then Angular checks to see whether the target can be used to create a property binding. There are five different types of property binding, which are listed in Table 12-4, along with the details of where they are described in detail.

Table 12-4. *The Angular Property Bindings*

Name	Description
`[property]`	This is the standard property binding, which is used to set a property on the JavaScript object that represents the host element in the Document Object Model (DOM), as described in the "Using the Standard Property and Attribute Bindings" section.
`[attr.name]`	This is the attribute binding, which is used to set the value of attributes on the host HTML element for which there are no DOM properties, as described in the "Using the Attribute Binding" section.
`[class.name]`	This is the special class property binding, which is used to configure class membership of the host element, as described in the "Using the Class Bindings" section.
`[style.name]`	This is the special style property binding, which is used to configure style settings of the host element, as described in the "Using the Style Bindings" section.

Understanding the Expression

The expression in a data binding is a fragment of JavaScript code that is evaluated to provide a data value to the target. The expression has access to the properties and methods defined by the component, which is how the binding in Listing 12-2 is able to invoke the `getClasses` method to provide the `ngClass` directive with the name of the class that the host element should be added to.

Expressions are not restricted to just calling methods or reading properties from the component; they can also be used to perform most standard JavaScript operations. As an example, Listing 12-3 shows an expression that has a literal string value being concatenated with the result of the `getClasses` method.

Listing 12-3. Performing a JavaScript Operation in an Expression in the template.html File

```
<div [ngClass]="'p-a-1 ' + getClasses()" >
    Hello, World.
</div>
```

The expression is enclosed in double quotes, which means that the string literal has to be defined using single quotes. The JavaScript concatenation operator is the + character, and the result from the expression will be the combination of both strings, like this:

```
p-a-1 bg-success
```

The effect is that the `ngClass` directive will add the host element to two classes: `p-a-1`, which Bootstrap uses to add padding around an element's content, and `bg-success`, which sets the background color. Figure 12-4 shows the combination of these two classes.

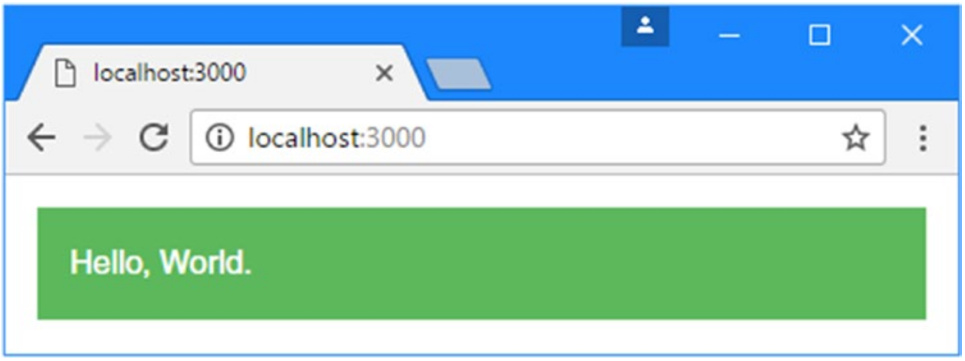


Figure 12-4. *Combining classes in a JavaScript expression*

It is easy to get carried away when writing expressions and include complex logic in the template. This can cause problems because the expressions are not checked by the TypeScript compiler nor can they be easily unit tested, which means that bugs are more likely to remain undetected until the application has been deployed. To avoid this issue, expressions should be as simple as possible and, ideally, used only to retrieve data from the component and format it for display. All the complex retrieval and processing logic should be defined in the component or the model, where it can be compiled and tested.

Understanding the Brackets

The square brackets (the [and] characters) tell Angular that this is a one-way data binding that has an expression that should be evaluated. Angular will still process the binding if you omit the brackets and the target is a directive, but the expression won't be evaluated and the content between the quote characters will be passed to the directive as a literal value. Listing 12-4 adds an element to the template with a binding that doesn't have square brackets.

Listing 12-4. Omitting the Brackets in a Data Binding in the template.html File

```
<div [ngClass]="'p-a-1 ' + getClasses()" >
    Hello, World.
</div>
<div ngClass="'p-a-1 ' + getClasses()" >
    Hello, World.
</div>
```

If you examine the HTML element in the browser's DOM viewer (by right-clicking in the browser window and selecting Inspect or Inspect Element from the pop-up menu), you will see that its `class` attribute has been set to the literal string, like this:

```
<div class="'p-a-1 ' + getClasses()">
```

The browser will try to process the classes to which the host element has been assigned, but the element's appearance won't be as expected since they don't correspond to the class names used by Bootstrap. This is a common mistake to make, so it is the first thing to check if a binding doesn't have the effect you expected.

The square brackets are not the only ones that Angular uses in data bindings. For quick reference, Table 12-5 provides the complete set of brackets, the meaning of each, and where they are described in detail.

Table 12-5. *The Angular Brackets*

Name	Description
`[target]="expr"`	The square brackets indicate a one-way data binding where data flows from the expression to the target. The different forms of this type of binding are the topic of this chapter.
`{{expression}}`	This is the string interpolation binding, which is described in the "Using the String Interpolation Binding" section.
`(target) ="expr"`	The round brackets indicate a one-way binding where the data flows from the target to the destination specified by the expression. This is the binding used to handle events, as described in Chapter 14.
`[(target)] ="expr"`	This combination of brackets—known as the banana-in-a-box—indicates a two-way binding, where data flows in both directions between the target and the destination specified by the expression, as described in Chapter 14.

Understanding the Host Element

The host element is the simplest part of a data binding. Data bindings can be applied to any HTML element in a template, and an element can have multiple bindings, each of which can manage a different aspect of the element's appearance or behavior. You will see elements with multiple bindings in later examples.

Using the Standard Property and Attribute Bindings

If the target of a binding doesn't match a directive, Angular will try to apply a property binding. The sections that follow describe the most common property bindings: the standard property binding and the attribute binding.

Using the Standard Property Binding

The browser uses the Document Object Model (DOM) to represent the HTML document. Each element in the HTML document, including the host element, is represented using a JavaScript object in the DOM. Like all JavaScript objects, the ones used to represent HTML elements have properties. These properties are used to manage the state of the element so that the `value` property, for example, is used to set the contents of an `input` element. When the browser parses an HTML document, it encounters each new HTML element, creates an object in the DOM to represent it, and uses the element's attributes to set the initial values for the object's properties.

The standard property binding lets you set the value of a property for the object that represents the host element, using the result of an expression. For example, setting the target of a binding to `value` will set the content of an `input` element, as shown in Listing 12-5.

Listing 12-5. Using the Standard Property Binding in the template.html File

```
<div [ngClass]="'p-a-1 ' + getClasses()" >
    Hello, World.
</div>
```

```
<div class="form-group m-t-1">
    <label>Name:</label>
    <input class="form-control" [value]="model.getProduct(1)?.name || 'None'" />
</div>
```

The new binding in this example specifies that the `value` property should be bound to the result of an expression that calls a method on the data model to retrieve a data object from the repository by specifying a key. It is possible that there is no data object with that key, in which case the repository method will return `null`.

To guard against using `null` for the host element's value property, the binding uses the template null conditional operator (the ? character) to safely navigate the result returned by the method, like this:

```
...
<input class="form-control" [value]="model.getProduct(1)?.name || 'None'" />
The first product is {{getProduct(1)?.name || 'None'}}.
...
```

If the result from the `getProduct` method isn't `null`, then the expression will read the value of the `name` property and use it as the result. But if the result from the method is `null`, then the `name` property won't be read, and the null coalescing operator (the `||` characters) will set the result to `None` instead.

GETTING TO KNOW THE HTML ELEMENT PROPERTIES

Using property bindings can require some work figuring out which property you need to set. There is some inconsistency in the HTML specification. The name of most properties matches the name of the attribute that sets their initial value, so that if you are used to setting the `value` attribute on an `input` element, for example, then you can achieve the same effect by setting the `value` property. Some property names don't match their attribute names, and some properties are not configured by attributes at all.

The Mozilla Foundation provides a useful reference for all the objects that are used to represent HTML elements in the DOM at `developer.mozilla.org/en-US/docs/Web/API`. For each element, Mozilla provides a summary of the properties that are available and what each is used for. Start with `HTMLElement` (`developer.mozilla.org/en-US/docs/Web/API/HTMLElement`), which provides the functionality common to all elements. You can then branch out into the objects that are for specific elements, such as `HTMLInputElement`, which is used to represent `input` elements.

When you save the changes to the template, the browser will reload and display an `input` element whose content is the `name` property of the data object with the key of `1` in the model repository, as shown in Figure 12-5.

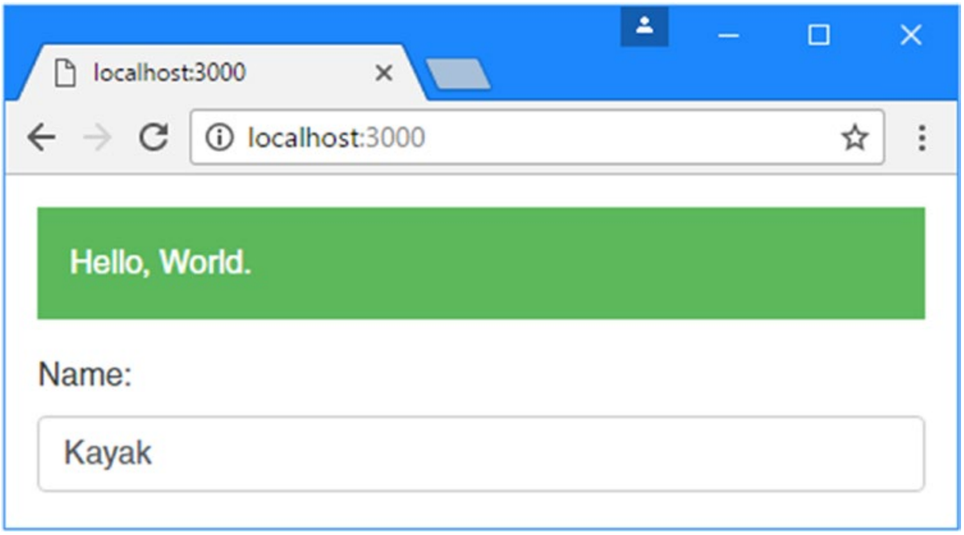


Figure 12-5. *Using the standard property binding*

Using the String Interpolation Binding

Angular provides a special version of the standard property binding, known as the *string interpolation binding*, that is used to include expression results in the text content of host elements. To understand why this special binding is useful, it helps to look at what binding is required when the standard property binding is used.

The `textContent` property is used to set the content of HTML elements, which means that the content of an element can be set using a data binding like the one shown in Listing 12-6.

Listing 12-6. Setting an Element's Content in the template.html File

```
<div [ngClass]="'p-a-1 ' + getClasses()"
     [textContent]="'Name: ' + (model.getProduct(1)?.name || 'None')" >
</div>
<div class="form-group m-t-1">
    <label>Name:</label>
    <input class="form-control" [value]="model.getProduct(1)?.name || 'None'" />
</div>
```

The expression in the new binding concatenates a literal string with the results of a method call in order to set the content of the `div` element.

The expression in this example is awkward to write, requiring careful attention to quotes, spaces, and brackets to ensure that the expected result is displayed in the output. The problem becomes worse for more complex bindings, where multiple dynamic values are interspersed among blocks of static content.

The string interpolation binding simplified this process by allowing fragments of expressions to be defined within the content of an element, as shown in Listing 12-7.

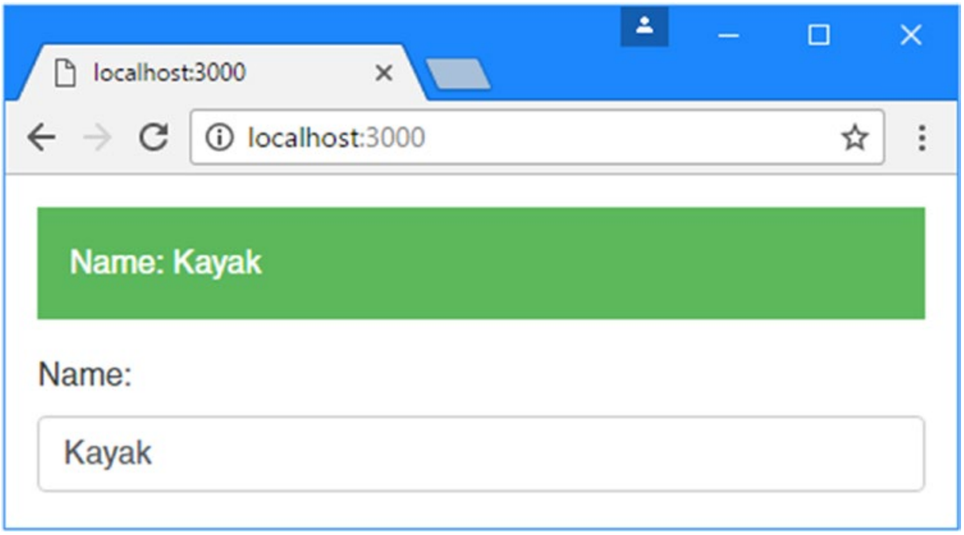
Listing 12-7. Using the String Interpolation Binding in the template.html File

```
<div [ngClass]="'p-a-1 ' + getClasses()">
    Name: {{model.getProduct(1)?.name || 'None'}}
```

```
</div>
<div class="form-group m-t-1">
    <label>Name:</label>
    <input class="form-control" [value]="model.getProduct(1)?.name || 'None'" />
</div>
```

The string interpolation binding is denoted using pairs of curly brackets ({{ and }}). A single element can contain multiple string interpolation bindings.

Angular combines the content of the HTML element with the contents of the brackets in order to create a binding for the `textContent` property. The result is the same as Listing 12-6, which is shown in Figure 12-6, but the process of writing the binding is simpler and less error-prone.



Name: Kayak

Name:

Kayak

Figure 12-6. *Using the string interpolation binding*

Using the Attribute Binding

here are some oddities in the HTML and DOM specifications that mean that not all HTML element attributes have equivalent properties in the DOM API, which means that there are aspects of the host element that cannot be set using the standard property binding.

For these situations, Angular provides the *attribute binding*, which is used to set an attribute on the host element rather than setting the value of the JavaScript object that represents it in the DOM.

The most commonly encountered attribute without a corresponding property is `colspan`, which is used to set the number of columns that a `td` element will occupy in a table. Listing 12-8 shows using the attribute binding to set the `colspan` element based on the number of objects in the data model.

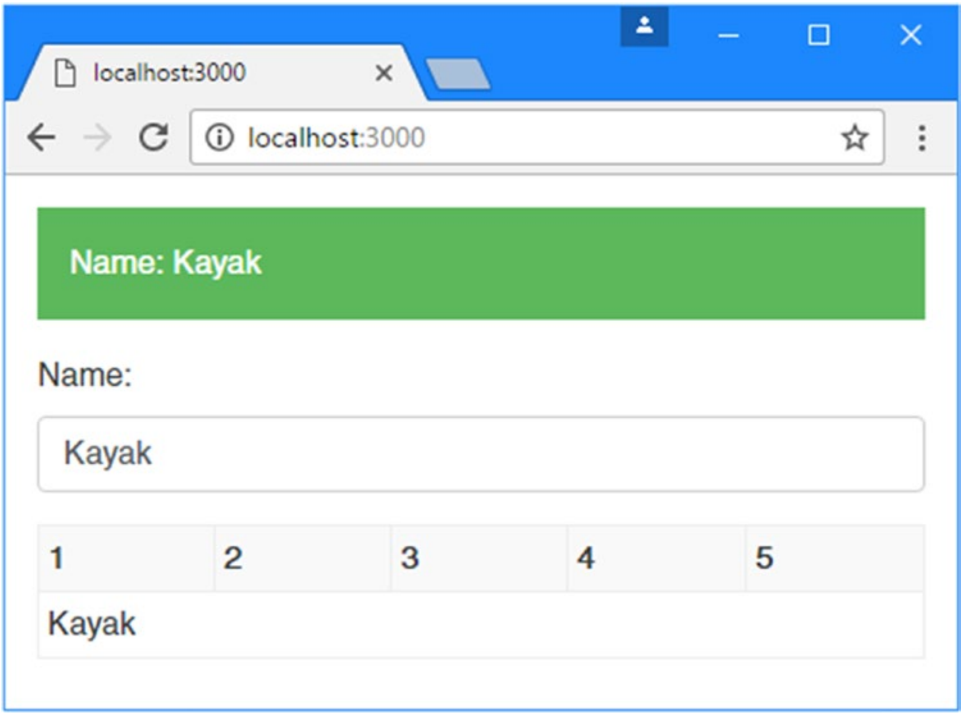
Listing 12-8. Using an Attribute Binding in the template.html File

```
<div [ngClass]="'p-a-1 ' + getClasses()">
    Name: {{model.getProduct(1)?.name || 'None'}}
</div>
<div class="form-group m-t-1">
    <label>Name:</label>
    <input class="form-control" [value]="model.getProduct(1)?.name || 'None'" />
</div>
<table class="table table-sm table-bordered table-striped m-t-1">
    <tr>
        <th>1</th><th>2</th><th>3</th><th>4</th><th>5</th>
    </tr>
    <tr>
        <td [attr.colspan]="model.getProducts().length">
            {{model.getProduct(1)?.name || 'None'}}
        </td>
    </tr>
</table>
```

The attribute binding is applied by defining a target that prefixes the name of the attribute with `attr.` (the term `attr`, followed by a period). In the listing, I have used the attribute binding to set the value of the `colspan` element on one of the `td` elements in the table, like this:

```
...
<td [attr.colspan]="model.getProducts().length">
...
```

Angular will evaluate the expression and set the value of the `colspan` attribute to the result. Since the data model is hardwired to start with five data objects, the effect is that the `colspan` attribute creates a table cell that spans five columns, as shown in Figure 12-7.



Name: Kayak

Name:

Kayak

1	2	3	4	5
Kayak				

Figure 12-7. *Using an attribute binding*

Setting Classes and Styles

Angular provides special support in property bindings for assigning the host element to classes and for configuring individual style properties. I describe these bindings in the sections that follow, along with details of the ngClass and ngStyle directives, which provide closely related features.

Using the Class Bindings

There are three different ways in which you can use data bindings to manage the class memberships of an element: the standard property binding, the special class binding, and the ngClass directive. All three are described in Table 12-6, and each works in a slightly different way and is useful in different circumstances, as described in the sections that follow.

Table 12-6. *The Angular Class Bindings*

Example	Description
`<div [class]="expr"></div>`	This binding evaluates the expression and uses the result to replace any existing class memberships.
`<div [class.myClass]="expr"></div>`	This binding evaluates the expression and uses the result to set the element's membership of myClass.
`<div [ngClass]="map"></div>`	This binding sets class membership of multiple classes using the data in a map object.

Setting All of an Element's Classes with the Standard Binding

The standard property binding can be used to set all of an element's classes in a single step, which is useful when you have a method or property in the component that returns all of the classes that an element should belong to in a single string, with the names separated by spaces. Listing 12-9 shows the revision of the getClasses method in the component that returns a different string of class names based on the price property of a Product object.

Listing 12-9. Providing All Classes in a Single String in the component.ts File

```
import { Component } from "@angular/core";
import { Model } from "./repository.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getClasses(key: number): string {
        let product = this.model.getProduct(key);
        return "p-a-1 " + (product.price < 50 ? "bg-info" : "bg-warning");
    }
}
```

The result from the getClasses method will include the p-a-1 class, which adds padding around the host element's content, for all Product objects. If the value of the price property is less than 50, the bg-info class will be included in the result, and if the value is 50 or more, the bg-warning class will be included (these classes set different background colors).

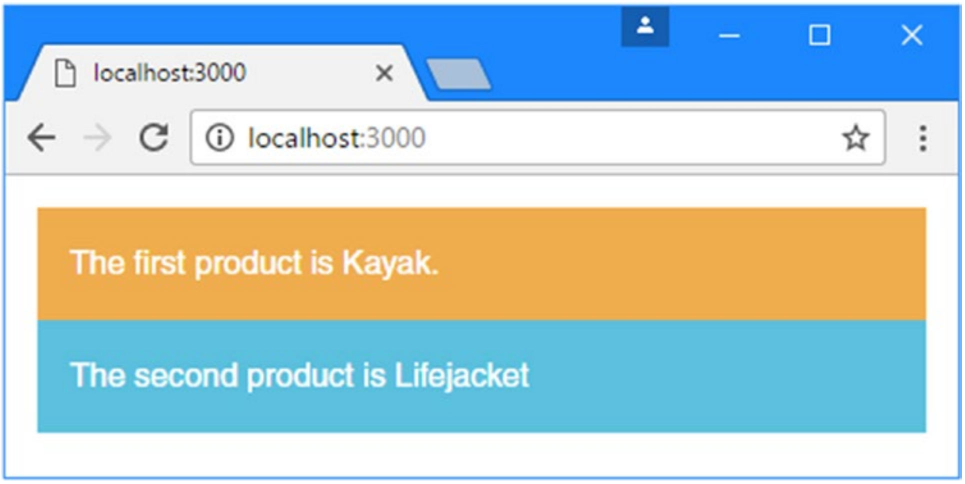
■ **Tip** You must ensure that the names of the classes are separated by spaces.

Listing 12-10 shows the standard property binding being used in the template to set the class property of host elements using the component's getClasses method.

Listing 12-10. Setting Class Memberships Using the Standard Property Binding in the template.html File

```
<div [class]="getClasses(1)">
    The first product is {{model.getProduct(1).name}}.
</div>
<div [class]="getClasses(2)">
    The second product is {{model.getProduct(2).name}}
</div>
```

When the standard property binding is used to set the class property, the result of the expression replaces any previous classes that an element belonged to, which means that it can be used only when the binding expression returns all the classes that are required, as in this example, producing the result shown in Figure 12-8.



The first product is Kayak.

The second product is Lifejacket

Figure 12-8. *Setting class memberships*

Setting Individual Classes Using the Special Class Binding

The special class binding provides finer-grained control than the standard property binding and allows the membership of a single class to be managed using an expression. This is useful if you want to build on the existing class memberships of an element, rather than replace them entirely. Listing 12-11 shows the use of the special class binding.

Listing 12-11. Using the Special Class Binding in the template.html File

```
<div [class]="getClasses(1)">
    The first product is {{model.getProduct(1).name}}.
</div>
<div class="p-a-1"
     [class.bg-success]="model.getProduct(2).price < 50"
     [class.bg-info]="model.getProduct(2).price >= 50">
        The second product is {{model.getProduct(2).name}}
</div>
```

The special class binding is specified with a target that combines the term `class`, followed by a period, followed by the name of the class whose membership is being managed. In the listing, there are two special class bindings, which manage the membership of the `bg-success` and `bg-info` classes.

The special class binding will add the host element to the specified class if the result of the expression is *truthy* (as described in the "Understanding Truthy and Falsy" sidebar). In this case, the host element will be a member of the `bg-success` class if the `price` property is less than 50 and a member of the `bg-info` class if the price property is 50 or more.

These bindings act independently from one another and do not interfere with any existing classes that an element belongs to, such as the `p-a-1` class, which Bootstrap uses to add padding around an element's content.

UNDERSTANDING TRUTHY AND FALSY

JavaScript has an odd feature, where the result of an expression can be truthy or falsy, providing a pitfall for the unwary. The following results are always falsy:

– The `false` (`boolean`) value

– The `0` (`number`) value

– The empty string (`""`)

– `null`

– `undefined`

– `NaN` (a special number value)

All other values are truthy, which can be confusing. For example, `"false"` (a string whose content is the word `false`) is truthy. The best way to avoid confusion is to only use expressions that evaluate to the `boolean` values `true` and `false`.

Setting Classes Using the ngClass Directive

The `ngClass` directive is a more flexible alternative to the standard and special property bindings and behaves differently based on the type of data that is returned by the expression, as described in Table 12-7.

Table 12-7. *The Expression Result Types Supported by the ngClass Directive*

Name	Description
String	The host element is added to the classes specified by the string. Multiple classes are separated by spaces.
Array	Each object in the array is the name of a class that the host element will be added to.
Object	Each property on the object is the name of one or more classes, separated by spaces. The host element will be added to the class if the value of the property is truthy.

The string and array features are useful, but it is the ability to use an object (known as a *map*) to create complex class membership policies that makes the `ngClass` directive especially useful. Listing 12-12 shows the addition of a component method that returns a map object.

Listing 12-12. Returning a Class Map Object in the component.ts File

```
import { Component } from "@angular/core";
import { Model } from "./repository.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getClasses(key: number): string {
        let product = this.model.getProduct(key);
        return "p-a-1 " + (product.price < 50 ? "bg-info" : "bg-warning");
    }

    getClassMap(key: number): Object {
        let product = this.model.getProduct(key);
        return {
            "text-xs-center bg-danger": product.name == "Kayak",
            "bg-info": product.price < 50
        };
    }
}
```

The `getClassMap` method returns an object with properties whose values are one or more class names, with values based on the property values of the `Product` object whose key is specified as the method argument. As an example, when the key is 1, the method returns this object:

```
{
  "text-xs-center bg-danger":true,
  "bg-info":false
}
```

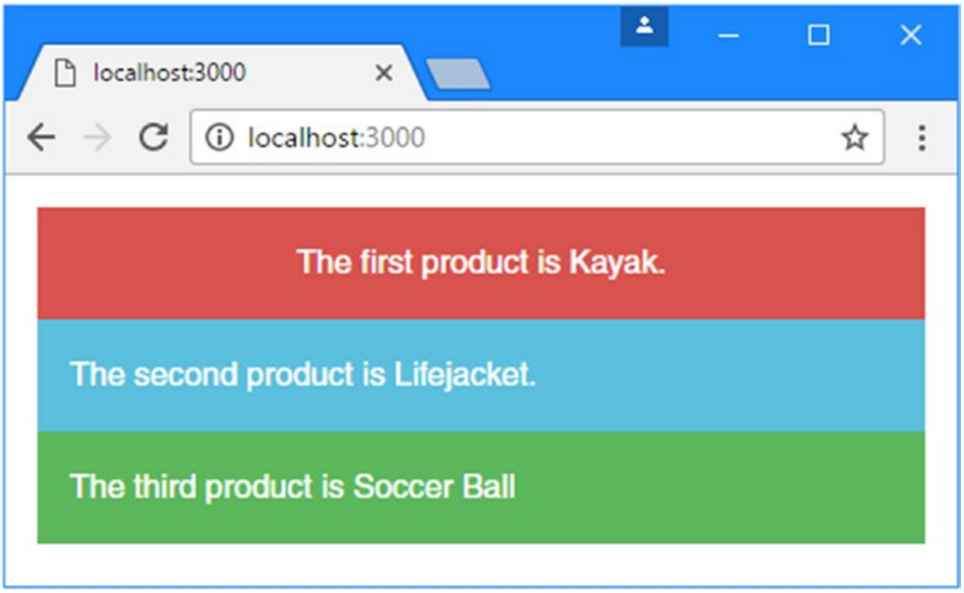
The first property will assign the host element to the `text-xs-center` class (which Bootstrap uses to center the text horizontally) and the `bg-danger` class (which sets the element's background color). The second property evaluates to `false`, which means that the host element will not be added to the `bg-info` class. It may seem odd to specify a property that doesn't result in an element being added to a class, but, as you will see shortly, the value of expressions is automatically updated to reflect changes in the application, and being able to define a map object that specifies memberships this way can be useful.

Listing 12-13 shows the `getClassMap` and the map objects it returns used as the expression for data bindings that target the `ngClass` directive.

Listing 12-13. Using the ngClass Directive in the template.html File

```
<div class="p-a-1" [ngClass]="getClassMap(1)">
    The first product is {{model.getProduct(1).name}}.
</div>
<div class="p-a-1" [ngClass]="getClassMap(2)">
    The second product is {{model.getProduct(2).name}}.
</div>
<div class="p-a-1" [ngClass]="{'bg-success': model.getProduct(3).price < 50,
                                'bg-info': model.getProduct(3).price >= 50}">
        The third product is {{model.getProduct(3).name}}
</div>
```

The first two `div` elements have bindings that use the `getClassMap` method. The third `div` element shows an alternative approach, which is to define the map in the template. For this element, membership of the `bg-info` and `bg-warning` classes is tied to the value of the price property of a `Product` object, as shown in Figure 12-9. Care should be taken with this technique because the expression contains JavaScript logic that cannot be readily tested.



The first product is Kayak.

The second product is Lifejacket.

The third product is Soccer Ball

Figure 12-9. *Using the ngClass directive*

Using the Style Bindings

There are three different ways in which you can use data bindings to set style properties of the host element: the standard property binding, the special style binding, and the `ngStyle` directive. All three are described in Table 12-8 and demonstrated in the sections that follow.

Table 12-8. *The Angular Style Bindings*

Example	Description
`<div [style.myStyle]="expr"></div>`	This is the standard property binding, which is used to set a single style property to the result of the expression.
`<div [style.myStyle.units]="expr"></div>`	This is the special style binding, which allows the units for the style value to be specified as part of the target.
`<div [ngStyle]="map"></div>`	This binding sets multiple style properties using the data in a map object.

Setting a Single Style Property

The standard property binding and the special style bindings are used to set the value of a single style property. The difference between these bindings is that the standard property binding must include the units required for the style, while the special binding allows for the units to be included in the binding target.

To demonstrate the difference, Listing 12-14 adds two new properties to the component.

Listing 12-14. Adding Properties in the component.ts File

```
import { Component } from "@angular/core";
import { Model } from "./repository.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getClasses(key: number): string {
        let product = this.model.getProduct(key);
        return "p-a-1 " + (product.price < 50 ? "bg-info" : "bg-warning");
    }

    getClassMap(key: number): Object {
        let product = this.model.getProduct(key);
        return {
            "text-xs-center bg-danger": product.name == "Kayak",
            "bg-info": product.price < 50
        };
    }

    fontSizeWithUnits: string = "30px";
    fontSizeWithoutUnits: string= "30";
}
```

The fontSizeWithUnits property returns a value that includes a quantity and the units that quantity is expressed in: 30 pixels. The fontSizeWithoutUnits property returns just the quantity, without any unit information. Listing 12-15 shows how these properties can be used with the standard and special bindings.

■ **Caution** Do not try to use the standard property binding to target the style property in order to set multiple style values. The object returned by the style property of the JavaScript object that represents the host element in the DOM is read-only. Some browsers will ignore this and allow changes to be made, but the results are unpredictable and cannot be relied on. If you want to set multiple style properties, then create a binding for each of them, or use the ngStyle directive.

Listing 12-15. Using Style Bindings in the template.html File

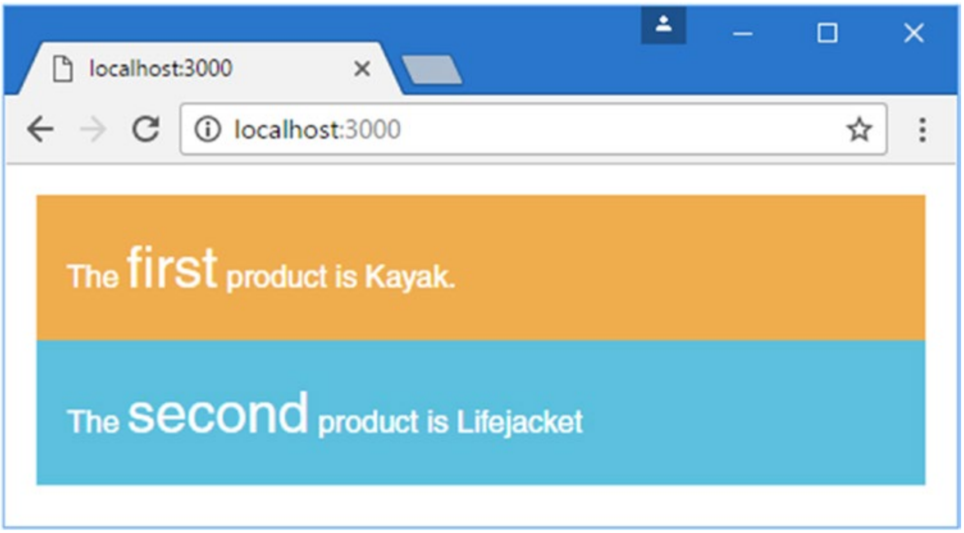
```
<div class="p-a-1 bg-warning">
    The <span [style.fontSize]="fontSizeWithUnits">first</span>
     product is {{model.getProduct(1).name}}.
</div>
<div class="p-a-1 bg-info">
    The <span [style.fontSize.px]="fontSizeWithoutUnits">second</span>
     product is {{model.getProduct(2).name}}
</div>
```

The target for the binding is style.fontSize, which sets the size of the font used for the host element's content. The expression for this binding uses the fontSizeWithUnits property, whose value includes the units, px for pixels, required to set the font size.

The target for the special binding is style.fontSize.px, which tells Angular that the value of the expression specifies the number in pixels. This allows the binding to use the component's fontSizeWithoutUnits property, which doesn't include units.

■ **Tip** You can specify style properties using the JavaScript property name format ([style.fontSize]) or using the CSS property name format ([style.font-size]).

The result of both bindings is the same, which is to set the font size of the span elements to 30 pixels, producing the result shown in Figure 12-10.



The first product is Kayak.

The second product is Lifejacket

Figure 12-10. *Setting individual style properties*

Setting Styles Using the ngStyle Directive

The ngStyle directive allows multiple style properties to be set using a map object, similar to the way that the ngClass directive works. Listing 12-16 shows the addition of a component method that returns a map containing style settings.

Listing 12-16. Creating a Style Map Object in the component.ts File

```
import { Component } from "@angular/core";
import { Model } from "./repository.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getClasses(key: number): string {
        let product = this.model.getProduct(key);
        return "p-a-1 " + (product.price < 50 ? "bg-info" : "bg-warning");
    }

    getStyles(key: number) {
        let product = this.model.getProduct(key);
        return {
            fontSize: "30px",
            "margin.px": 100,
            color: product.price > 50 ? "red" : "green"
        };
        }
}
```

The map object returned by the `getStyle` method shows that the `ngStyle` directive is able to support both of the formats that can be used with property bindings, either including the units in the value or the property name. Here is the map object that the `getStyles` method produces when the value of the key argument is 1:

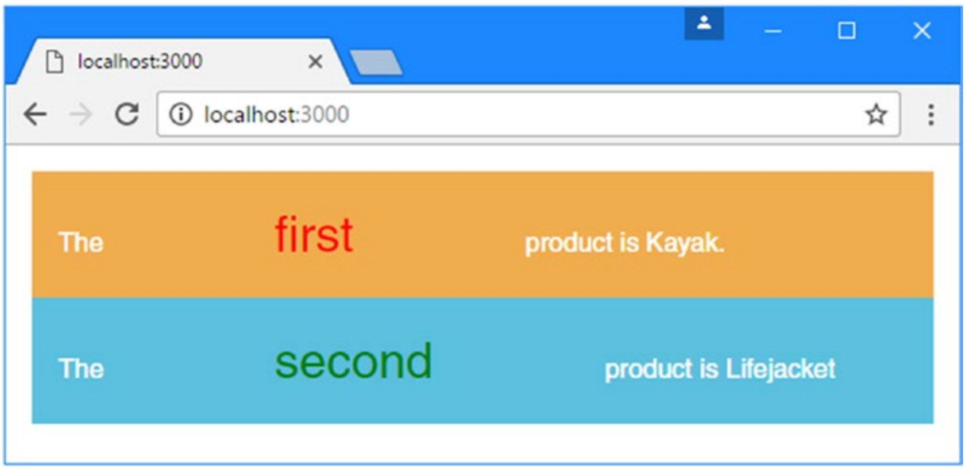
```
{
  "fontSize":"30px",
  "margin.px":100,
  "color":"red"
}
```

Listing 12-17 shows data bindings in the template that use the `ngStyle` directive and whose expressions call the `getStyles` method.

Listing 12-17. Using the ngStyle Directive in the template.html File

```
<div class="p-a-1 bg-warning">
    The <span [ngStyle]="getStyles(1)">first</span>
     product is {{model.getProduct(1).name}}.
</div>
<div class="p-a-1 bg-info">
    The <span [ngStyle]="getStyles(2)">second</span>
     product is {{model.getProduct(2).name}}
</div>
```

The result is that each `span` element receives a tailored set of styles, based on the argument passed to the `getStyles` method, as shown in Figure 12-11.



The first product is Kayak.

The second product is Lifejacket

Figure 12-11. *Using the ngStyle directive*

Updating the Data in the Application

When you start out with Angular, it can seem like a lot of effort to deal with the data bindings, remembering which binding is required in different situations. You might be wondering if it is worth the effort.

Bindings are definitively worth understanding, and the reason is that bindings' expressions are reevaluated when the data they depend on changes. As an example, if you are using a string interpolation binding to display the value of a property, then the binding will automatically update when the value of the property is changed.

To provide a demonstration, I am going to jump ahead and show you how to take manual control of the updating process. This is not a technique that is required in normal Angular development, but it provides a solid demonstration of why bindings are so important. Listing 12-18 shows some changes to the component that enable the demonstration.

Listing 12-18. Preparing the Component in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    constructor(ref: ApplicationRef) {
        (<any>window).appRef = ref;
        (<any>window).model = this.model;
    }

    getProductByPosition(position: number): Product {
        return this.model.getProducts()[position];
    }

    getClassesByPosition(position: number): string {
        let product = this.getProductByPosition(position);
        return "p-a-1 " + (product.price < 50 ? "bg-info" : "bg-warning");
    }
}
```

I have imported the `ApplicationRef` type from the `@angular/core` module. When Angular performs the bootstrapping process, it creates an `ApplicationRef` object to represent the application. Listing 12-18 adds a constructor to the component that receives an `ApplicationRef` object as an argument, using the Angular dependency injection feature, which I describe in Chapter 19. Without going into detail now, declaring a constructor argument like this tells Angular that the component wants to receive the `ApplicationRef` object when a new instance is created.

Within the constructor, there are two statements that make a demonstration possible but would undermine many of the benefits of using TypeScript and Angular if used in a real project.

```
...
(<any>window).appRef = ref;
(<any>window).model = this.model;
...
```

These statements define variables in the global namespace and assign the ApplicationRef and Model objects to them. It is good practice to keep the global namespace as clear as possible, but exposing these objects allows them to be manipulated through the browser's JavaScript console, which is important for this example.

The other methods added to the constructor allow a Product object to be retrieved from the repository based on its position, rather than by its key, and to generate a class map that differs based on the value of the price property.

Listing 12-19 shows the corresponding changes to the template, which uses the ngClass directive to set class memberships and the string interpolation binding to display the value of the Product.name property.

Listing 12-19. Preparing for Changes in the template.html File

```
<div [ngClass]="getClassesByPosition(0)">
    The first product is {{getProductByPosition(0).name}}.
</div>
<div [ngClass]="getClassesByPosition(1)">
    The second product is {{getProductByPosition(1).name}}
</div>
```

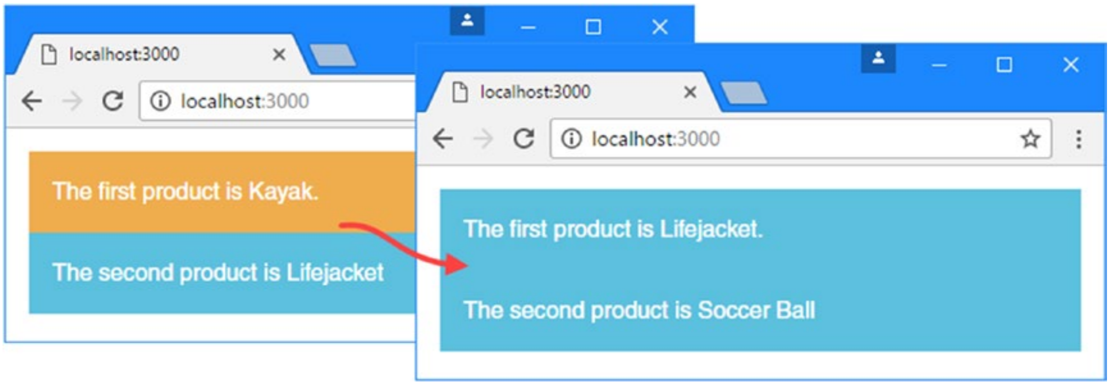
Save the changes to the component and template. Once the browser has reloaded the page, enter the following statement into the browser's JavaScript console and press Return:

```
model.products.shift()
```

This statement calls the shift method on the array of Product objects in the model, which removes the first item from the array and returns it. You won't see any changes yet because Angular doesn't know that the model has been modified. To tell Angular to check for changes, enter the following statement into the browser's JavaScript console and press Return:

```
appRef.tick()
```

The tick method starts the Angular change detection process, where Angular looks at the data in the application and the expressions in the data binding and processes any changes. The data bindings in the template use specific array indexes to display data, and now that an object has been removed from the model, the bindings will be updated to display new values, as shown in Figure 12-12.



The first product is Kayak.

The second product is Lifejacket

The first product is Lifejacket.

The second product is Soccer Ball

Figure 12-12. *Manually updating the application model*

It is worth taking a moment to think about what happened when the change detection process ran. Angular reevaluated the expressions on the bindings in the template and updated their values. In turn, the `ngClass` directive and the string interpolation binding reconfigured their host elements by changing their class memberships and displaying new content.

The happens because Angular data bindings are *live*, meaning that the relationship between the expression, the target, and the host element continues to exist after the initial content is displayed to the user and dynamically reflects changes to the application state. This effect is, I admit, much more impressive when you don't have to make changes using the JavaScript console. I explain how Angular allows the user to trigger changes using events and forms in Chapter 14.

Summary

In this chapter, I described the structure of Angular data bindings and showed you how they are used to create relationships between the data in the application and the HTML elements that are displayed to the user. I introduced the property bindings and described how two of the built-in directives—`ngClass` and `ngStyle`—are used. In the next chapter, I explain how the rest of the built-in directives work.

CHAPTER 13

Using the Built-In in Directives

In this chapter, I describe the built-in directives that are responsible for some of the most commonly required functionality for creating web applications: selectively including content, choosing between different fragments of content, and repeating content. I also describe some limitations that Angular puts on the expressions that are used for one-way data bindings and the directives that provide them. Table 13-1 puts the built-in template directives in context.

***Table 13-1.** Putting the Built-in Directives in Context*

Question	Answer
What are they?	The built-in directives described in this chapter are responsible for selectively including content, selecting between fragments of content, and repeating content for each item in an array. There are also directives for setting an element's styles and class memberships, as described in Chapter 13.
Why are they useful?	The tasks that can be performed with these directives are the most common and fundamental in web application development, and they provide the foundation for adapting the content shown to the user based on the data in the application.
How are they used?	The directives are applied to HTML elements in templates. There are examples throughout this chapter (and in the rest of the book).
Are there any pitfalls or limitations?	The syntax for using the built-in template directives requires you to remember that some of them (including `ngIf` and `ngFor`) must be prefixed with an asterisk, while others (including `ngClass`, `ngStyle`, and `ngSwitch`) must be enclosed in square brackets. I explain why this is required in the "Understanding Micro-Template Directives" sidebar, but it is easy to forget and get an unexpected result.
Are there any alternatives?	You could write your own custom directives—a process that I described in Chapters 15 and 16—but the built-in directives are well-written and comprehensively tested. For most applications, using the built-in directives is preferable, unless they cannot provide exactly the functionality that is required.

Table 13-2 summarizes the chapter.

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Table 13-2. *Chapter Summary*

Problem	Solution	Listing
Conditionally display content based on a data binding expression	Use the `ngIf` directive	1–3
Choose between different content based on the value of a data binding expression	Use the `ngSwitch` directive	4, 5
Generate section of content for each object produced by a data binding expression	Use the `ngFor` directive	6–12
Repeat a block of content	Use the `ngTemplateOutlet` directive	13–14
Prevent template errors	Avoid modifying the application state as a side effect of a data binding expression	15–19
Avoid context errors	Ensure that data binding expressions use only the properties and methods provided by the template's component	20–22

Preparing the Example Project

This chapter relies on the `example` project that was created in Chapter 11 and modified in Chapter 12. To prepare for the topic of this chapter, Listing 13-1 shows changes to the component class that remove features that are no longer required and adds new methods and a property.

Listing 13-1. Changes in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    constructor(ref: ApplicationRef) {
        (<any>window).appRef = ref;
        (<any>window).model = this.model;
    }

    getProductByPosition(position: number): Product {
        return this.model.getProducts()[position];
    }

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }
    getProducts(): Product[] {
        return this.model.getProducts();
    }

    getProductCount(): number {
        return this.getProducts().length;
    }

    targetName: string = "Kayak";
}
```

Listing 13-2 shows the contents of the template file, which displays the number of products in the data model by calling the component's new `getProductCount` method.

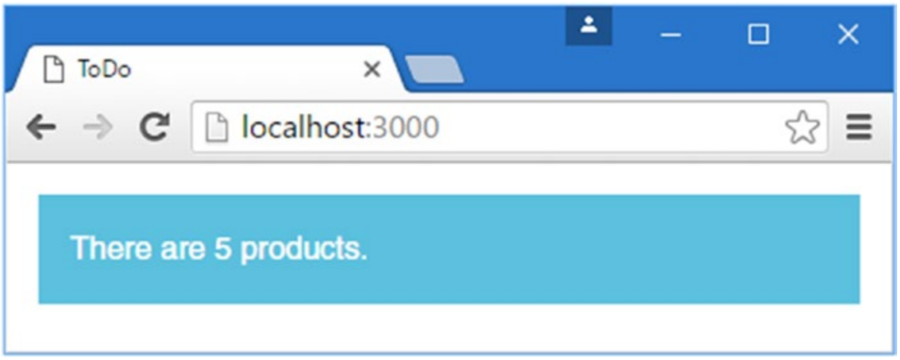
Listing 13-2. The Contents of the template.html File

```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>
```

Run the following command from the command line in the `example` folder to start the TypeScript compiler and the development HTTP server:

```
npm start
```

A new browser window will open and load the `index.html` file from the `example` folder, displaying the content shown in Figure 13-1.



There are 5 products.

Figure 13-1. *Running the example application*

Using the Built-in Directives

Angular comes with a set of built-in directives that provide features that are commonly required in web applications so that you don't have to reinvent the wheel in your own projects. Table 13-3 describes the directives that are available, which I demonstrate in the sections that follow (except for the `ngClass` and `ngStyle` directives, which are covered in Chapter 12).

Table 13-3. *The Built-in Directives*

Example	Description
`<div *ngIf="expr"></div>`	The ngIf directive is used to include an element and its content in the HTML document if the expression evaluates as true. The asterisk before the directive name indicates that this is a micro-template directive, as described in the "Understanding Micro-Template Directives" sidebar.
`<div [ngSwitch]="expr"> <span *ngSwitchCase="expr"></span> <span *ngSwitchDefault></span> </div>`	The ngSwitch directive is used to choose between multiple elements to include in the HTML document based on the result of an expression, which is then compared to the result of the individual expressions defined using ngSwitchCase directives. If none of the ngSwitchCase values matches, then the element to which the ngSwitchDefault directive has been applied will be used. The asterisks before the ngSwitchCase and ngSwitchDefault directives indicate they are micro-template directives, as described in the "Understanding Micro-Template Directives" sidebar.
`<div *ngFor="#item of expr"></div>`	The ngFor directive is used to generate the same set of elements for each object in an array. The asterisk before the directive name indicates that this is a micro-template directive, as described in the "Understanding Micro-Template Directives" sidebar.
`<template [ngTemplateOutlet]="myTempl"> </template>`	The ngTemplateOutlet directive is used to repeat a block of content in a template.
`<div ngClass="expr"></div>`	The ngClass directive is used to manage class membership, as described in Chapter 12.
`<div ngStyle="expr"></div>`	The ngStyle directive is used to manage styles applied directly to elements (as opposed to applying styles through classes), as described in Chapter 12.

Using the ngIf Directive

The ngIf is the simplest of the built-in directives and is used to include a fragment of HTML in the document when an expression evaluates as true, as shown in Listing 13-3.

Listing 13-3. Using the ngIf Directive in the template.html File

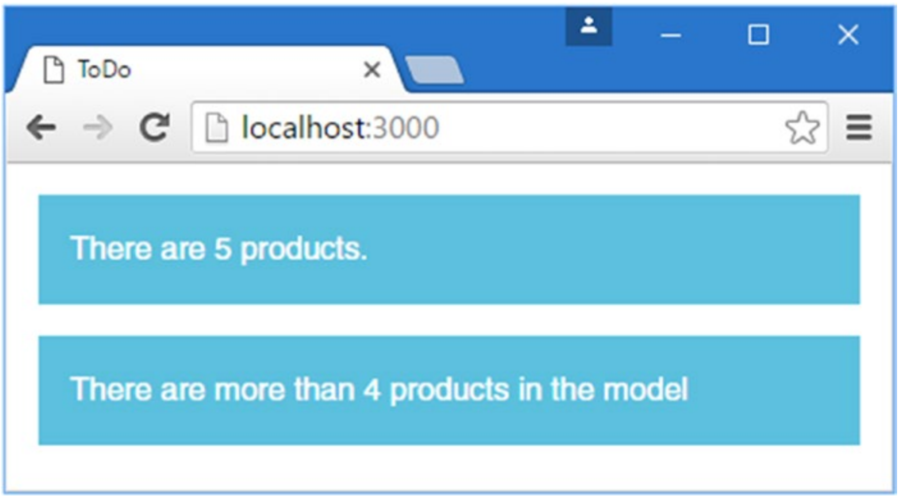
```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>

<div *ngIf="getProductCount() > 4" class="bg-info p-a-1 m-t-1">
    There are more than 4 products in the model
</div>
```

```
<div *ngIf="getProductByPosition(0).name != 'Kayak'" class="bg-info p-a-1 m-t-1">
    The first product isn't a Kayak
</div>
```

The `ngIf` directive has been applied to two `div` elements, with expressions that check the number of `Product` objects in the model and whether the name of the first `Product` is Kayak.

The first expression evaluates as `true`, which means that `div` element and its content will be included in the HTML document; the second expression evaluates as `false`, which means that the second `div` element will be excluded. Figure 13-2 shows the result.

■ **Note** The `ngIf` directive adds and removes elements from the HTML document, rather than just showing or hiding them. Use the property or style bindings, described in Chapter 12, if you want to leave elements in place and control their visibility, either by setting the `hidden` element property to `true` or setting the `display` style property to `none`.



There are 5 products.

There are more than 4 products in the model

Figure 13-2. *Using the ngIf directive*

UNDERSTANDING MICRO-TEMPLATE DIRECTIVES

Some directives, such as `ngFor`, `ngIf`, and the nested directives used with `ngSwitch` are prefixed with an asterisk, as in `*ngFor`, `*ngIf`, and `*ngSwitch`. The asterisk is shorthand for using directives that rely on content provided as part of the template, known as a *micro-template*. Directives that use micro-templates are known as *structural directives*, a description that I revisit in Chapter 16, when I show you how to create them.

Listing 13-3 applied the `ngIf` directive to `div` elements, which tells the directive to use the `div` element and its content as the micro-template for each of the objects that it processes. Behind the scenes, Angular expands the micro-template and the directive like this:

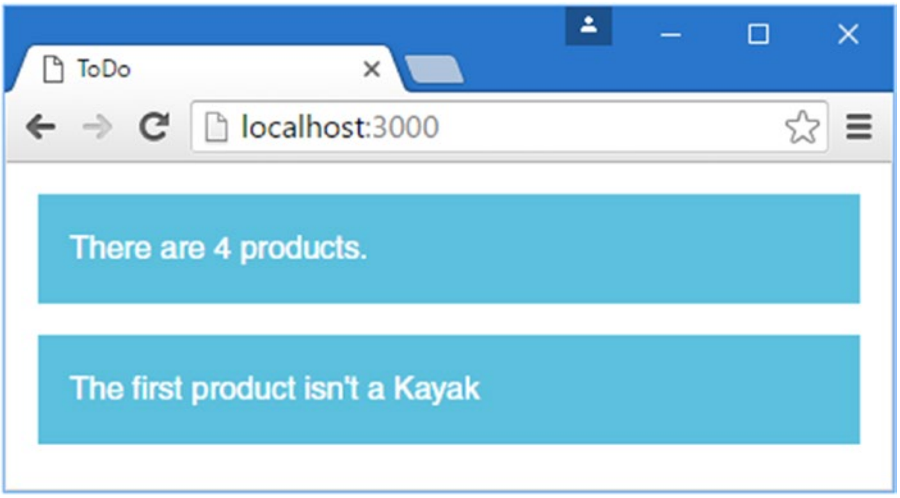
```
...
<template ngIf="model.getProductCount() > 4">
    <div class="bg-info p-a-1 m-t-1">
        There are more than 4 products in the model
    </div>
</template>
...
```

You can use either syntax in your templates, but if you use the compact syntax, then you must remember to use the asterisk. I explain how to create your own micro-template directives in Chapter 14.

Like all directives, the expression used for ngIf will be reevaluated to reflect changes in the data model. Run the following statements in the browser's JavaScript console to remove the first data object and to run the change detection process:

```
model.products.shift()
appRef.tick()
```

The effect of modifying the model is to remove the first div element, because there are too few Product objects now, and to add the second div element, because the name property of the first Product in the array is no longer Kayak. Figure 13-3 shows the change.



There are 4 products.

The first product isn't a Kayak

Figure 13-3. *The effect of reevaluating directive expressions*

Using the ngSwitch Directive

The ngSwitch directive selects one of several elements based on the expression result, similar to a JavaScript switch statement. Listing 13-4 shows the ngSwitch directive being used to choose an element based on the number of objects in the model.

Listing 13-4. Using the ngSwitch Directive in the template.html File

```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>

<div class="bg-info p-a-1 m-t-1" [ngSwitch]="getProductCount()">
    <span *ngSwitchCase="2">There are two products</span>
    <span *ngSwitchCase="5">There are five products</span>
    <span *ngSwitchDefault>This is the default</span>
</div>
```

The ngSwitch directive syntax can be confusing to use. The element that the ngSwitch directive is applied to is always included in the HTML document, and the directive name isn't prefixed with an asterisk. It must be specified within square brackets, like this:

```
...
<div class="bg-info p-a-1 m-t-1" [ngSwitch]="getProductCount()">
...
```

Each of the inner elements, which are span elements in this example, is a micro-template, and the directives that specify the target expression result are prefixed with an asterisk, like this:

```
...
<span *ngSwitchCase="5">There are five products</span>
...
```

The ngSwitchCase directive is used to specify a particular expression result. If the ngSwitch expression evaluates to the specified result, then that element and its contents will be included in the HTML document. If the expression doesn't evaluate to the specified result, then the element and its contents will be excluded from the HTML document.

The ngSwitchDefault directive is applied to a fallback element—equivalent to the default label in a JavaScript switch statement—which is included in the HTML document if the expression result doesn't match any of the results specified by the ngSwitchCase directives.

For the initial data in the application, the directives in Listing 13-4 produce the following HTML:

```
<div class="bg-info p-a-1 m-t-1" ng-reflect-ng-switch="5">
    <span>There are five products</span>
</div>
```

The div element, to which the ngSwitch directive has been applied, is always included in the HTML document. For the initial data in the model, the span element whose ngSwitchCase directive has a result of 5 is also included, producing the result shown on the left of Figure 13-4.

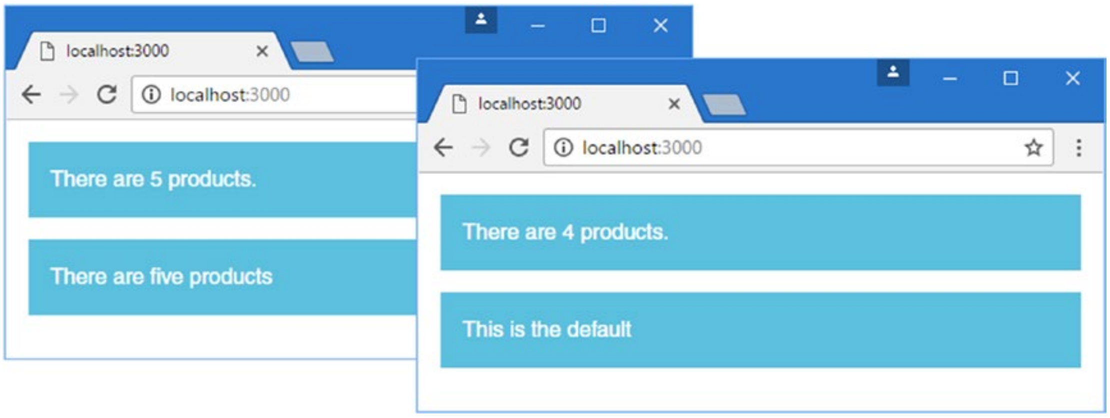


Figure 13-4. *Using the ngSwitch directive*

The ngSwitch binding responds to changes in the data model, which you can test by executing the following statements in the browser's JavaScript console:

```
model.products.shift()
appRef.tick()
```

These statements remove the first item from the model and force Angular to run the change detection process. Neither of the results for the two ngSwitchCase directives matches the result from the getProductCount expression, so the ngSwitchDefault element is included in the HTML document, as shown on the right of Figure 13-4.

Avoiding Literal Value Problems

A common problem arises when using the ngSwitchCase directive to specify literal string values, and care must be taken to get the right effect, as shown in Listing 13-5.

Listing 13-5. Switching on Component and String Literal Values in the template.html File

```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>

<div class="bg-info p-a-1 m-t-1" [ngSwitch]="getProduct(1).name">
    <span *ngSwitchCase="targetName">Kayak</span>
    <span *ngSwitchCase="'Lifejacket'">Lifejacket</span>
    <span *ngSwitchDefault>Other Product</span>
</div>
```

The values assigned to the ngSwitchCase directives are also expressions, which means that you can invoke methods, perform simple inline operations, and read property values, just as you would for the basic data bindings.

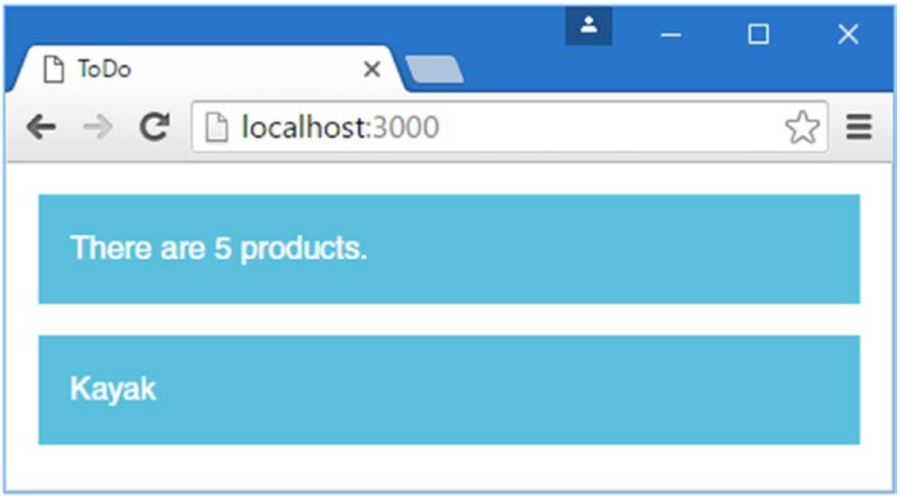
As an example, this expression tells Angular to include the span element to which the directive has been applied when the result of evaluating the ngSwitch expression matches the value of the targetName property defined by the component:

```
...
<span *ngSwitchCase="targetName">Kayak</span>
...
```

If you want to compare a result to a specific string, then you must double quote it, like this:

```
...
<span *ngSwitchCase="'Lifejacket'">Lifejacket</span>
...
```

This expression tells Angular to include the span element when the value of the ngSwitch expression is equal to the literal string value Lifejacket, producing the result shown in Figure 13-5.



There are 5 products.

Kayak

Figure 13-5. *Using expressions and literal values with the ngSwitch directive*

Using the ngFor Directive

The ngFor directive repeats a section of content for each object in a sequence of objects, providing the template equivalent of a foreach loop and providing the ability to enumerate a collection of objects. In Listing 13-6, I have used the ngFor directive to populate a table by generating a row for each Product object in the model.

Listing 13-6. Using the ngFor Directive in the template.html File

```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>

<table class="table table-sm table-bordered m-t-1">
```

```
    <tr><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts()">
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
```

The expression used with the ngFor directive is more complex than for the other built-in directives, but it will start to make sense when you see how the different parts fit together. Here is the directive that I used in the example:

```
...
<tr *ngFor="let item of getProducts()">
...
```

The asterisk before the name is required because the directive is using a micro-template, as described in the "Understanding Micro-Template Directives" sidebar. This will make more sense as you become familiar with Angular, but at first you just have to remember that this directive requires an asterisk to use (or, as I often do, forget until you see an error displayed in the browser's JavaScript console and *then* remember).

For the expression itself, there are two distinct parts, joined together with the of keyword. The right-hand part of the expression provides the data source that will be enumerated.

```
...
<tr *ngFor="let item of getProducts()">
...
```

This example specifies the component's getProducts method as the source of data, which allows content to be for each of the Product objects in the model. The right-hand side is an expression in its own right, which means you can prepare data or perform simple manipulation operations within the template.

The left-hand side of the ngFor expression defines a *template variable*, denoted by the let keyword, which is how data is passed between elements within an Angular template.

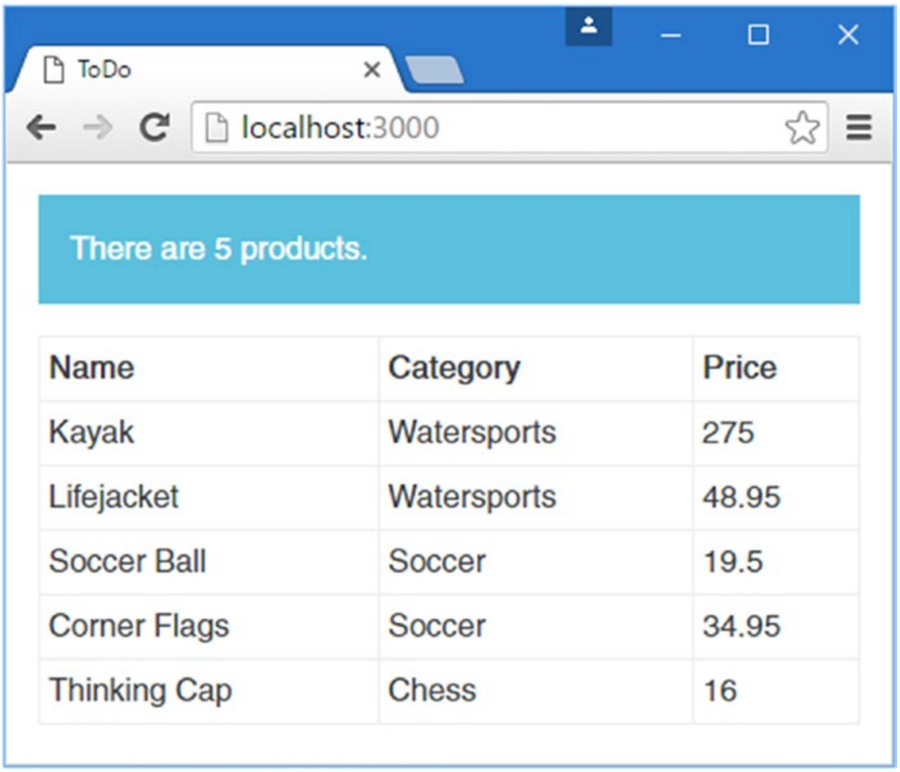
```
...
<tr *ngFor="let item of getProducts()">
...
```

The ngFor directive assigns the variable to each object in the data source so that it is available for use by the nested elements. The local template variable in the example is called item, and it is used to access the Product object's properties for the td elements, like this:

```
...
<td>{{item.name}}</td>
...
```

Put together, the directive in the example tells Angular to enumerate the objects returned by the component's getProducts method, assign each of them to a variable called item, and then generate a tr element and its td children, evaluating the template expressions they contain.

For the example in Listing 13-6, the result is a table where the ngFor directive is used to generate table rows for each of the Product objects in the model and where each table row contains td elements that display the value of the Product object's name, category, and price properties, as shown in Figure 13-6.



There are 5 products.

Name	Category	Price
Kayak	Watersports	275
Lifejacket	Watersports	48.95
Soccer Ball	Soccer	19.5
Corner Flags	Soccer	34.95
Thinking Cap	Chess	16

Figure 13-6. *Using the ngFor directive to create table rows*

Using Other Template Variables

The most important template variable is the one that refers to the data object being processed, which was `item` in the previous example. The `ngFor` directive supports a range of other values that can be assigned to variables and then referred to within the nested HTML elements, as described in Table 13-4 and demonstrated in the sections that follow.

Table 13-4. *The ngFor Local Template Values*

Name	Description
`index`	This `number` value is assigned to the position of the current object.
`odd`	This `boolean` value returns `true` if the current object has an odd-numbered position in the data source.
`even`	This `boolean` value returns `true` if the current object has an even-numbered position in the data source.
`first`	This `boolean` value returns `true` if the current object is the first one in the data source.
`last`	This `boolean` value returns `true` if the current object is the last one in the data source.

Using the Index Value

The index value is set to the position of the current data object and is incremented for each object in the data source. In Listing 13-7, I have defined a table that is populated using the ngFor directive and that assigns the index value to a local template variable called i, which is then used in a string interpolation binding.

Listing 13-7. Using the Index Value in the template.html File

```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>

<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index">
        <td>{{i +1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
```

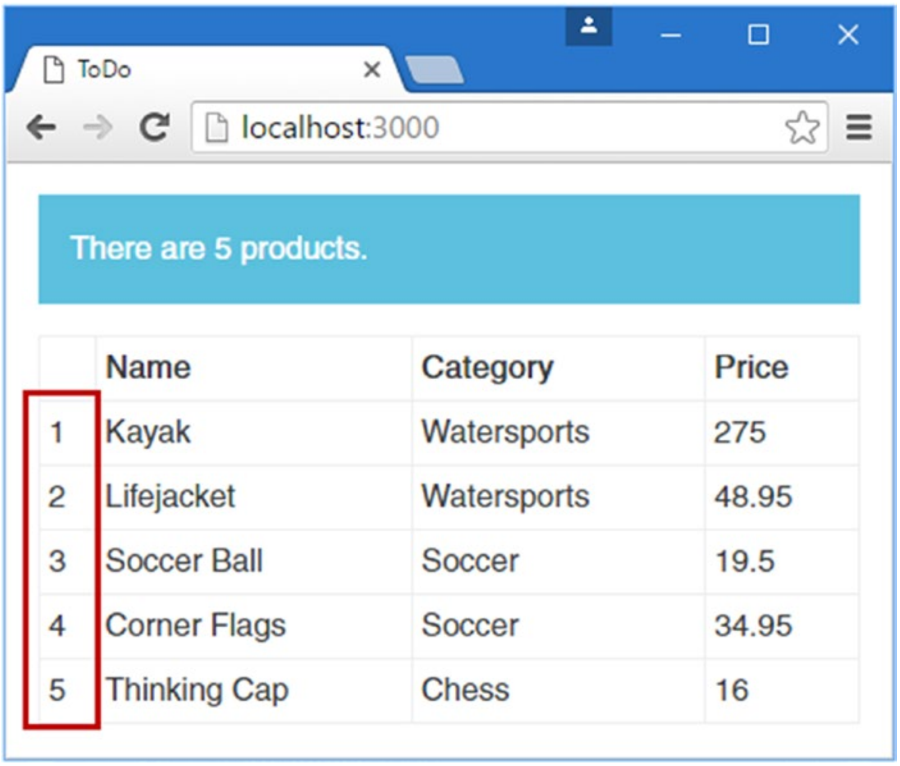
A new term is added to the ngFor expression, separated from the existing one using a semicolon (the ; character). The new expression uses the let keyword to assign the index value to a local template variable called i, like this:

```
...
<tr *ngFor="let item of getProducts(); let i = index">
...
```

This allows the value to be accessed within the nested elements using a binding, like this:

```
...
<td>{{i + 1}}</td>
...
```

The index value is zero-based, and adding 1 to the value creates a simple counter, producing the result shown in Figure 13-7.



There are 5 products.

	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 13-7. *Using the index value*

Using the Odd and Even Values

The odd value is `true` when the `index` value for a data item is odd. Conversely, the even value is `true` when the index value for a data item is even. In general, you only need to use either the odd or even values, since they are `boolean` values where odd is `true` when even is `false`, and vice versa. In Listing 13-8, the odd value is used to manage the class membership of the `tr` elements in the table.

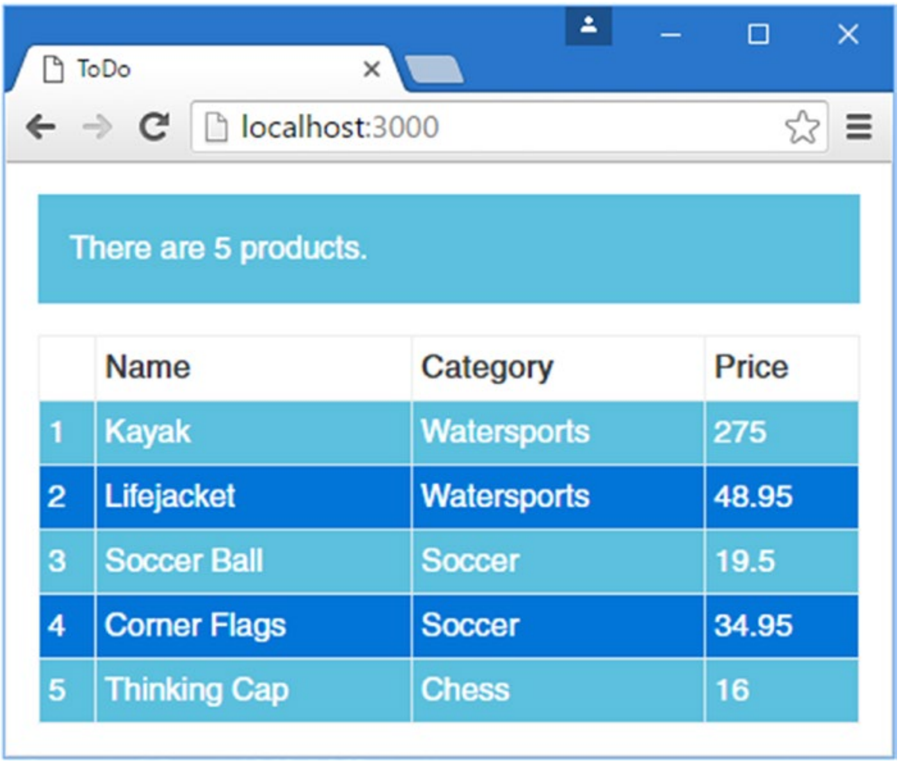
Listing 13-8. Using the Odd Value in the template.html File

```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>

<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index; let odd = odd"
            [class.bg-primary]="odd" [class.bg-info]="!odd">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
```

I have used a semicolon and added another term to the ngFor expression that assigns the odd value to a local template variable that is also called odd.

```
...
<tr *ngFor="let item of getProducts(); let i = index; let odd = odd"
    [class.bg-primary]="odd" [class.bg-info]="!odd">
...
```

This may seem redundant, but you cannot access the ngFor values directly and must use a local variable even if it has the same name. I used the class binding to assign alternate rows to the bg-primary and bg-info classes, which are Bootstrap background color classes that stripe the table rows, as shown in Figure 13-8.



There are 5 products.

	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 13-8. *Using the odd value*

EXPANDING THE *NGFOR DIRECTIVE

Notice that in Listing 13-8, I am able to use the template variable in expressions applied to the same tr element that defines it. This is possible because ngFor is a micro-template directive—denoted by the * that precedes the name—and so Angular expands the HTML so that it looks like this:

```
...
<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <template ngFor let-item [ngForOf]="getProducts()"
            let-i="index" let-odd="odd">
        <tr [class.bg-primary]="odd" [class.bg-info]="!odd">
            <td>{{i + 1}}</td>
            <td>{{item.name}}</td>
            <td>{{item.category}}</td>
            <td>{{item.price}}</td>
        </tr>
    </template>
</table>
...
```

You can see that the `template` element defines the variables, using the somewhat awkward `let-<name>` attributes, which are then accessed by the `tr` and `td` elements within it. As with so much in Angular, what appears to happen by magic turns out to be straightforward once you understand what is going on behind the scenes, and I explain these features in detail in Chapter 16. A good reason to use the `*ngFor` syntax is that it provides a more elegant way to express the directive expression, especially when there are multiple template variables.

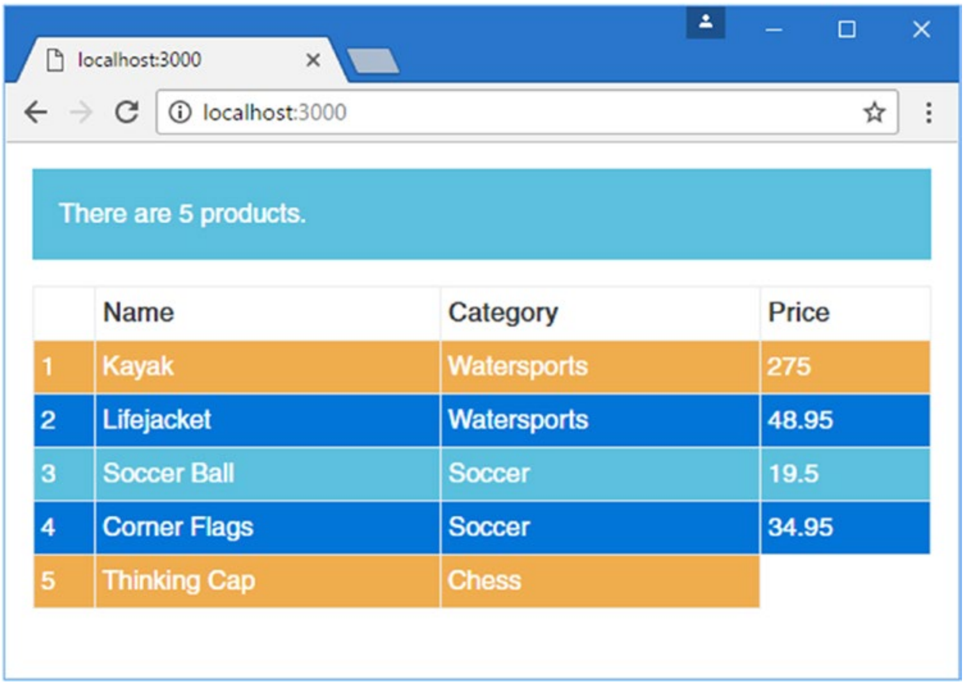
Using the First and Last Values

The `first` value is `true` only for the first object in the sequence provided by the data source and is `false` for all other objects. Conversely, the `last` value is `true` only for the last object in the sequence. Listing 13-9 uses these values to treat the first and last objects differently from the others in the sequence.

Listing 13-9. Using the first and last Values in the template.html File

```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>

<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index; let odd = odd;
            let first = first; let last = last"
            [class.bg-primary]="odd" [class.bg-info]="!odd"
            [class.bg-warning]="first || last">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td *ngIf="!last">{{item.price}}</td>
    </tr>
</table>
```

The new terms in the `ngFor` expression assign the `first` and `last` values to template variables called `first` and `last`. These variables are then used by a `class` binding on the `tr` element, which assigns the element to the `bg-warning` class when either is `true`, and used by the `ngIf` directive on one of the `td` elements, which will exclude the element for the `last` item in the data source, producing the effect shown in Figure 13-9.



There are 5 products.

	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	

Figure 13-9. *Using the first and last values*

Minimizing Element Operations

When there is a change to the data model, the `ngFor` directive evaluates its expression and updates the elements that represent its data objects. The update process can be expensive, especially if the data source is replaced with one that contains different objects representing the same data. Replacing the data source may seem like an odd thing to do, but it happens often in web applications, especially when the data is retrieved from a web service, like the ones I describe in Chapter 24. The same data values are represented by new objects, which present an efficiency problem for Angular. To demonstrate the problem, I added a method to the component that replaces one of the `Product` objects in the data model, as shown in Listing 13-10.

Listing 13-10. Replacing an Object in the repository.model.ts File

```
import { Product } from "./product.model";
import { SimpleDataSource } from "./datasource.model";

export class Model {
    private dataSource: SimpleDataSource;
    private products: Product[];
    private locator = (p:Product, id:number) => p.id == id;

    constructor() {
        this.dataSource = new SimpleDataSource();
        this.products = new Array<Product>();
        this.dataSource.getData().forEach(p => this.products.push(p));
    }
    // ...other methods omitted for brevity...

    swapProduct() {
        let p = this.products.shift();
        this.products.push(new Product(p.id, p.name, p.category, p.price));
    }
}
```

The swapProduct method removes the first object from the array and adds a new object that has the same values for the id, name, category, and price properties. This is an example of data values being represented by a new object.

Run the following statements using the browser's JavaScript console to modify the data model and run the change-detection process:

```
model.swapProduct()
appRef.tick()
```

When the ngFor directive examines its data source, it sees that it has two operations to perform to reflect the change to the data. The first operation is to destroy the HTML elements that represent the first object in the array. The second operation is to create a new set of HTML elements to represent the new object at the end of the array.

Angular has no way of knowing that the data objects it is dealing with have the same values and that it could perform its work more efficiently by simply moving the existing elements within the HTML document.

This problem affects only two elements in this example, but the problem is much more severe when the data in the application is refreshed from an external data source using Ajax, where all of the data model objects can be replaced. Since it is not aware that there have been few real changes, the ngFor directive has to destroy all of its HTML elements and re-create them, which can be an expensive and time-consuming operation.

To improve the efficiency of an update, you can define a component method that will help Angular determine when two different objects represent the same data, as shown in Listing 13-11.

Listing 13-11. Adding the Object Comparison Method in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    // ...constructor and methods omitted for brevity...

    getKey(index: number, product: Product) {
        return product.id;
    }
}
```

The method has to define two parameters: the position of the object in the data source and the data object. The result of the method uniquely identifies an object, and two objects are considered to be equal if they produce the same result.

Two Product objects will be considered equal if they have the same id value. Telling the ngFor expression to use the comparison method is done by adding a trackBy term to the expression, as shown in Listing 13-12.

Listing 13-12. Providing an Equality Method in the template.html File

```
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>

<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index; let odd = odd;
            let first = first; let last = last; trackBy:getKey"
            [class.bg-primary]="odd" [class.bg-info]="!odd"
            [class.bg-warning]="first || last">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td *ngIf="!last">{{item.price}}</td>
    </tr>
</table>
```

With this change, the ngFor directive will know that the Product that is removed from the array using the swapProduct method defined in Listing 13-12 is equivalent to the one that is added to the array, even though they are different objects. Rather than delete and create elements, the existing elements can be moved, which is a much simpler and quicker task to perform.

Changes can still be made to the elements—such as by the ngIf directive, which will remove one of the td elements because the new object will be the last item in the data source, but even this is faster than treating the objects separately.

TESTING THE EQUALITY METHOD

Checking whether the equality method has an effect is a little tricky. The best way that I have found requires using the browser's F12 developer tools, in this case using the Chrome browser.

Once the application has loaded, right-click the td element that contains the word Kayak in the browser window and select Inspect from the pop-up menu. This will open the Developer Tools window and show the Elements panel.

Click the ellipsis button (marked ...) in the left margin and select Add Attribute from the menu. Add an id attribute with the value old. This will result in an element that looks like this:

```
<td id="old">Kayak</td>
```

Adding an id attribute makes it possible to access the object that represents the HTML element using the JavaScript console. Switch to the Console panel and enter the following statement:

```
window.old
```

When you hit Return, the browser will locate the element by its `id` attribute value and display the following result:

```
<td id="old">Kayak</td>
```

Now execute the following statements in the JavaScript console, hitting Return after each one:

```
model.swapProduct()
appRef.tick()
```

Once the change to the data model has been processed, executing the following statement in the JavaScript console will determine whether the `td` element to which the `id` attribute was added has been moved or destroyed:

```
window.old
```

If the element has been moved, then you will see the element shown in the console, like this:

```
<td id="old">Kayak</td>
```

If the element has been destroyed, then there won't be an element whose `id` attribute is `old`, and the browser will display the word `undefined`.

Using the ngTemplateOutlet Directive

The `ngTemplateOutlet` directive is used to repeat a block of content at a specified location, which can be useful when you need to generate the same content in different places and want to avoid duplication. Listing 13-13 shows the directive being used.

Listing 13-13. Using the ngTemplateOutlet Directive in the template.html File

```
<template #titleTemplate>
    <h4 class="p-a-1 bg-success">Repeated Content</h4>
</template>

<template [ngTemplateOutlet]="titleTemplate"></template>

<div class="bg-info p-a-1 m-a-1">
    There are {{getProductCount()}} products.
</div>

<template [ngTemplateOutlet]="titleTemplate"></template>
```

The first step is to define the template that contains the content that you want to repeat using the directive. This is done using the `template` element and assigning it a name using a *reference variable*, like this:

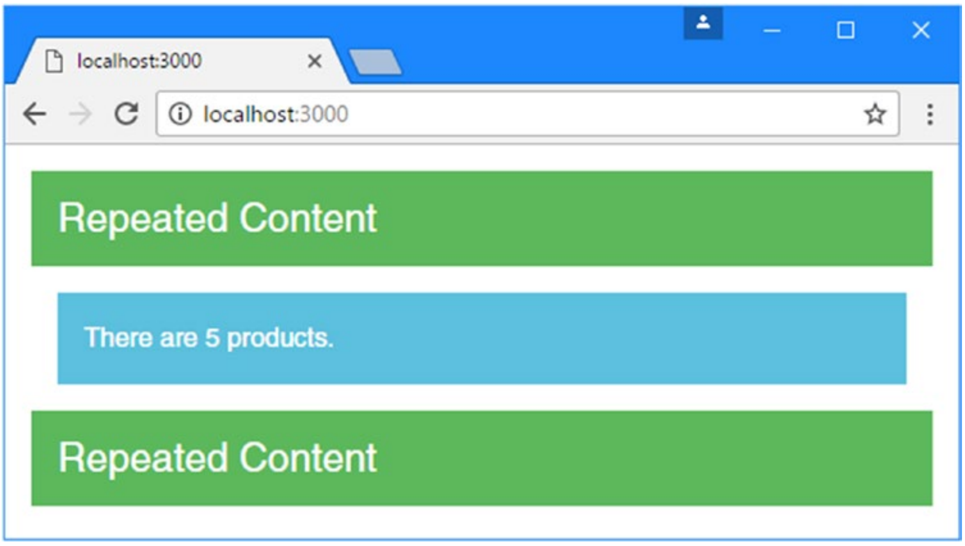
```
...
<template #titleTemplate let-title="title">
    <h4 class="p-a-1 bg-success">{{title}}</h4>
</template>
...
```

When Angular encounters a reference variable, it sets its value to the element to which it has been defined, which is the `template` element in this case.

The second step is to insert the content into the HTML document, using the `ngTemplateOutlet` directive, like this:

```
...
<template [ngTemplateOutlet]="titleTemplate"></template>
...
```

The expression is the name of the reference variable that was assigned to the content that should be inserted. The directive replaces the host element with the contents of the specified `template` element. Neither the `template` element that contains the repeated content nor the one that is the host element for the binding is included in the HTML document. Figure 13-10 shows how the directive has used the repeated content.



Repeated Content

There are 5 products.

Repeated Content

Figure 13-10. *Using the ngTemplateOutlet directive*

Providing Context Data

The ngTemplateOutlet directive can be used to provide the repeated content with a context object that can be used in data bindings defined within the template element, as shown in Listing 13-14.

Listing 13-14. Providing Context Data in the template.html File

```
<template #titleTemplate let-text="title">
    <h4 class="p-a-1 bg-success">{{text}}</h4>
</template>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Header'}">
</template>

<div class="bg-info p-a-1 m-a-1">
    There are {{getProductCount()}} products.
</div>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Footer'}">
</template>
```

To receive the context data, the template element that contains the repeated content defines a let- attribute that specifies the name of a variable, similar to the expanded syntax used for the ngFor directive. The value of the expression assigns the let- variable a value, like this:

```
...
<template #titleTemplate let-text="title">
...
```

The let- attribute in this case creates a variable called text, which is assigned a value by evaluating the expression title. To provide the data against which the expression is evaluated, the template element to which the ngTemplateOutlet directive has been applied provides a map object, like this:

```
...
<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Footer'}">
</template>
...
```

The target of this new binding is ngOutletContext, which looks like another directive but is actually an example of an *input property*, which some directives use to receive data values and that I describe in detail in Chapter 15. The expression for the binding is a map object whose property name corresponds to the let- attribute on the other template element. The result is that the repeated content can be tailored using bindings, as shown in Figure 13-11.

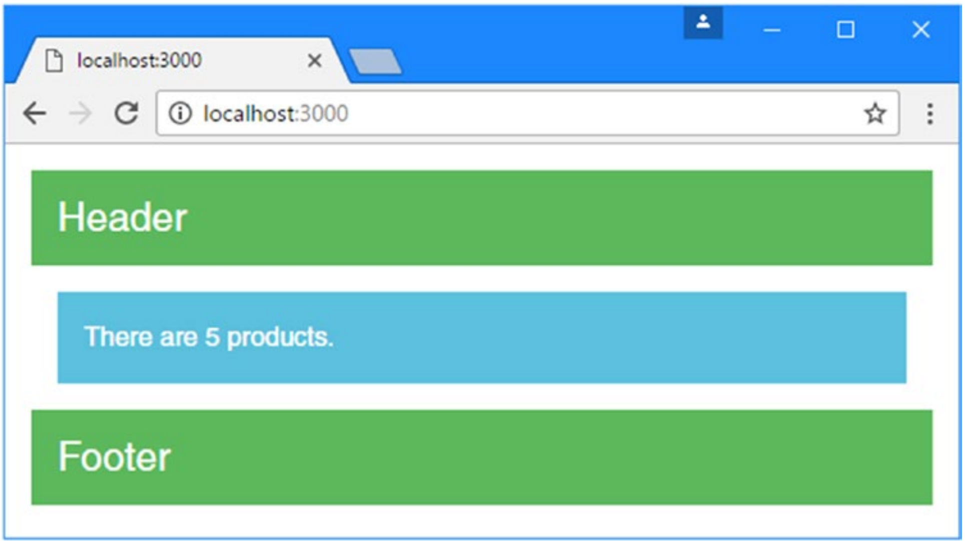


***Figure 13-11.** Providing context data for repeated content*

USING THE CONCISE SYNTAX

The `ngTemplateOutlet` directive can be used in a more concise syntax, like this:

```
...
<div *ngTemplateOutlet="titleTemplate"      [ngOutletContext]="{title: 'Footer'}">
</div>
...
```

There is little advantage to applying the directive this way because it removes the host element from the HTML document and replaces it with the content of the `template` element, which means that it doesn't really matter which element the directive is applied to.

Understanding One-Way Data Binding Restrictions

Although the expressions used in one-way data binding and directives look like JavaScript code, you can't use all the JavaScript—or TypeScript—language features. I explain the restrictions and the reasons for them in the sections that follow.

Using Idempotent Expressions

One-way data bindings must be *idempotent*, meaning that they can be evaluated repeatedly without changing the state of the application. To demonstrate why, I added a debugging statement to the component's `getProductCount` method, as shown in Listing 13-15.

■ **Note** Angular *does* support modifying the application state, but it must be done using the techniques I describe in Chapter 14.

Listing 13-15. Adding a Statement in the component.ts File

```
...
getProductCount(): number {
    console.log("getProductCount invoked");
    return this.getProducts().length;
}
...
```

When the changes are saved and the browser reloads the page, you will see a long series of messages like these in the browser's JavaScript console:

```
...
getProductCount invoked
getProductCount invoked
getProductCount invoked
getProductCount invoked
...
```

As the messages show, Angular evaluates the binding expression several times before displaying the content in the browser. If an expression modifies the state of an application, such as removing an object from a queue, you won't get the results you expect by the time the template is displayed to the user. To avoid this problem, Angular restricts the way that expressions can be used. In Listing 13-16, I added a `counter` property to the component to help demonstrate.

Listing 13-16. Adding a Property in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    // ...constructor and methods omitted for brevity...

    targetName: string = "Kayak";

    counter: number = 1;
}
```

In Listing 13-17, I added a binding whose expression increments the counter when it is evaluated.

Listing 13-17. Adding a Binding in the template.html File

```
<template #titleTemplate let-text="title">
    <h4 class="p-a-1 bg-success">{{text}}</h4>
</template>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Header'}">
</template>

<div class="bg-info p-a-1 m-a-1">
    There are {{getProductCount()}} products.
</div>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Footer'}">
</template>

<div class='bg-info p-a-1'>
    Counter: {{counter = counter + 1}}
</div>
```

When the browser loads the page, you will see an error in the JavaScript console, like this:

```
EXCEPTION: Template parse errors:
Parser Error: Bindings cannot contain assignments at column 11 in [
        Counter: {{counter = counter + 1}}
] in Products@17:27
```

Angular will report an error if a data binding expression contains an operator that can be used to a data, such as =, +=, -+, ++, and --.

In addition, when Angular is running in development mode, it performs an additional check to make sure that one-way data bindings have not been modified after their expressions are evaluated. To demonstrate, Listing 13-18 adds a property to the component that removes and returns a `Product` object from the model array.

■ **Tip** I demonstrated how to switch between development mode (which is the default) and production mode in Chapter 10.

Listing 13-18. Modifying Data in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    // ...constructor and methods omitted for brevity...

    counter: number = 1;

    get nextProduct(): Product {
        return this.model.getProducts().shift();
    }
}
```

In Listing 13-19, you can see the data binding that I used to read the nextProduct property.

Listing 13-19. Binding to a Property in the template.html File

```
<template #titleTemplate let-text="title">
    <h4 class="p-a-1 bg-success">{{text}}</h4>
</template>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Header'}">
</template>

<div class="bg-info p-a-1 m-a-1">
    There are {{getProductCount()}} products.
</div>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Footer'}">
</template>

<div class='bg-info p-a-1'>
    Next Product is {{nextProduct.name}}
</div>
```

When you save the changes and Angular processes the template, you will see that the attempt to change the application data in the data binding produces the following error in the JavaScript console:

```
ORIGINAL EXCEPTION: Expression has changed after it was checked.
Previous value: 'There are 5 products.'.
Current value: 'There are 4 products.'
```

Understanding the Expression Context

When Angular evaluates an expression, it does so in the context of the template's component, which is how the template is able to access methods and properties without any kind of prefix, like this:

```
...
<div class="bg-info p-a-1">
    There are {{getProductCount()}} products.
</div>
...
```

When Angular processes these expressions, the component provides the `getProductCount` method, which Angular invokes with the specified arguments and then incorporates the result into the HTML document. The component is said to provide the template's *expression context*.

The expression context means you can't access objects defined outside of the template's component and, in particular, templates can't access the global namespace. The global namespace is used to define common utilities, such as the `console` object, which defines the `log` method I have been using to write out debugging information to the browser's JavaScript console. The global namespace also includes the `Math` object, which provides access to some useful arithmetical methods, such as `min` and `max`.

To demonstrate this restriction, Listing 13-20 adds a string interpolation binding to the template that relies on the `Math.floor` method to round down a `number` value to the nearest integer.

Listing 13-20. Accessing the Global Namespace in the template.html File

```
<template #titleTemplate let-text="title">
    <h4 class="p-a-1 bg-success">{{text}}</h4>
</template>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Header'}">
</template>

<div class="bg-info p-a-1 m-a-1">
    There are {{getProductCount()}} products.
</div>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Footer'}">
</template>

<div class='bg-info p-a-1'>
    The rounded price is {{Math.floor(getProduct(1).price)}}
</div>
```

When Angular processes the template, it will produce the following error in the browser's JavaScript console:

```
EXCEPTION: TypeError: Cannot read property 'floor' of undefined
```

The error message doesn't specifically mention the global namespace. Instead, Angular has tried to evaluate the expression using the component as the context and failed to find a `Math` property.

If you want to access functionality in the global namespace, then it must be provided by the component, acting as on behalf of the template. In the case of the example, the component could just define a `Math` property that is assigned to the global object, but template expressions should be as clear and simple as possible, so a better approach is to define a method that provides the template with the specific functionality it requires, as shown in Listing 13-21.

Listing 13-21. Defining a Method in the component.ts File

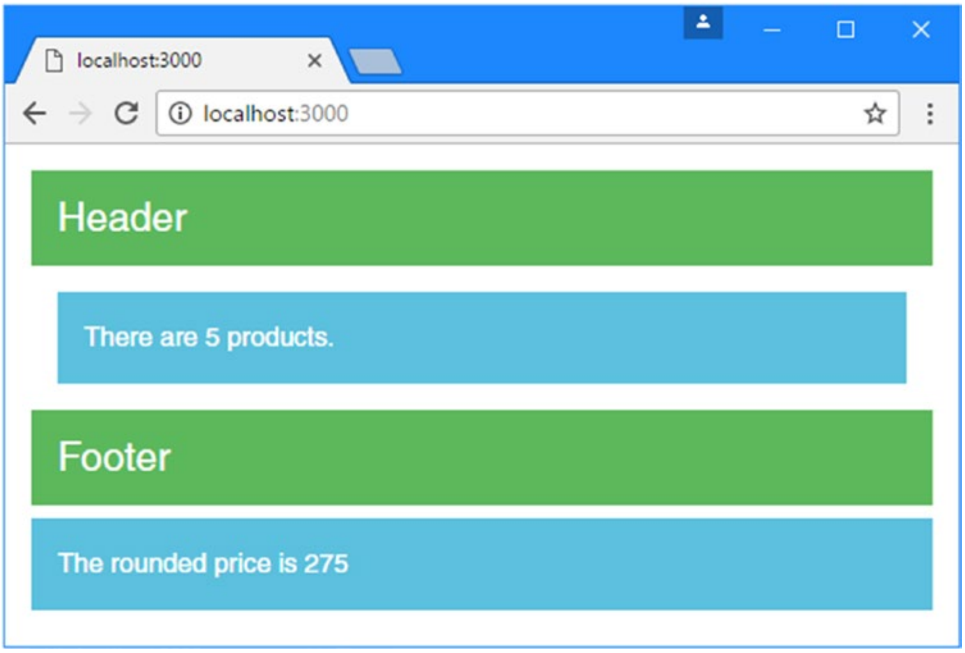
```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    // ...constructor and methods omitted for brevity...

    counter: number = 1;

    get nextProduct(): Product {
        return this.model.getProducts().shift();
    }

    getProductPrice(index: number): number {
        return Math.floor(this.getProduct(index).price);
    }
}
```

In Listing 13-22, I have changed the data binding in the template to use the newly defined method.

Listing 13-22. Access Global Namespace Functionality in the template.html File

```
<template #titleTemplate let-text="title">
    <h4 class="p-a-1 bg-success">{{text}}</h4>
</template>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Header'}">
</template>

<div class="bg-info p-a-1 m-a-1">
    There are {{getProductCount()}} products.
</div>

<template [ngTemplateOutlet]="titleTemplate"
          [ngOutletContext]="{title: 'Footer'}">
</template>

<div class='bg-info p-a-1'>
    The rounded price is {{getProductPrice(1)}}
</div>
```

When Angular processes the template, it will call the `getProductPrice` method and indirectly take advantage of the `Math` object in the global namespace, producing the result shown in Figure 13-12.



Header

There are 5 products.

Footer

The rounded price is 275

Figure 13-12. *Accessing global namespace functionality*

Summary

In this chapter, I explained how to use the built-in template directives. I showed you how to select content with the `ngIf` and `ngSwitch` directives and how to repeat content using the `ngFor` directive. I explained why some directive names are prefixed with an asterisk and described the limitations that are placed on template expressions used with these directives and with one-way data bindings in general. In the next chapter, I describe how data bindings are used for events and form elements.

CHAPTER 14

Using Events and Forms

In this chapter, I continue describing the basic Angular functionality, focusing on features that respond to user interaction. I explain how to create event bindings and how to use two-way bindings to manage the flow of data between the model and the template. One of the main forms of user interaction in a web application is the use of HTML forms, and I explain how event and two-way data bindings are used to support them and validate the content that the user provides. Table 14-1 puts events and forms in context.

Table 14-1. *Putting Event Bindings and Forms in Context*

Question	Answer
What are they?	Event bindings evaluate an expression when an event is triggered, such as a user pressing a key, moving the mouse, or submitting a form. The broader form-related features build on this foundation to create forms that are automatically validated to ensure that the user provides useful data.
Why are they useful?	These features allow the user to change the state of the application, changing or adding to the data in the model.
How are they used?	Each feature is used in a different way. See the examples for details.
Are there any pitfalls or limitations?	In common with all Angular bindings, the main pitfall is using the wrong kind of bracket to denote a binding. Pay close attention to the examples in this chapter and check the way you have applied bindings when you don't get the results you expect.
Are there any alternatives?	No. These features are a core part of Angular.

Table 14-2 summarizes the chapter.

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Table 14-2. *Chapter Summary*

Problem	Solution	Listing
Enable forms support	Add the `@angular/forms` module to the application	1–3
Respond to an event	Use an event binding	6–8
Get details of an event	Use the `$event` object	9
Refer to elements in the template	Define template variables	10
Enable the flow of data in both directions between the element and the component	Use a two-way data binding	11, 12
Capture user input	Use an HTML form	13, 14
Validate the data provided by the user	Perform form validation	15–24
Define validation information using JavaScript code	Use a model-based form	25–30
Extend the built-in form validation features	Define a custom form validation class	31–32

Preparing the Example Project

For this chapter, I will continue using the `example` project that I created in Chapter 11 and have been modifying in the chapters since.

Adding the Forms Module

The features demonstrated in this chapter rely on the Angular forms module, which must be added to the application. The first step is to add the forms package to the application, starting with a new entry to the `dependencies` section of the `package.json` file, as shown in Listing 14-1.

Listing 14-1. Adding the Forms Package in the package.json File

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/forms": "2.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4"
  },
  "devDependencies": {
      "lite-server": "2.2.2",
      "typescript": "2.0.2",
      "typings": "1.3.2",
      "concurrently": "2.2.0"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

Run the following command in the `example` folder to download and install the forms package:

```
npm install
```

The next step is to update the configuration for the SystemJS package so that it knows how to find the forms package when the application is loaded, as shown in Listing 14-2.

Listing 14-2. Adding the Forms Module in the systemjs.config.js File

```
(function(global) {

    var paths = {
        "rxjs/*": "node_modules/rxjs/bundles/Rx.min.js",
        "@angular/*": "node_modules/@angular/*"
    }

    var packages = { "app":  {} };

    var angularModules = ["common", "compiler",
     "core", "platform-browser", "platform-browser-dynamic",
     "forms"];

    angularModules.forEach(function(pkg) {
        packages["@angular/" + pkg] = {
            main: "/bundles/" + pkg + ".umd.min.js"
        };
    });

    System.config({ paths: paths, packages: packages });

})(this);
```

The Angular module must be updated in order to declare that the application relies on the forms module, as shown in Listing 14-3.

Listing 14-3. Declaring a Dependency in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule} from "@angular/forms";

@NgModule({
    imports: [BrowserModule, FormsModule],
    declarations: [ProductComponent],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

The `imports` property of the `NgModule` decorator specifies the dependencies of the application. Adding `FormsModule` to the list of dependencies enables the form features and makes them available for use throughout the application.

Preparing the Component and Template

Listing 14-4 removes the constructor and some of the methods from the component class in order to keep the code as simple as possible.

Listing 14-4. Simplifying the Component in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }
}
```

Listing 14-5 simplifies the component's template, leaving just a table that is populated using the `ngFor` directive.

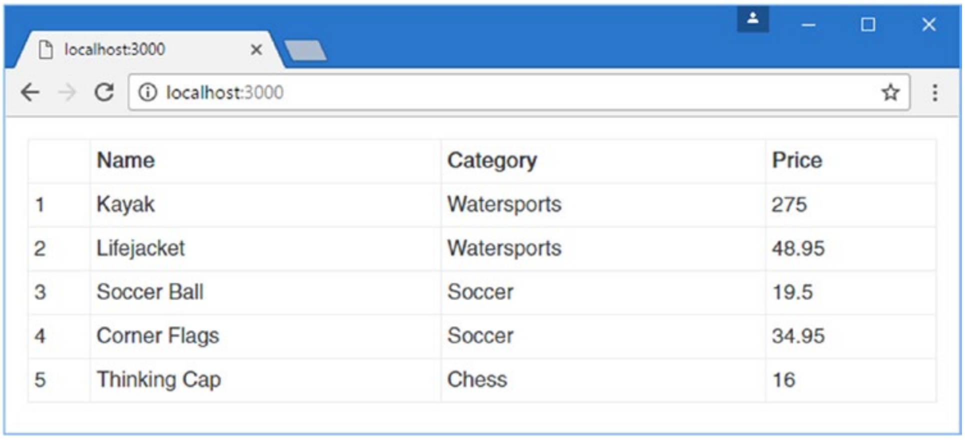
Listing 14-5. Simplifying the Template in the template.html File

```
<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
```

To start the development server, open a command prompt, navigate to the `example` folder, and run the following command:

```
npm start
```

A new browser window or tab will open and display the table shown in Figure 14-1.



	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 14-1. *Running the example application*

Using the Event Binding

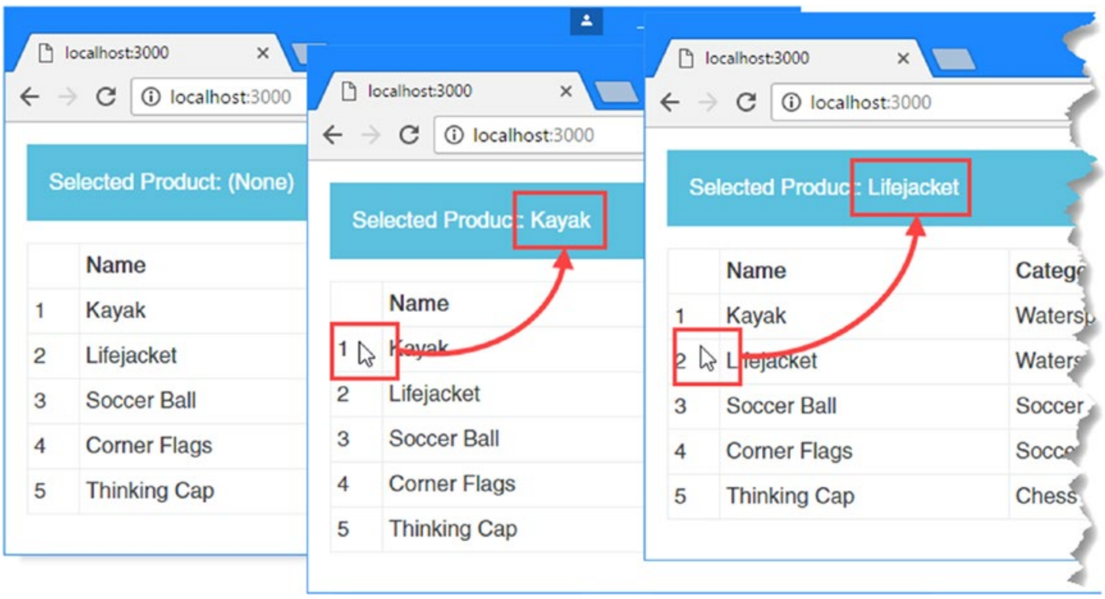
The *event binding* is used to respond to the events sent by the host element. Listing 14-6 demonstrates the event binding, which allows a user to interact with an Angular application.

Listing 14-6. Using the Event Binding in the template.html File

```
<div class="bg-info p-a-1">
    Selected Product: {{selectedProduct || '(None)'}}
</div>
<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index">
```

```
        <td (mouseover)="selectedProduct=item.name">{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
```

When you save the changes to the template, you can test the binding by moving the mouse pointer over the first column, which displays a series of numbers. As the mouse moves from row to row, the name of the product displayed in that row is displayed at the top of the page, as shown in Figure 14-2.



Selected Product: (None)

	Name
1	Kayak
2	Lifejacket
3	Soccer Ball
4	Corner Flags
5	Thinking Cap

Selected Product: Kayak

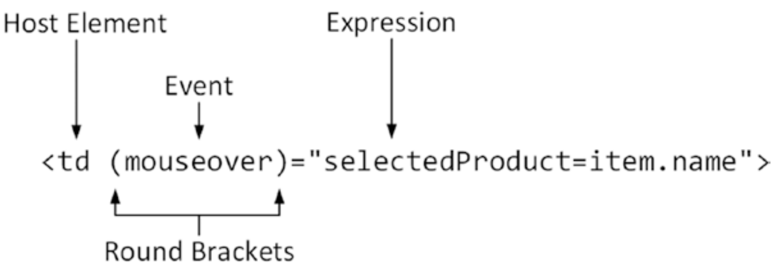
	Name
1	Kayak
2	Lifejacket
3	Soccer Ball
4	Corner Flags
5	Thinking Cap

Selected Product: Lifejacket

	Name	Catego
1	Kayak	Watersp
2	Lifejacket	Waters
3	Soccer Ball	Soccer
4	Corner Flags	Socce
5	Thinking Cap	Chess

Figure 14-2. *Using an event binding*

This is a simple example, but it shows the structure of an event binding, which is illustrated in Figure 14-3.



```
<td (mouseover)="selectedProduct=item.name">
```

Figure 14-3. *The anatomy of an event binding*

An event binding has these four parts:

- The *host element* is the source of events for the binding.
- The *round brackets* tell Angular that this is an event binding, which is a form of one-way binding where data flows from the element to the rest of the application.
- The *event* specifies which event the binding is for.
- The *expression* is evaluated when the event is triggered.

Looking at the binding in Listing 14-6, you can see that the host element is a `td` element, meaning that this is the element that will be the source of events. The binding specifies the `mouseover` event, which is triggered when the mouse pointer moves over the part of the screen occupied by the host element.

Unlike one-way bindings, the expressions in event bindings are allowed to make changes to the state of the application and can contain assignment operators, such as `=`. The expression for the binding assigns a variable called `selectedProduct` a value of `item.name`. The `selectedProduct` variable is used in a string interpolation binding at the top of the template, like this:

```
...
<div class="bg-info p-a-1">
    Selected Product: {{selectedProduct || '(None)'}}
</div>
...
```

Notice that the string interpolation binding is updated when the value of the `selectedProduct` variable is changed by the event binding. Manually starting the change detection process using the `ApplicationRef.tick` method is no longer required because the bindings and directives in this chapter take care of the process automatically.

WORKING WITH DOM EVENTS

If you are unfamiliar with the events that an HTML element can send, then there is a good summary available at `developer.mozilla.org/en-US/docs/Web/Events`. There are a lot of events, however, and not all of them are supported widely or consistently in all browsers. A good place to start is the "DOM Events" and "HTML DOM Events" sections of the `mozilla.org` page, which define the basic interactions that a user has with an element (clicking, moving the pointer, submitting forms, and so on) and that can be relied on to work in most browsers.

If you use the less common events, then you should make sure they are available and work as expected in your target browsers. The excellent `http://caniuse.com` provides details of which features are implemented by different browsers, but you should also perform thorough testing.

Understanding Dynamically Defined Properties

You may be wondering where the `selectedProduct` variable appeared from in Listing 14-6, because it is used in the template without being first defined in the component. In fact, it was created the first time the event binding was triggered, because JavaScript allows properties to be defined on objects dynamically.

The object in this case is the component, and this example is a useful reminder that while TypeScript adds structure when you are writing code, the Angular application is plain JavaScript at runtime. This means you can take advantage of JavaScript's dynamic features when it is useful to do so. It also means you can create unexpected results if you are not paying attention, so care is required.

Although you can define properties dynamically, a safer approach is to define all the properties that a template uses in the component, and this is something that you will have to do if you write other methods and properties that depend on them; otherwise, the TypeScript compiler will report errors. In Listing 14-7, the component has been updated to keep track of the selected product, which means defining the `selectedProduct` property that was previously created dynamically.

Listing 14-7. Enhancing the Component in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }

    selectedProduct: string;

    getSelected(product: Product): boolean {
        return product.name == this.selectedProduct;
    }
}
```

In addition to the `selectedProduct` property, there is a new method called `getSelected` that accepts a `Product` object and compares its name to the `selectedProduct` property. In Listing 14-8, the `getSelected` method is used by a class binding to control membership of the `bg-info` class, which is a Bootstrap class that assigns a background color to an element.

Listing 14-8. Setting Class Membership in the template.html File

```
<div class="bg-info p-a-1">
    Selected Product: {{selectedProduct || '(None)'}}
</div>
<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
            [class.bg-info]="getSelected(item)">
```

```
        <td (mouseover)="selectedProduct=item.name">{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
```

The result is that `tr` elements are added to the `bg-info` class when the `selectedProduct` property value matches the `name` property of the `Product` object used to create them, which is changed by the event binding when the `mouseover` event is triggered, as shown in Figure 14-4.

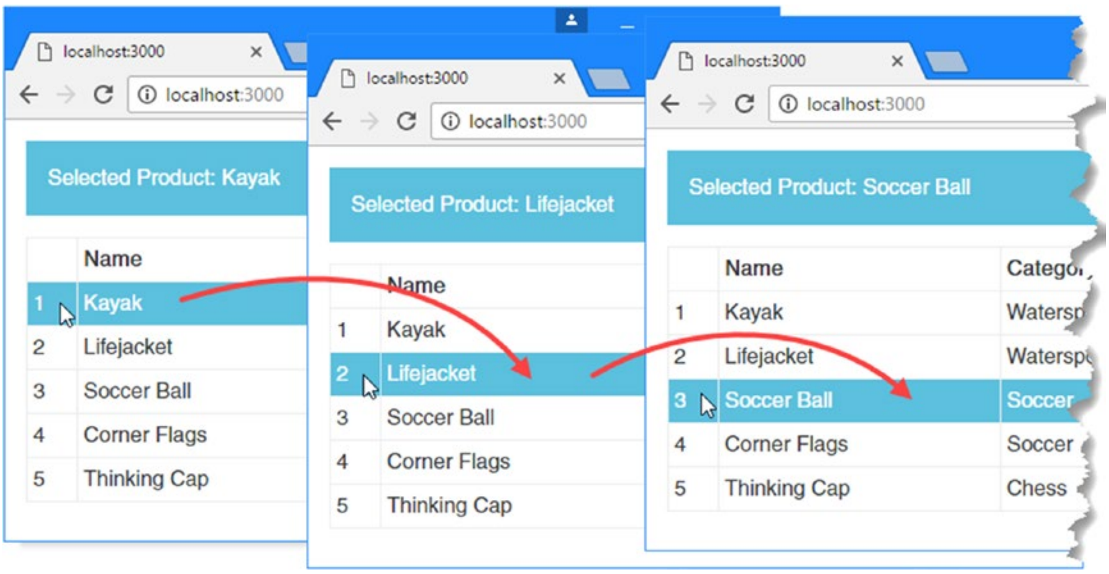


Figure 14-4. *Highlighting table rows through an event binding*

This example shows how user interaction drives new data into the application and starts the change-detection process, causing Angular to reevaluate the expressions used by the string interpolation and class bindings. This flow of data is what brings Angular applications to life: the bindings and directives described in Chapters 12 and 13 respond dynamically to changes in the application state, creating content generated and managed entirely within the browser.

Using Event Data

The previous example used the event directive to connect together two pieces of data provided by the component: when the `mouseevent` is triggered, the binding sets the component's `selectedProduct` property using a data value that was provided to the `ngfor` directive from the component's `getProducts` method.

The event binding can also be used to introduce new data into the application from the event itself. Listing 14-9 adds an `input` element to the template and uses the event binding to listen for the `input` event, which is triggered when the content of the `input` element changes.

Listing 14-9. Using an Event Object in the template.html File

```
<div class="bg-info p-a-1">
    Selected Product: {{selectedProduct || '(None)'}}
</div>
<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
            [class.bg-info]="getSelected(item)">
        <td (mouseover)="selectedProduct=item.name">{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
<div class="form-group">
    <label>Product Name</label>
    <input class="form-control" (input)="selectedProduct=$event.target.value" />
</div>
```

When the browser triggers an event, it provides an object that describes it. There are different types of event object for different categories of event (mouse events, keyboard events, form events, and so on), but all events share the three properties described in Table 14-3.

Table 14-3. *The Properties Common to All DOM Event Objects*

Name	Description
type	This property returns a string that identifies the type of event that has been triggered.
target	This property returns the object that triggered the event, which will generally be the object that represents the HTML element in the DOM.
timeStamp	This property returns a number that contains the time that the event was triggered, expressed as milliseconds since January 1, 1970.

The event object is assigned to a template variable called $event, and the new binding expression in Listing 14-9 uses this variable to access the event object's target property.

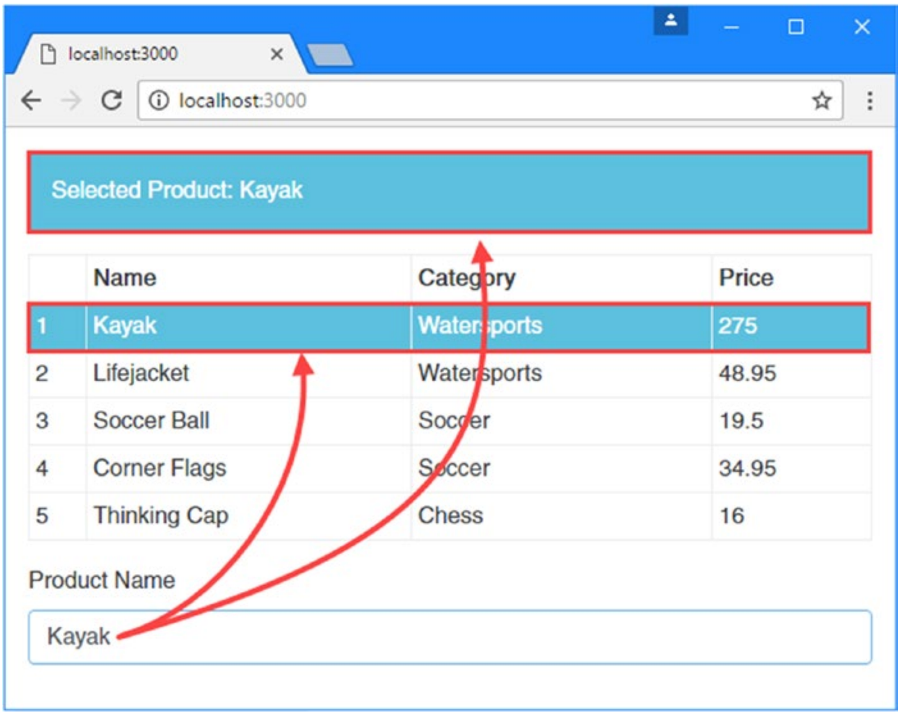
The input element is represented in the DOM by an HTMLInputElement object, which defines a value property that can be used to get and set the contents of the input element.

The binding expression responds to the input event by setting the value of the component's selectedProduct property to the value of the input element's value property, like this:

```
...
<input class="form-control" (input)="selectedProduct=$event.target.value" />
...
```

The input event is triggered when the user edits the contents of the input element, so the component's selectedProduct property is updated with the contents of the input element after each keystroke. As the user types into the input element, the text that has been entered is displayed at the top of the browser window using the string interpolation binding.

The ngClass binding applied to the tr elements sets the background color of the table rows when the selectedProduct property matches the name of the product they represent. And, now that the value of the selectedProduct property is driven by the contents of the input element, typing the name of a product will cause the appropriate row to be highlighted, as shown in Figure 14-5.



Selected Product: Kayak

	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Product Name

Kayak

Figure 14-5. *Using event data*

Using different bindings to work together is at the heart of effective Angular development and makes it possible to create applications that respond immediately to user interaction and to changes in the data model.

Using Template Reference Variables

In Chapter 13, I explained how template variables are used to pass data around within a template, such as defining a variable for the current object when using the ngFor directive. *Template reference variables* are a form of template variable that can be used to refer to elements within the template, as shown in Listing 14-10.

Listing 14-10. Using a Template Variable in the template.html File

```
<div class="bg-info p-a-1">
    Selected Product: {{product.value || '(None)'}}
</div>
<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
```

```
            (mouseover)="product.value=item.name"
            [class.bg-info]="product.value==item.name">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
<div class="form-group">
    <label>Product Name</label>
    <input #product class="form-control" (input)="false" />
</div>
```

Reference variables are defined using the # character, followed by the variable name. In the listing, I defined a variable called `product` like this:

```
...
<input #product class="form-control" (input)="false" />
...
```

When Angular encounters a reference variable in a template, it sets its value to the element to which it has been applied. For this example, the `product` reference variable is assigned the object that represents the `input` element in the DOM, the `HTMLInputElement` object. Reference variables can be used by other bindings in the same template. This is demonstrated by the string interpolation binding, which also uses `product` variable, like this:

```
...
Selected Product: {{product.value || '(None)'}}
...
```

This binding displays the `value` property defined by the `HTMLInputElement` that has been assigned to the product variable or the string `(None)` if the `value` property returns `null`. Template variables can also be used to change the state of the element, as shown in this binding:

```
...
<tr *ngFor="let item of getProducts(); let i = index"
    (mouseover)="product.value=item.name"
    [class.bg-info]="product.value==item.name">
...
```

The event binding responds the `mouseover` event by setting the `value` property on the `HTMLInputElement` that has been assigned to the `product` variable. The result is that moving the mouse over one of the `tr` elements will update the contents of the `input` element.

There is one slightly awkward aspect to this example, which is the binding for the `input` event on the `input` element.

```
...
<input #product class="form-control" (input)="false" />
...
```

Angular won't update the data bindings in the template when the user edits the contents of the input element unless there is an event binding on that element. Setting the binding to false gives Angular something to evaluate just so the update process will begin and distribute the current contents of the input element throughout the template. This is a quirk of stretching the role of a template reference variable a little too far and isn't something you will need to do in most real projects. As you will see in later examples—and later chapters—most data bindings rely on variables defined by the template's component.

FILTERING KEY EVENTS

The input event is triggered every time the content in the input element is changed. This provides an immediate and responsive set of changes, but it isn't what every application requires, especially if updating the application state involves expensive operations.

The event binding has built-in support to be more selective when binding to keyboard events, which means that updates will be performed only when a specific key is pressed. Here is a binding that responds to every keystroke:

```
...
<input #product class="form-control" (keyup)="selectedProduct=product.value" />
...
```

The keyup event is a standard DOM event, and the result is that application is updated as the user releases each key while typing in the input element. I can be more specific about which key I am interested in by specifying its name as part of the event binding, like this:

```
...
<input #product class="form-control" (keyup.enter)="selectedProduct=product.value" />
...
```

The key that the binding will respond to is specified by appending a period after the DOM event name, followed by the name of the key. This binding is for the enter key, and the result is that the changes in the input element won't be pushed into the rest of the application until that key is pressed.

Using Two-Way Data Bindings

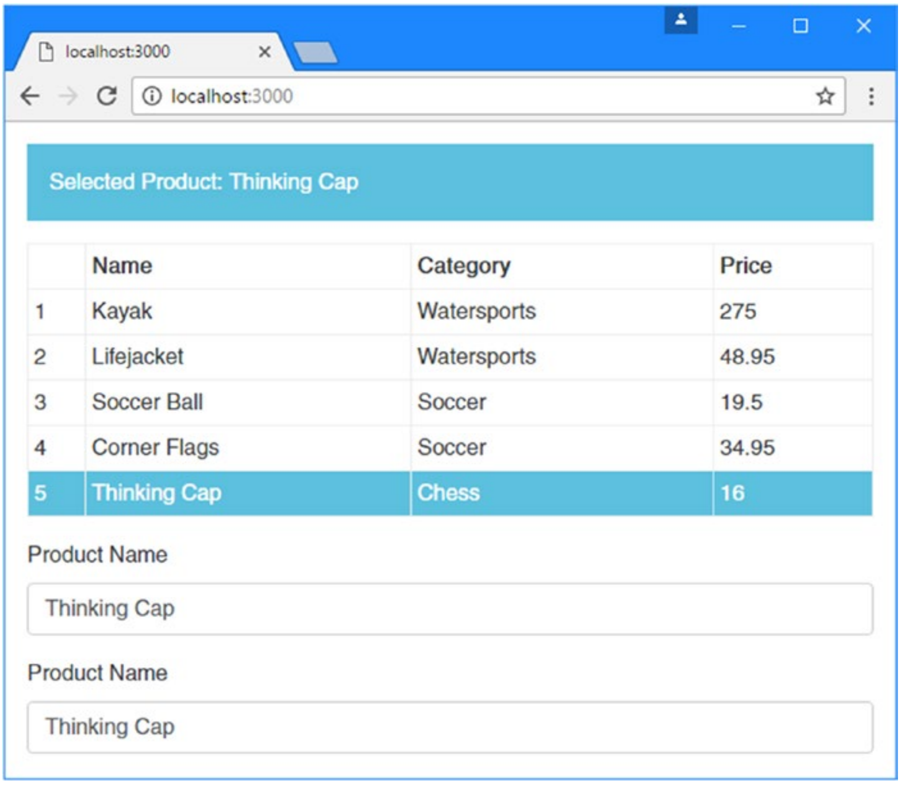
Bindings can be combined to create a two-way flow of data for a single element, allowing the HTML document to respond when the application model changes and allowing the application to respond when the element sends an event, as shown in Listing 14-11.

Listing 14-11. Creating a Two-Way Binding in the template.html File

```
<div class="bg-info p-a-1">
    Selected Product: {{selectedProduct || '(None)'}}
</div>
<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
            [class.bg-info]="getSelected(item)">
        <td (mouseover)="selectedProduct=item.name">{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>

<div class="form-group">
    <label>Product Name</label>
    <input class="form-control" (input)="selectedProduct=$event.target.value"
        [value]="selectedProduct || ''" />
</div>

<div class="form-group">
    <label>Product Name</label>
    <input class="form-control" (input)="selectedProduct=$event.target.value"
        [value]="selectedProduct || ''" />
</div>
```

Each of the `input` elements has two bindings: an event binding and a property binding. The event binding responds to the `input` event by updating the component's `selectedProduct` property. The property binding ties the value of the `selectedProduct` property to the element's `value` property.

The result is that the contents of the two `input` elements are synchronized, and editing one causes the other to be updated as well. And, since there are other bindings in the template that depend on the `selectedProduct` property, editing the contents of an `input` element also changes the data displayed by string interpolation binding and changes the highlighted table row, as shown in Figure 14-6.



Selected Product: Thinking Cap

	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Product Name

Thinking Cap

Product Name

Thinking Cap

Figure 14-6. *Creating a two-way data binding*

This is an example that makes most sense when you experiment with it in the browser. Enter some text into one of the `input` elements and you will see the same text displayed in the other `input` element and in the `div` element whose content is managed by the string interpolation binding. If you enter the name of a product into one of the input elements, such as `Kayak` or `Lifejacket`, then you will also see the corresponding row in the table highlighted.

The event binding for the `mouseover` event still takes effect, which means as you move the mouse pointer over the first row in the table, the changes to the `selectedProduct` value will cause the `input` elements to display the product name.

Using the ngModel Directive

The `ngModel` directive is used to simplify two-way bindings so that you don't have to apply both an event and a property binding to the same element. Listing 14-12 shows how to replace the separate bindings with the `ngModel` directive.

Listing 14-12. Using the ngModel Directive in the template.html File

```
<div class="bg-info p-a-1">
    Selected Product: {{selectedProduct || '(None)'}}
</div>
```

```
<table class="table table-sm table-bordered m-t-1">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
            [class.bg-info]="getSelected(item)">
        <td (mouseover)="selectedProduct=item.name">{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>

<div class="form-group">
    <label>Product Name</label>
    <input class="form-control" [(ngModel)]="selectedProduct" />
</div>

<div class="form-group">
    <label>Product Name</label>
    <input class="form-control" [(ngModel)]="selectedProduct" />
</div>
```

Using the ngModel directive requires combining the syntax of the property and event bindings, as illustrated in Figure 14-7.

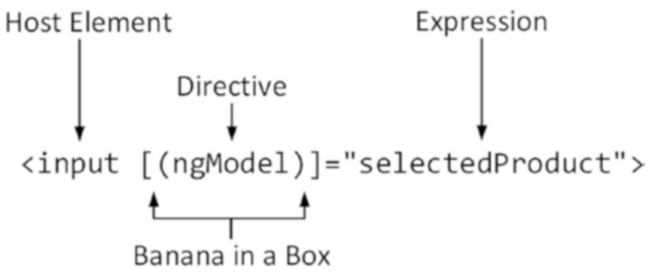


Figure 14-7. *The anatomy of a two-way data binding*

A combination of square and round brackets is used to denote a two-way data binding, with the round brackets placed inside the square ones: `[(` and `)]`. The Angular development team refers to this as the "banana in a box" binding because that's what the brackets and parentheses look like when placed like this `[()]`. Well, sort of.

The target for the binding is the `ngModel` directive, which is included in Angular to simplify creating two-way data bindings on form elements, such as the `input` elements used in the example.

The expression for a two-way data binding is the name of a property, which is used to set up the individual bindings behind the scenes. When the contents of the `input` element change, the new content will be used to update the value of the `selectedProduct` property. Equally, when the value of the `selectedProduct` value changes, it will be used to update the contents of the element.

The `ngModel` directive knows the combination of events and properties that the standard HTML elements define. Behind the scenes, an event binding is applied to the `input` event, and a property binding is applied to the `value` property.

■ **Tip** It is important that you remember to use both brackets and parentheses with the ngModel binding. If you use just parentheses—(ngModel)—then you are setting an event binding for an event called ngModel, which doesn't exist. The result is an element that won't be updated or won't update the rest of the application. You can use the ngModel directive with just square brackets—[ngModel]—and Angular will set the initial value of the element but won't listen for events, which means that changes made by the user won't be automatically reflected in the application model.

Working with Forms

Most web applications rely on forms for receiving data from users. The two-way ngModel binding described in the previous section provides the foundation for creating basic forms, to which more advanced features will be applied. In this section, I create a form that allows new products to be created and added to the application's data model and then describe some of the more advanced form features that Angular provides.

Adding a Form to the Example Application

Listing 14-13 shows some enhancements to the component that will be used when the form is created and removes some features that are no longer required.

Listing 14-13. Enhancing the Component in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }

    newProduct: Product = new Product();

    get jsonProduct() {
        return JSON.stringify(this.newProduct);
    }

    addProduct(p: Product) {
        console.log("New Product: " + this.jsonProduct);
    }
}
```

The listing adds a new property called newProduct, which will be used to store the data entered into the form by the user. There is also a jsonProduct property with a getter that returns a JSON representation of the newProduct property and that will be used in the template to show the effect of the two-way bindings. (I can't create a JSON representation of an object directly in the template because the JSON object is defined in the global namespace, which, as I explained in Chapter 13, cannot be accessed directly from template expressions.)

The final addition is an addProduct method that writes out the value of the jsonProduct method to the console; this will let me demonstrate some basic form-related features before adding support for updating the data model later in the chapter.

In Listing 14-14, the existing template content has been replaced with a series of input elements for each of the properties defined by the Product class.

Listing 14-14. Adding Input Elements in the template.html File

```
<div class="bg-info p-a-1 m-b-1">Model Data: {{jsonProduct}}</div>

<div class="form-group">
    <label>Name</label>
    <input class="form-control" [(ngModel)]="newProduct.name" />
</div>
<div class="form-group">
    <label>Category</label>
    <input class="form-control" [(ngModel)]="newProduct.category" />
</div>
<div class="form-group">
    <label>Price</label>
    <input class="form-control" [(ngModel)]="newProduct.price" />
</div>
<button class="btn btn-primary" (click)="addProduct(newProduct)">Create</button>
```

Each input element is grouped together with a label and contained in a div element, which is styled using the Bootstrap form-group class. Individual input elements are assigned to the Bootstrap form-control class to manage the layout and style.

The ngModel binding has been applied to each input element to create a two-way binding with the corresponding property on the component's newProduct object, like this:

```
...
<input class="form-control" [(ngModel)]="newProduct.name" />
...
```

There is also a button element, which has a binding for the click event that calls the component's addProduct method, passing in the newProduct value as an argument.

```
...
<button class="btn btn-primary" (click)="addProduct(newProduct)">Create</button>
...
```

Finally, a string interpolation binding is used to display a JSON representation of the component's newProduct property at the top of the template, like this:

```
...
<div class="bg-info p-a-1 m-b-1">Model Data: {{jsonProduct}}</div>
...
```

The overall result, illustrated in Figure 14-8, is a set of input elements that update the properties of a Product object managed by the component, which are reflected immediately in the JSON data.

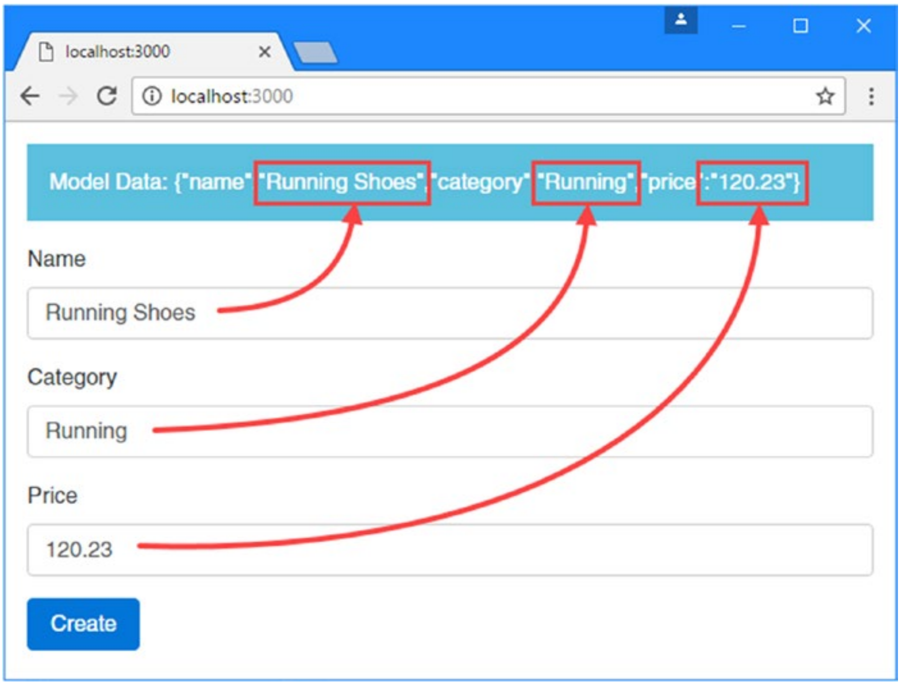


Figure 14-8. *Using the form elements to create a new object in the data model*

When the Create button is clicked, the JSON representation of the component's newProduct property is written to the browser's JavaScript console, producing a result like this:

```
New Product: {"name":"Running Shoes","category":"Running","price":"120.23"}
```

Adding Form Data Validation

At the moment, any data can be entered into the input elements in the form. Data validation is essential in web applications because users will enter a surprising array of data values, either in error or because they want to get to the end of the process as quickly as possible and enter garbage values to proceed.

Angular provides an extensible system for validating the content of form elements, based on the approach used by the HTML5 standard. There are four attributes that you can add to input elements, each of which defines a validation rule, as described in Table 14-4.

Table 14-4. *The Built-in Angular Validation Attributes*

Attribute	Description
`required`	This attribute is used to specify a value that must be provided.
`minlength`	This attribute is used to specify a minimum number of characters.
`maxlength`	This attribute is used to specify a maximum number of characters. This type of validation cannot be applied directly to form elements because it conflicts with the HTML5 attribute of the same name. It can be used with model-based forms, which are described later in the chapter.
`pattern`	This attribute is used to specify a regular expression that the value provided by the user must match.

You may be familiar with these attributes because they are part of the HTML specification, but Angular builds on these properties with some additional features. Listing 14-15 removes all but one of the `input` elements to demonstrate the process of adding validation to the form as simply as possible. (I restore the missing elements later in the chapter.)

Listing 14-15. Adding Form Validation in the template.html File

```
<div class="bg-info p-a-1 m-b-1">Model Data: {{jsonProduct}}</div>

<form novalidate (ngSubmit)="addProduct(newProduct)">
    <div class="form-group">
        <label>Name</label>
        <input class="form-control"
            name="name"
            [(ngModel)]="newProduct.name"
            required
            minlength="5"
            pattern="^[A-Za-z ]+$"/>
    </div>
    <button class="btn btn-primary" type="submit">
        Create
    </button>
</form>
```

Angular requires elements that are being validated to define the `name` attribute, which is used to identify the element in the validation system. Since this `input` element is being used to capture the value of the `Product.name` property, the `name` attribute on the element has been set to `name`.

This listing also adds three of the four validation attributes to the `input` element. The `required` attribute specifies that the user must provide a value, the `minlength` attribute specifies that there should be at least three characters, and the `pattern` attribute specifies that only alphabetic characters and spaces are allowed.

The validation attributes that Angular uses are the same ones used by the HTML 5 specification, so I have added the `novalidate` attribute to the form element, which tells the browser not to use its native validation features, which are inconsistently implemented by different browsers and generally get in the way. Since Angular will be providing the validation, the browser's own implementation of these features is not required.

Finally, notice that a `form` element has been added to the template. Although you can use `input` elements independently, the Angular validation features work only when there is a `form` element present, and Angular will report an error if you add the `ngControl` directive to an element that is not contained in a `form`.

When using a `form` element, the convention is to use an event binding for a special event called `ngSubmit` like this:

```
...
<form novalidate (ngSubmit)="addProduct(newProduct)">
...
```

The `ngSubmit` binding handles the `form` element's `submit` event. You can achieve the same effect binding to the `click` event on individual `button` elements within the `form` if you prefer.

Styling Elements Using Validation Classes

Once you have saved the template changes in Listing 14-15 and the browser has reloaded the HTML, right-click the `input` element in the browser window and select Inspect or Inspect Element from the pop-up window. The browser will display the HTML representation of the element in the Developer Tools window, and you will see that the `input` element has been added to three classes, like this:

```
...
<input class="form-control ng-pristine ng-invalid ng-touched" minlength="5"
    name="name" pattern="^[A-Za-z ]+$" required="" ng-reflect-name="name">
...
```

The classes to which an `input` element is assigned provide details of its validation state. There are three pairs of validation classes, which are described in Table 14-5. Elements will always be members of one class from each pair, for a total of three classes. The same classes are applied to the `form` element to show the overall validation status of all the elements it contains. As the status of the `input` element changes, the `ngControl` directive switches the classes automatically for both the individual elements and the form element.

Table 14-5. *The Angular Form Validation Classes*

Name	Description
`ng-untouched ng-touched`	An element is assigned to the `ng-untouched` class if it has not been visited by the user, which is typically done by tabbing through the form fields. Once the user has visited an element, it is added to the ng-touched class.
`ng-pristine ng-dirty`	An element is assigned to the `ng-pristine` class if its contents have not been changed by the user and to the `ng-dirty` class otherwise. Once the contents have been edited, an element remains in the `ng-dirty` class, even if the user then returns to the previous contents.
`ng-valid ng-invalid`	An element is assigned to the `ng-valid` class if its contents meet the criteria defined by the validation rules that have been applied to it and to the `ng-invalid` class otherwise.

These classes can be used to style form elements to provide the user with validation feedback. Listing 14-16 adds a `style` element to the template and defines styles that indicate when the user has entered invalid or valid data.

■ **Tip** In real applications, styles should be defined in separate stylesheets and included in the application through the `index.html` file or using a component's decorator settings (which I describe in Chapter 17). I have included the styles directly in the template for simplicity, but this makes real applications harder to maintain because it makes it difficult to figure out where styles are coming from when there are multiple templates in use.

Listing 14-16. Providing Validation Feedback in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<div class="bg-info p-a-1 m-b-1">Model Data: {{jsonProduct}}</div>

<form novalidate (ngSubmit)="addProduct(newProduct)">
    <div class="form-group">
        <label>Name</label>
        <input class="form-control"
            name="name"
            [(ngModel)]="newProduct.name"
            required
            minlength="5"
            pattern="^[A-Za-z ]+$"/>
    </div>
    <button class="btn btn-primary" type="submit">
        Create
    </button>
</form>
```

These styles set green and red borders for `input` elements whose content has been edited and is valid (and so belong to both the `ng-dirty` and `ng-valid` classes) and whose content is invalid (and so belong to the `ng-dirty` and `ng-invalid` classes). Using the `ng-dirty` class means that the appearance of the elements won't be changed until after the user has entered some content.

Angular validates the contents and changes the class memberships of the `input` elements after each keystroke or focus change. The browser detects the changes to the elements and applies the styles dynamically, which provides users with validation feedback as they enter data into the form, as shown in Figure 14-9.

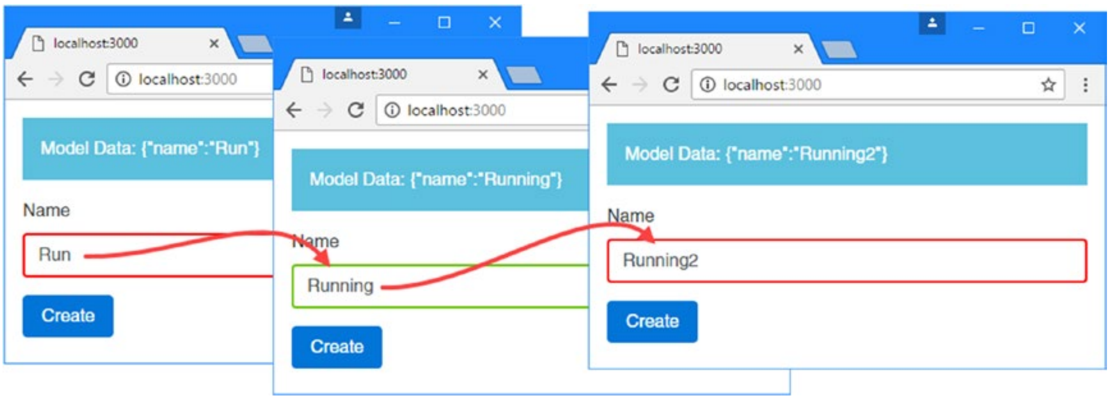

localhost:3000
Model Data: {"name":"Run"}
Name
Run
Create
Model Data: {"name":"Running"}
Running
Model Data: {"name":"Running2"}
Running2

Figure 14-9. *Providing validation feedback*

As I start to type, the `input` element is shown as invalid because there are not enough characters to satisfy the `minlength` attribute. Once there are five characters, the border is green, indicating that the data is valid. When I type the character `2`, the border turns red again because the `pattern` attribute is set to allow only letters and spaces.

■ **Tip** If you look at the JSON data at the top of the page in Figure 14-9, you will see that the data bindings are still being updated, even when the data values are not valid. Validation runs alongside data bindings, and you should not act on form data without checking that the overall form is valid, as described in the “Validating the Entire Form” section.

Displaying Field-Level Validation Messages

Using colors to provide validation feedback tells the user that something is wrong but doesn’t provide any indication of what the user should do about it. The `ngModel` directive provides access to the validation status of the elements it is applied to, which can be used to display guidance to the user when there is a problem. Listing 14-17 adds validation messages for each of the attributes applied to the `input` element using the support provided by the `ngModel` directive.

Listing 14-17. Adding Validation Messages in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<div class="bg-info p-a-1 m-b-1">Model Data: {{jsonProduct}}</div>

<form novalidate (ngSubmit)="addProduct(newProduct)">
    <div class="form-group">
        <label>Name</label>
        <input class="form-control"
```

```
            name="name"
            [(ngModel)]="newProduct.name"
            #name="ngModel"
            required
            minlength="5"
            pattern="^[A-Za-z ]+$"/>
            <ul class="text-danger list-unstyled" *ngIf="name.dirty && name.invalid">
                <li *ngIf="name.errors.required">
                    You must enter a product name
                </li>
                <li *ngIf="name.errors.pattern">
                    Product names can only contain letters and spaces
                </li>
                <li *ngIf="name.errors.minlength">
                    Product names must be at least
                    {{name.errors.minlength.requiredLength}} characters
                </li>
            </ul>
    </div>
    <button class="btn btn-primary" type="submit">
        Create
    </button>
</form>
```

To get validation working, I have to create a template reference variable to access the validation state in expressions, which I do like this:

```
...
<input class="form-control" name="name" [(ngModel)]="newProduct.name"
    #name="ngModel" required minlength="5" pattern="^[A-Za-z ]+$"/>
...
```

I create a template reference variable called `name` and set its value to `ngModel`. This use of `ngModel` value is a little confusing: it is a feature provided by the `ngModel` directive to give access to the validation status. This will make more sense once you have read Chapters 15 and 16, in which I explain how to create custom directives and you see how they provide access to their features. For this chapter, it is enough to know that in order to display validation messages, you need to create a template reference variable and assign it `ngModel` in order to access the validation data for the `input` element. The object that is assigned to the template reference variable defines the properties that are described in Table 14-6.

***Table 14-6.** The Validation Object Properties*

Name	Description
path	This property returns the name of the element.
valid	This property returns true if the element's contents are valid and false otherwise.
invalid	This property returns true if the element's contents are invalid and false otherwise.
pristine	This property returns true if the element's contents have not been changed.
dirty	This property returns true if the element's contents have been changed.
touched	This property returns true if the user has visited the element.
untouched	This property returns true if the user has not visited the element.
errors	This property returns an object whose properties correspond to each attribute for which there is a validation error.
value	This property returns the value of the element, which is used when defining custom validation rules, as described in the "Creating Custom Form Validators" section.

Listing 14-17 displays the validation messages in a list. The list should be shown only if there is at least one validation error, so I applied the ngIf directive to the ul element, with an expression that uses the dirty and invalid properties, like this:

```
...
<ul class="text-danger list-unstyled" *ngIf="name.dirty && name.invalid">
...
```

Within the ul element, there is an li element that corresponds to each validation error that can occur. Each li element has an ngIf directive that uses the errors property described in Table 14-6, like this:

```
...
<li *ngIf="name.errors.required">You must enter a product name</li>
...
```

The errors.required property will be defined only if the element's contents have failed the required validation check, which ties the visibility of the li element to the outcome of that particular validation check.

USING THE SAFE NAVIGATION PROPERTY WITH FORMS

The errors property is created only when there are validation errors, which is why I check the value of the invalid property in the expression on the ul element. An alternative approach is to use the safe navigation property, which is used in templates to navigate through a series of properties without generating an error if one of them returns null. Here is an alternative approach to defining the template in Listing 14-17 that doesn't check the valid property and relies on the safe navigation property instead:

```
...
<ul class="text-danger list-unstyled" *ngIf="name.dirty">
    <li *ngIf="name.errors?.required">
        You must enter a product name
    </li>
    <li *ngIf="name.errors?.pattern">
        Product names can only contain letters and spaces
    </li>
    <li *ngIf="name.errors?.minlength">
        Product names must be at least
        {{name.errors.minlength.requiredLength}} characters
    </li>
</ul>
...
```

Appending a `?` character after a property name tells Angular not to try to access any subsequent properties or methods if the property is `null` or `undefined`. In this example, I have applied the `?` character after the `errors` property, which means Angular won't try to read the `required`, `pattern`, or `minlength` properties if the `error` property hasn't been defined.

Each property defined by the `errors` object returns an object whose properties provide details of why the content has failed the validation check for its attribute, which can be used to make the validation messages more helpful to the user. Table 14-7 describes the `error` properties provided for each attribute.

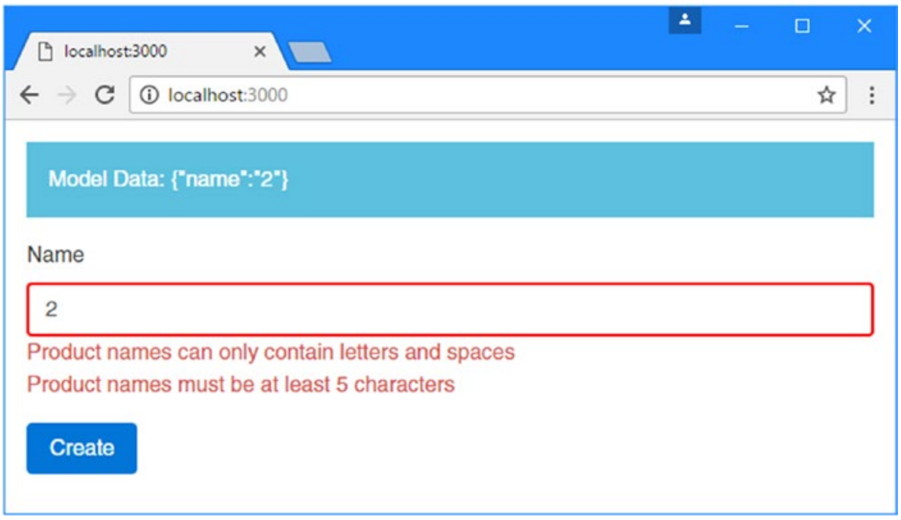
Table 14-7. *The Angular Form Validation Error Description Properties*

Name	Description
`required`	This property returns `true` if the `required` attribute has been applied to the input element. This is not especially useful because this can be deduced from the fact that the `required` property exists.
`minlength.requiredLength`	This property returns the number of characters required to satisfy the `minlength` attribute.
`minlength.actualLength`	This property returns the number of characters entered by the user.
`pattern.requiredPattern`	This property returns the regular expression that has been specified using the `pattern` attribute.
`pattern.actualValue`	This property returns the contents of the element.

These properties are not useful for displaying directly to the user, who is unlikely to understand an error message that includes a regular expression, although they can be useful during development to figure out validation problems. The exception is the `minlength.requiredLength` property, which can be useful for avoiding duplicating the value assigned to the `minlength` attribute on the element, like this:

```
...
<li *ngIf="name.errors.minlength">
  Product names must be at least {{name.errors.minlength.requiredLength}} characters
</li>
...
```

The overall result is a set of validation messages that are shown as soon as the user starts editing the input element and that change to reflect each new keystroke, as illustrated in Figure 14-10.



Model Data: {"name":"2"}

Product names can only contain letters and spaces

Product names must be at least 5 characters

Figure 14-10. *Displaying validation messages*

Using the Component to Display Validation Messages

Including separate elements for all possible validation errors quickly becomes verbose in complex forms. A better approach is to add some logic to the component to prepare the validation messages in a method, which can then be displayed to the user through the ngFor directive in the template. Listing 14-18 shows the addition of a component method that accepts the validation state for an input element and produces an array of validation messages.

Listing 14-18. Generating Validation Messages in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }
    newProduct: Product = new Product();

    get jsonProduct() {
        return JSON.stringify(this.newProduct);
    }

    addProduct(p: Product) {
        console.log("New Product: " + this.jsonProduct);
    }

    getValidationMessages(state: any, thingName?: string) {
        let thing: string = state.path || thingName;
        let messages: string[] = [];
        if (state.errors) {
            for (let errorName in state.errors) {
                switch (errorName) {
                    case "required":
                        messages.push(`You must enter a ${thing}`);
                        break;
                    case "minlength":
                        messages.push(`A ${thing} must be at least
                            ${state.errors['minlength'].requiredLength}
                            characters`);
                        break;
                    case "pattern":
                        messages.push(`The ${thing} contains
                             illegal characters`);
                        break;
                }
            }
        }
        return messages;
    }
}
```

The getValidationMessages method uses the properties described in Table 14-6 to produce validation messages for each error, returning them in a string array. To make this code as widely applicable as possible, the method accepts a value that describes the data item that an input element is intended to collect from the user, which is then used to generate error messages, like this:

```
...
messages.push(`You must enter a ${thing}`);
...
```

This is an example of the JavaScript/ES6 string interpolation feature, which allows strings to be defined like templates, without having to use the + operator to include data values. Template strings are part of the JavaScript/ES6 standard, but the TypeScript compiler converts them to older-style JavaScript strings so they work with older browsers. Note that the template string is denoted with backtick characters (the ` character and not the regular JavaScript ' character).

The getValidationMessages method defaults to using the path property as the descriptive string if an argument isn't received when the method is invoked, like this:

```
...
let thing: string = state.path || thingName;
...
```

Listing 14-19 shows how the getValidationMessages can be used in the template to generate validation error messages for the user without needing to define separate elements and bindings for each one.

Listing 14-19. Getting Validation Messages from the Component in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<div class="bg-info p-a-1 m-b-1">Model Data: {{jsonProduct}}</div>

<form novalidate (ngSubmit)="addProduct(newProduct)">
    <div class="form-group">
        <label>Name</label>
        <input class="form-control" [(ngModel)]="newProduct.name"
            name="name"
            #name="ngModel"
            required
            minlength="5"
            pattern="^[A-Za-z ]+$"/>
        <ul class="text-danger list-unstyled" *ngIf="name.dirty && name.invalid">
            <li *ngFor="let error of getValidationMessages(name)">
                {{error}}
            </li>
        </ul>
    </div>
    <button class="btn btn-primary" type="submit">
        Create
    </button>
</form>
```

There is no visual change, but the same method can be used to produce validation messages for multiple elements, which results in a simpler template that is easier to read and maintain.

Validating the Entire Form

Displaying validation error messages for individual fields is useful because it helps emphasize where problems need to be fixed. But it can also be useful to validate the entire form. Care must be taken not to overwhelm the user with error messages until they try to submit the form, at which point a summary of any problems can be useful. In preparation, Listing 14-20 adds two new members to the component.

Listing 14-20. Enhancing the Component in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    // ...other methods omitted for brevity...

    formSubmitted: boolean = false;

    submitForm(form: NgForm) {
        this.formSubmitted = true;
        if (form.valid) {
            this.addProduct(this.newProduct);
            this.newProduct = new Product();
            form.reset();
            this.formSubmitted = false;
        }
    }
}
```

The `formSubmitted` property will be used to indicate whether the form has been submitted and will be used to prevent validation of the entire form until the user has tried to submit.

The `submitForm` method will be invoked when the user submits the form and receives an `NgForm` object as its argument. This object represents the form and defines the set of validation properties, which are used to describe the overall validation status of the form so that, for example, the `invalid` property will be `true` if there are validation errors on any of the elements contained by the form. In addition to the validation property, `NgForm` provides the `reset` method, which resets the validation status of the form and returns it to its original and pristine state.

The effect is that the whole form will be validated when the user performs a submit and, if there are no validation errors, a new object will be added to the data model before the form is reset so that it can be used again.

Listing 14-21 shows the changes required to the template to take advantage of these new features and implement form-wide validation.

Listing 14-21. Performing Form-Wide Validation in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)">
```

```
    <div class="bg-danger p-a-1 m-b-1"
        *ngIf="formSubmitted && form.invalid">
        There are problems with the form
    </div>

    <div class="form-group">
        <label>Name</label>
        <input class="form-control"
            name="name"
            [(ngModel)]="newProduct.name"
            #name="ngModel"
            required
            minlength="5"
            pattern="^[A-Za-z ]+$"/>
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || name.dirty) && name.invalid">
            <li *ngFor="let error of getValidationMessages(name)">
                {{error}}
            </li>
        </ul>
    </div>
    <button class="btn btn-primary" type="submit">
        Create
    </button>
</form>
```

The form element now defines a reference variable called form, which has been assigned to ngForm. This is how the ngForm directive provides access to its functionality, through a process that I describe in Chapter 15. For now, however, it is important to know that the validation information for the entire form can be accessed through the form reference variable.

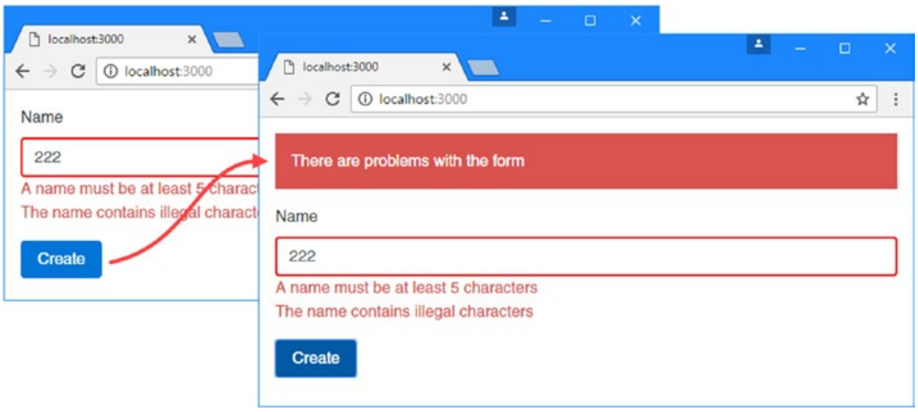
The listing also changes the expression for the ngSubmit binding so that it calls the submitForm method defined by the controller, passing in the template variable, like this:

```
...
<form novalidate ngForm="productForm" #form="ngForm" (ngSubmit)="submitForm(form)">
...
```

It is this object that is received as the argument of the submitForm method and that is used to check the validation status of the form and to reset the form so that it can be used again.

Listing 14-21 also adds a div element that uses the formSubmitted property from the component along with the valid property (provided by the form template variable) to show a warning message when the form contains invalid data, but only after the form has been submitted.

In addition, the ngIf binding has been updated to display the field-level validation messages so that they will be shown when the form has been submitted, even if the element itself hasn't been edited. The result is a validation summary that is shown only when the user submits the form with invalid data, as illustrated by Figure 14-11.



There are problems with the form

Name

222

A name must be at least 5 characters

The name contains illegal characters

Create

Figure 14-11. *Displaying a validation summary message*

Displaying Summary Validation Messages

In a complex form it can be helpful to provide the user with a summary of all the validation errors that have to be resolved.

The NgForm object assigned to the form template reference variable provides access to the individual elements through a property named controls. This property returns an object that has properties for each of the individual elements in the form. For example, there is a name property that represents the input element in the example, which is assigned an object that represents that element and defines the same validation properties that are available for individual elements. In Listing 14-22, I have added a method to the component that receives the object assigned to the form element's template reference variables and uses its controls property to generate a list of errors messages for the entire form.

Listing 14-22. Generating Form-Wide Validation Messages in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    // ...other methods omitted for brevity...

    getFormValidationMessages(form: NgForm): string[] {
        let messages: string[] = [];
        Object.keys(form.controls).forEach(k => {
            this.getValidationMessages(form.controls[k], k)
                .forEach(m => messages.push(m));
        });
        return messages;
    }
}
```

The getFormValidationMessages method builds its list of messages by calling the getValidationMessages method defined in Listing 14-18 for each control in the form. The Object.keys method creates an array from the properties defined by the object returned by the controls property, which is enumerated using the forEach method.

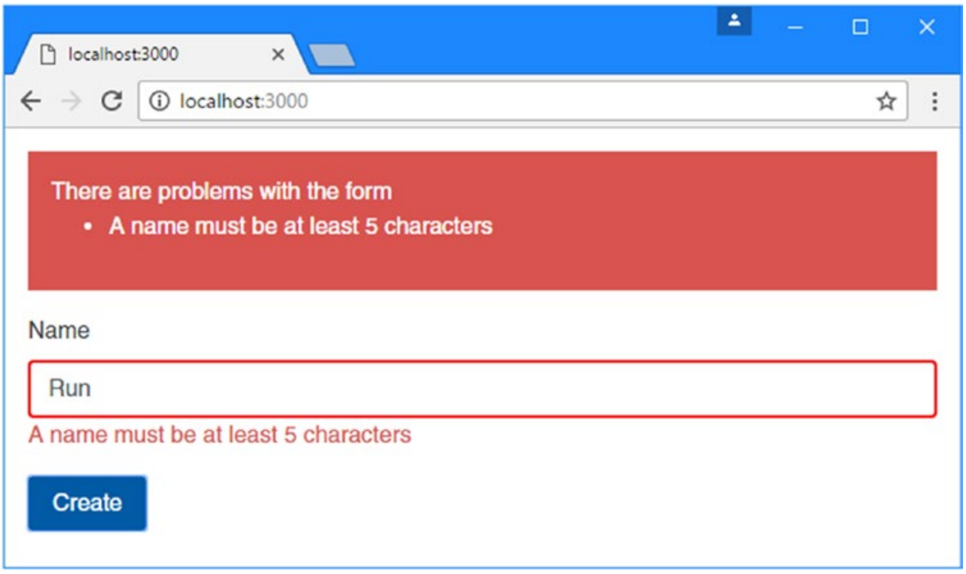
■ **Tip** I have to provide the getValidationMessages method with a name to use in the validation messages because the path property isn't set on the objects I get from the controls property.

In Listing 14-23, I have used this method to include the individual messages at the top of the form, which will be visible once the user clicks the Create button.

Listing 14-23. Displaying Form-Wide Validation Messages in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)">

    <div class="bg-danger p-a-1 m-b-1"
        *ngIf="formSubmitted && form.invalid">
        There are problems with the form
        <ul>
            <li *ngFor="let error of getFormValidationMessages(form)">
                {{error}}
            </li>
        </ul>
    </div>

    <div class="form-group">
        <label>Name</label>
        <input class="form-control"
            name="name"
            [(ngModel)]="newProduct.name"
            #name="ngModel"
            required
            minlength="5"
            pattern="^[A-Za-z ]+$"/>
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || name.dirty) && name.invalid">
            <li *ngFor="let error of getValidationMessages(name)">
                {{error}}
            </li>
        </ul>
    </div>
    <button class="btn btn-primary" type="submit">
        Create
    </button>
</form>
```

The result is that validation messages are displayed alongside the `input` element and collected together at the top of the form once it has been submitted, as shown in Figure 14-12.



There are problems with the form

- A name must be at least 5 characters

Run

A name must be at least 5 characters

Figure 14-12. *Displaying an overall validation summary*

Disabling the Submit Button

The final adjustment in this section is to disable the button once the user has submitted the form, preventing the user from clicking it again until all the validation errors have been resolved. This is a commonly used technique even though it has little bearing on the application, which won't accept the data from the form while it contains invalid values, but which provides useful reinforcement to the user that they cannot proceed until the validation problems have been resolved.

In Listing 14-24, I have used the property binding on the `button` element and added an `input` element for the `price` property to show how the approach scales up with multiple elements in the form.

Listing 14-24. Disabling the Button and Adding an Input Element in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)">

    <div class="bg-danger p-a-1 m-b-1"
        *ngIf="formSubmitted && form.invalid">
        There are problems with the form
        <ul>
```

```
            <li *ngFor="let error of getFormValidationMessages(form)">
                {{error}}
            </li>
        </ul>
    </div>

    <div class="form-group">
        <label>Name</label>
        <input class="form-control"
            name="name"
            [(ngModel)]="newProduct.name"
            #name="ngModel"
            required
            minlength="5"
            pattern="^[A-Za-z ]+$"/>
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || name.dirty) && name.invalid">
            <li *ngFor="let error of getValidationMessages(name)">
                {{error}}
            </li>
        </ul>
    </div>

    <div class="form-group">
        <label>Price</label>
        <input class="form-control" name="price" [(ngModel)]="newProduct.price"
            #price="ngModel" required pattern="^[0-9\.]+$"/>
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || price.dirty) && price.invalid">
            <li *ngFor="let error of getValidationMessages(price)">
                {{error}}
            </li>
        </ul>
    </div>

    <button class="btn btn-primary" type="submit"
        [disabled]="formSubmitted && form.invalid"
        [class.btn-secondary]="formSubmitted && form.invalid">
            Create
    </button>
</form>
```

For extra emphasis, I used the class binding to add the `button` element to the `btn-secondary` class when the form has been submitted and has invalid data. This class applies a Bootstrap CSS style, as shown in Figure 14-13.

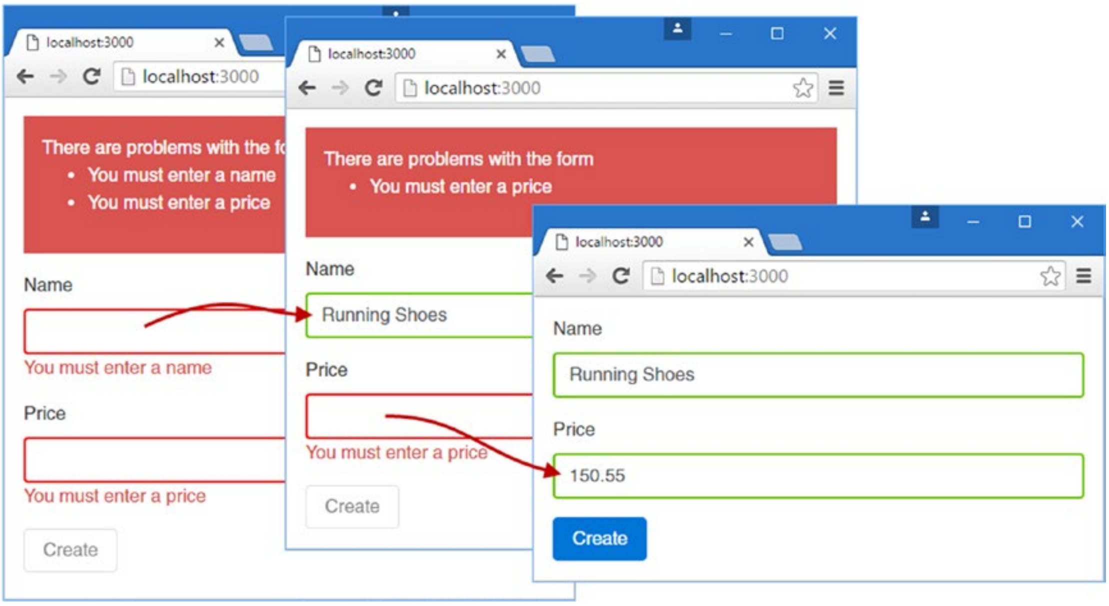


Figure 14-13. *Disabling the submit button*

Using Model-Based Forms

The form in the previous section relies on HTML elements and attributes to define the fields that make up the form and also to apply the validation constraints. The advantage of this approach is that it is familiar and simple. The disadvantage is that large forms become complex and difficult to maintain, with each field demanding its own block of content to manage its layout and its validation requirements and to display any validation messages.

Angular provides another approach, known as *model-based forms*, in which the details of the form and its validation are defined in code rather in a template. This approach scales up better, but it requires some up-front effort, and the results are not as natural as defining everything in the template. In the sections that follow, I set up and apply a model that describes the form and the validation it requires.

Enabling Model-Based Forms Feature

The support for model-based forms requires a new dependency to be declared in the application's Angular module, as shown in Listing 14-25.

Listing 14-25. Enabling Model-Based Forms in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule } from "@angular/forms";
```

```
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent],
    bootstrap: [ProductComponent]
})
export class AppModule {}
```

The model-based forms feature is defined in a module called `ReactiveFormsModule`, which is defined in the `@angular/forms` JavaScript module, which was added to the project at the start of the chapter.

Defining the Form Model Classes

I am going to start by defining classes that will describe the form so that I can keep the template as simple as possible. You don't have to follow this approach completely, but if you are going to adopt model-based form, it makes sense to handle as much of the form as possible in the model and minimize the complexity of the template. I added a file called `form.model.ts` to the app folder and added the code shown in Listing 14-26.

Listing 14-26. The Contents of the form.model.ts File in the app Folder

```
import { FormControl, FormGroup, Validators } from "@angular/forms";

export class ProductFormControl extends FormControl {
    label: string;
    modelProperty: string;

    constructor(label:string, property:string, value: any, validator: any) {
        super(value, validator);
        this.label = label;
        this.modelProperty = property;
    }
}

export class ProductFormGroup extends FormGroup {

    constructor() {
        super({
            name: new ProductFormControl("Name", "name", "", Validators.required),

            category: new ProductFormControl("Category", "category", "",
                Validators.compose([Validators.required,
                    Validators.pattern("^[A-Za-z ]+$"),
                    Validators.minLength(3),
                    Validators.maxLength(10)])),

            price: new ProductFormControl("Price", "price", "",
                Validators.compose([Validators.required,
                    Validators.pattern("^[0-9\.]+$")]))
        });
    }
    get productControls(): ProductFormControl[] {
        return Object.keys(this.controls)
            .map(k => this.controls[k] as ProductFormControl);
    }
}
```

The two classes defined in the listing extend the ones that Angular uses to manage forms and their contents behind the scenes. The `FormControl` class is used to represent a single element in a form, such as `input` element, and the `FormGroup` class is used to manage a `form` element and its contents.

The new subclasses add features that will make it easier to generate the HTML form programmatically. The `ProductFormControl` class extends the `FormControl` class with properties that specify the text for the `label` element associated with an `input` element and the name of the `Product` class property that the `input` element will represent. The `ProductControlGroup` class extends `FormGroup` with a property that presents an array of the `ProductFormControl` objects that have been defined in the form and that will be used in the template to generate content using the `ngFor` directive.

The important part of this class is the constructor for the `ProductFormGroup` class, which is responsible for setting up the model that will be used to create and validate the form. The constructor for the `FormGroup` class, which is the superclass for `ProductFormGroup`, accepts an object whose property names correspond to the names of the `input` elements in the template, each of which is assigned a `ProductFormControl` object that will represent it and that specifies the validation checks that are required. The first property in the object passed to the super constructor is the simplest:

```
...
name: new ProductFormControl("Name", "name", "", Validators.required),
...
```

The property is called `name`, which tells Angular that it corresponds to an `input` element called `name` in the template. The arguments for the `ProductFormControl` constructor specify the content for the `label` element that will be associated with the `input` element (`Name`), the name of the `Product` class property that the `input` element will be bound to (`name`), the initial value for the data binding (the empty string), and the validation checks that are required. Angular defines a class called `Validators` in the `@angular/forms` module that has properties for each of the built-in validation checks, as described in Table 14-8.

Table 14-8. *The Validator Properties*

Name	Description
`Validators.required`	This property corresponds to the `required` attribute and ensures that a value is entered.
`Validators.minLength`	This property corresponds to the `minlength` attribute and ensures a minimum number of characters.
`Validators.maxLength`	This property corresponds to the `maxlength` attribute and ensures a maximum number of characters.
`Validators.pattern`	This property corresponds to the `pattern` attribute and matches a regular expression.

Validators can be combined using the `Validators.compose` method so that several checks are performed on a single element, like this:

```
...
category: new ProductFormControl("Category", "category", "",
    Validators.compose([Validators.required,
        Validators.pattern("^[A-Za-z ]+$"),
        Validators.minLength(3),
        Validators.maxLength(10)])),
...
```

The `Validators.compose` method accepts an array of validators. The constructor arguments defined by the `pattern`, `minLength`, and `maxLength` validators correspond to the attribute values. The overall effect for this element is that values are required, must contain only alphabet characters and spaces, and must be between 3 and 10 characters.

The next step is to move the methods that generate validation error messages from the component into the new form model classes, as shown in Listing 14-27. This keeps all the form-related code together and helps keep the component as simple as possible. (I have also added validation message support for the `maxLength` validator in the `ProductFormControl` class's `getValidationMessages` method.)

Listing 14-27. Moving the Validation Message Methods in the form.model.ts File

```
import { FormControl, FormGroup, Validators } from "@angular/forms";

export class ProductFormControl extends FormControl {
    label: string;
    modelProperty: string;

    constructor(label:string, property:string, value: any, validator: any) {
        super(value, validator);
        this.label = label;
        this.modelProperty = property;
    }

    getValidationMessages() {
        let messages: string[] = [];
        if (this.errors) {
            for (let errorName in this.errors) {
                switch (errorName) {
                    case "required":
                        messages.push(`You must enter a ${this.label}`);
                        break;
                    case "minlength":
                        messages.push(`A ${this.label} must be at least
                            ${this.errors['minlength'].requiredLength}
                            characters`);
                        break;
                    case "maxlength":
                        messages.push(`A ${this.label} must be no more than
                            ${this.errors['maxlength'].requiredLength}
                            characters`);
                        break;
                    case "pattern":
                        messages.push(`The ${this.label} contains
                            illegal characters`);
                        break;
                }
            }
        }
        return messages;
    }
}

export class ProductFormGroup extends FormGroup {

    constructor() {
        super({
            name: new ProductFormControl("Name", "name", "", Validators.required),

            category: new ProductFormControl("Category", "category", "",
                Validators.compose([Validators.required,
                    Validators.pattern("^[A-Za-z ]+$"),
                    Validators.minLength(3),
                    Validators.maxLength(10)])),

            price: new ProductFormControl("Price", "price", "",
                Validators.compose([Validators.required,
                    Validators.pattern("^[0-9\.]+$")]))
        });
    }

    get productControls(): ProductFormControl[] {
        return Object.keys(this.controls)
            .map(k => this.controls[k] as ProductFormControl);
    }

    getFormValidationMessages(form: any) : string[] {
        let messages: string[] = [];
        this.productControls.forEach(c => c.getValidationMessages()
            .forEach(m => messages.push(m)));
        return messages;
    }
}
```

The validation messages are generated in the same way as they were previously, with minor adjustments to reflect the fact that the code is now part of the form model rather than the component.

Using the Model for Validation

Now that I have a form model, I can use it to validate the form. Listing 14-28 shows how the component class has been updated to enable model-based forms and to make the form model classes available to the template. It also removes the methods that generate the validation error messages, which were moved into the form model classes in Listing 14-27.

Listing 14-28. Using a Form Model in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();
    form: ProductFormGroup = new ProductFormGroup();

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }

    newProduct: Product = new Product();

    get jsonProduct() {
        return JSON.stringify(this.newProduct);
    }

    addProduct(p: Product) {
        console.log("New Product: " + this.jsonProduct);
    }

    formSubmitted: boolean = false;

    submitForm(form: NgForm) {
        this.formSubmitted = true;
        if (form.valid) {
            this.addProduct(this.newProduct);
            this.newProduct = new Product();
            form.reset();
            this.formSubmitted = false;
        }
    }
}
```

The listing imports the `ProductFormGroup` class from the `form.model` module and uses it to define a property called `form`, which makes the custom form model class available for use in the template.

Listing 14-29 updates the template to use the model-based features to handle validation, replacing the attribute-based validation configuration defined in the template.

Listing 14-29. Using a Form Model in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">

    <div class="bg-danger p-a-1 m-b-1" *ngIf="formSubmitted && form.invalid">
        There are problems with the form
        <ul>
            <li *ngFor="let error of form.getFormValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>

    <div class="form-group">
        <label>Name</label>
        <input class="form-control" name="name" [(ngModel)]="newProduct.name"
            formControlName="name" />
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || form.controls['name'].dirty) &&
                     form.controls['name'].invalid">
            <li *ngFor="let error of form.controls['name'].getValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>

    <div class="form-group">
        <label>Category</label>
        <input class="form-control" name="name" [(ngModel)]="newProduct.category"
            formControlName="category" />
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || form.controls['category'].dirty) &&
                     form.controls['category'].invalid">
            <li *ngFor="let error of form.controls['category']
                    .getValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>

    <div class="form-group">
        <label>Price</label>
        <input class="form-control" name="price" [(ngModel)]="newProduct.price"
            formControlName="price" />
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || form.controls['price'].dirty) &&
                 form.controls['price'].invalid">
            <li *ngFor="let error of form.controls['price'].getValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>

    <button class="btn btn-primary" type="submit"
        [disabled]="formSubmitted && form.invalid"
        [class.btn-secondary]="formSubmitted && form.invalid">
            Create
    </button>
</form>
```

The first changes are to the form element. Using model-based validation requires the formGroup directive, like this:

```
...
<form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">
...
```

The value assigned to the formGroup directive is the component's form property, which returns the ProductFormGroup object, which is the source of validation information about the form.

The next changes are to the input elements. The individual validation attributes and the template variable that was assigned the special ngForm value have been removed. A new forControlName attribute has been added, which identifies the input element to the model-based form system, using the name used in the ProductFormGroup in Listing 14-26.

```
...
<input class="form-control" name="name" [(ngModel)]="newProduct.name"
    formControlName="name" />
...
```

This attribute also allows Angular to add and remove the validation classes for the input element. In this case, the formControlName attribute has been set to name, which tells Angular that this element should be validated using specific validators.

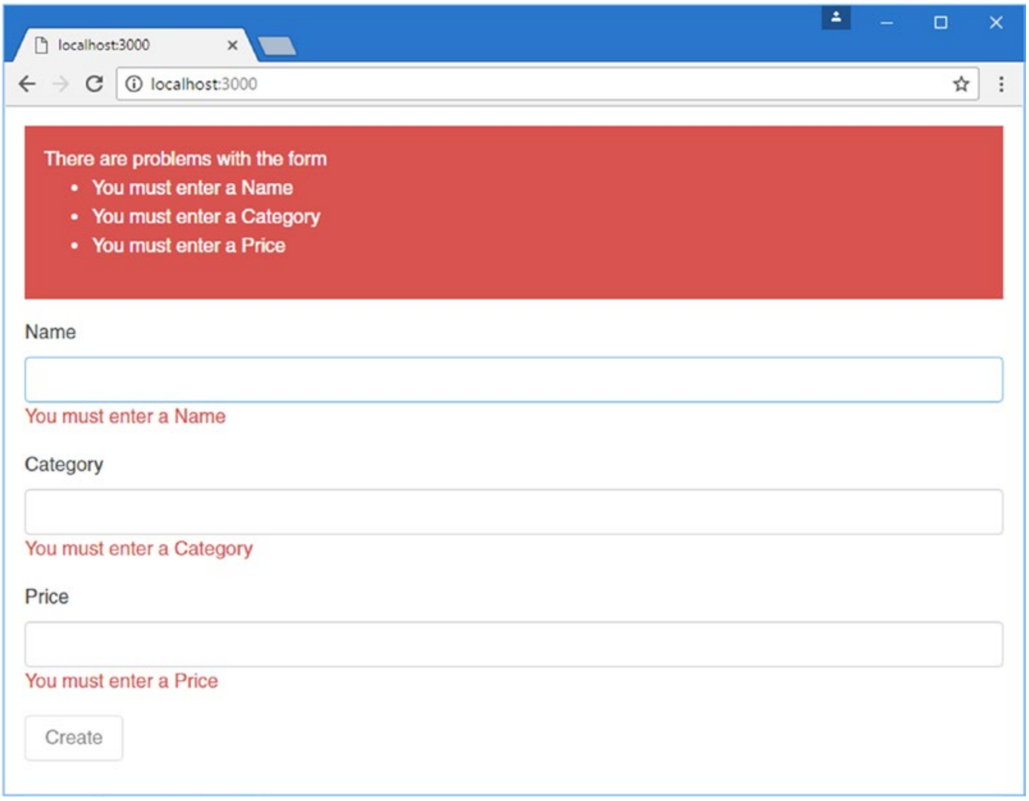
```
...
name: new ProductFormControl("Name", "name", "", Validators.required),
...
```

The component's form property provides access to the validation information for each element, like this:

```
...
<li *ngFor="let error of form.controls['name'].getValidationMessages()">     {{error}} </li>
...
```

The FormGroup class provides a controls property that returns a collection of the FormControl objects that it is managing, indexed by name. Individual FormControl objects can be retrieved from the collection and either inspected to get the validation state or used to generate validation messages.

As part of the changed in Listing 14-29, I have added all three input elements required to get the data to create new Product objects, each of which is checked using the validation model, as shown in Figure 14-14.



There are problems with the form

- You must enter a Name
- You must enter a Category
- You must enter a Price

Name

You must enter a Name

Category

You must enter a Category

Price

You must enter a Price

Figure 14-14. *Using model-based form validation*

Generating the Elements from the Model

There is a lot of duplication in Listing 14-29. The validation attributes have been moved into code, but each input element still requires a supporting framework of content to handle its layout and to display its validation messages to the user.

The next step is to simplify the template by using the form model to generate the elements in the form and not just validate them. Listing 14-30 shows how the standard Angular directives can be combined with the form model to generate the form programmatically.

Listing 14-30. Using the Model to Generate the Form in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">
```

```
    <div class="bg-danger p-a-1 m-b-1" *ngIf="formSubmitted && form.invalid">
        There are problems with the form
        <ul>
            <li *ngFor="let error of form.getFormValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>

    <div class="form-group" *ngFor="let control of form.productControls">
        <label>{{control.label}}</label>
        <input class="form-control"
            [(ngModel)]="newProduct[control.modelProperty]"
            name="{{control.modelProperty}}"
            formControlName="{{control.modelProperty}}" />
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || control.dirty) && control.invalid">
            <li *ngFor="let error of control.getValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>

    <button class="btn btn-primary" type="submit"
        [disabled]="formSubmitted && form.invalid"
        [class.btn-secondary]="formSubmitted && form.invalid">
            Create
    </button>
</form>
```

This listing uses the ngFor directive to create form elements using the description provided by the ProductFormControl and ProductFormGroup model classes. Each element is configured with the same attributes as in Listing 14-29, but their values are taken from the model descriptions, which allows the template to be simplified and rely on the model for both the definition of the form elements and their validation.

Once you have a basic form model in place, you can expand it and extend it to reflect the needs of the application. For example, you can add new elements; extend the FormControl subclass to contain additional information, such as values for the type attribute of the input element; generate select elements for some fields; and provide placeholder values to help guide the user.

Creating Custom Form Validators

Angular supports custom form validators, which can be used to enforce a validation policy that is specified to the application, rather than the general-purpose validation that the built-in validators provide. To demonstrate, I added a file called limit.formvalidator.ts to the app folder and used it to define the class shown in Listing 14-31.

Listing 14-31. The Contents of the limit.formvalidator.ts File in the app Folder

```
import { FormControl } from "@angular/forms";

export class LimitValidator {

    static Limit(limit:number) {
        return (control:FormControl) : {[key: string]: any} => {
            let val = Number(control.value);
            if (val != NaN && val > limit) {
                return {"limit": {"limit": limit, "actualValue": val}};
            } else {
                return null;
            }
        }
    }
}
```

Custom validators are factories that create functions used to perform validation. In this case, the `LimitValidator` class defines the `Limit` method, which is `static` and is the factory that returns the validation function. The argument to the `Limit` method is the largest value that should be allowed to pass validation.

When Angular invokes the validation function returned by the `Limit` method, it provides a `FormControl` method as the argument. The custom validation function in the listing uses the `value` property to get the value entered by the user, convert it to a `number`, and compare it to the allowed limit.

Validation functions return `null` for valid values and return an object that contains details of the error for invalid values. To describe a validation error, the object defines a property that specifies which validation rule has failed, which is `limit` in this case, and assigns the property another object that provides details. The `limit` property returns an object that has a `limit` property that is set to the validation limit and an `actualValue` property that is set to the value entered by the user.

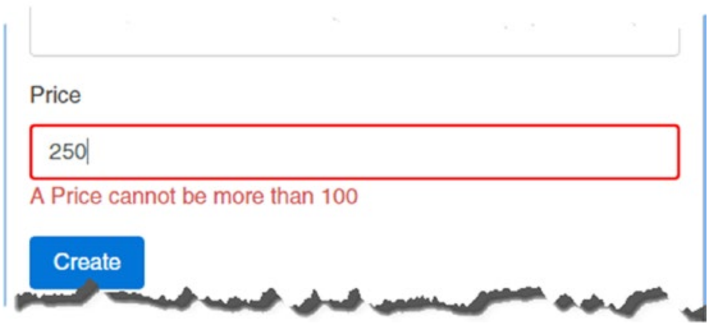
Applying a Custom Validator

Listing 14-32 shows how the form model has been extended to support the new custom validator class and apply it to the `input` element for the product's price property.

Listing 14-32. Applying a Custom Validator in the form.model.ts File

```
import { FormControl, FormGroup, Validators } from "@angular/forms";
import { LimitValidator } from "./limit.formvalidator";

export class ProductFormControl extends FormControl {
    label: string;
    modelProperty: string;

    constructor(label:string, property:string, value: any, validator: any) {
        super(value, validator);
        this.label = label;
        this.modelProperty = property;
    }
    getValidationMessages() {
        let messages: string[] = [];
        if (this.errors) {
            for (let errorName in this.errors) {
                switch (errorName) {
                    case "required":
                        messages.push(`You must enter a ${this.label}`);
                        break;
                    case "minlength":
                        messages.push(`A ${this.label} must be at least
                            ${this.errors['minlength'].requiredLength}
                            characters`);
                        break;
                    case "maxlength":
                        messages.push(`A ${this.label} must be no more than
                            ${this.errors['maxlength'].requiredLength}
                            characters`);
                        break;
                    case "limit":
                        messages.push(`A ${this.label} cannot be more
                                than ${this.errors['limit'].limit}`);
                        break;
                    case "pattern":
                        messages.push(`The ${this.label} contains
                             illegal characters`);
                        break;
                }
            }
        }
        return messages;
    }
}

export class ProductFormGroup extends FormGroup {

    constructor() {
        super({
            name: new ProductFormControl("Name", "name", "", Validators.required),
            category: new ProductFormControl("Category", "category", "",
                Validators.compose([Validators.required,
                    Validators.pattern("^[A-Za-z ]+$"),
                    Validators.minLength(3),
                    Validators.maxLength(10)])),
            price: new ProductFormControl("Price", "price", "",
                Validators.compose([Validators.required,
                    LimitValidator.Limit(100),
                    Validators.pattern("^[0-9\.]+$")]))
        });
    }
    get productControls(): ProductFormControl[] {
        return Object.keys(this.controls)
            .map(k => this.controls[k] as ProductFormControl);
    }

    getFormValidationMessages(form: any) : string[] {
        let messages: string[] = [];
        this.productControls.forEach(c => c.getValidationMessages()
            .forEach(m => messages.push(m)));
        return messages;
    }
}
```

The result is that the value entered into the `Price` field has a limit of `100`, and larger values display the validation error message shown in Figure 14-15.



A Price cannot be more than 100

Figure 14-15. *A custom validation message*

Summary

In this chapter, I introduced the way that Angular supports user interaction using events and forms. I explained how to create event bindings, how to create two-way bindings, and how they can be simplified using the `ngModel` directive. I also described the support that Angular provides for managing and validating HTML forms. In the next chapter, I explain how to create custom directives.

CHAPTER 15

Creating Attribute Directives

In this chapter, I describe how custom directives can be used to supplement the functionality provided by the built-in ones provided by Angular. The focus of this chapter is *attribute directives*, which are the simplest type that can be created and that change the appearance or behavior of a single element. In Chapter 16, I explain how to create *structural directives*, which are used to change the layout of the HTML document. Components are also a type of directive, and I explain how they work in Chapter 17.

Throughout these chapters, I describe how custom directives work by re-creating the features provided by some of the built-in directives. This isn't something you would typically do in a real project, but it provides a useful baseline against which the process can be explained. Table 15-1 puts attribute directives into context.

Table 15-1. *Putting Attribute Directives in Context*

Question	Answer
What are they?	Attribute directives are classes that are able to modify the behavior or appearance of the element they are applied to. The style and class bindings described in Chapter 12 are examples of attribute directives.
Why are they useful?	The built-in directives cover the most common tasks required in web application development but don't deal with every situation. Custom directives allow application-specific features to be defined.
How are they used?	Attribute directives are classes to which the `@Directive` decorator has been applied. They are enabled in the `directives` property of the component responsible for a template and applied using a CSS selector.
Are there any pitfalls or limitations?	The main pitfall when creating a custom directive is the temptation to write code to perform tasks that can be better handled using directive features such as input and output properties and host element bindings.
Are there any alternatives?	Angular supports two other types of directive—structural directives and components—that may be more suitable for a given task. You can sometimes combine the built-in directives to create a specific effect If you prefer to avoid writing custom code, although the result can be brittle and leads to complex HTML that is hard to read and maintain.

Table 15-2 summarizes the chapter.

Table 15-2. *Chapter Summary*

Problem	Solution	Listing
Create an attribute directive	Apply the `@Directive` to a class	1–5
Access host element attribute values	Apply the `@Attribute` decorator to a constructor parameter	6–9
Create a data-bound input property	Apply the `@Input` decorator to a class property	10–11
Receive a notification when a data-bound input property value changes	Implement the `ngOnChanges` method	12
Define an event	Apply the `@Output` decorator	13, 14
Create a property binding or event binding on the host element	Apply the `@HostBinding` or `@HostListener` decorators	15–19
Export a directive's functionality for use in the template	Use the `exportAs` property of the `@Directive` decorator	20, 21

Preparing the Example Project

As I have been doing throughout this part of the book, I will continue using the `example` project from the previous chapter. To prepare for this chapter, I have added a table to the template that displays the products in the data model and removed the form-level validation messages, as shown in Listing 15-1.

Listing 15-1. Preparing the Template in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<div class="col-xs-6">
    <form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">
        <div class="form-group" *ngFor="let control of form.productControls">
            <label>{{control.label}}</label>
            <input class="form-control"
                [(ngModel)]="newProduct[control.modelProperty]"
                name="{{control.modelProperty}}"
                formControlName="{{control.modelProperty}}" />
            <ul class="text-danger list-unstyled"
                    *ngIf="(formSubmitted || control.dirty) && control.invalid">
                <li *ngFor="let error of control.getValidationMessages()">
                    {{error}}
                </li>
            </ul>
        </div>
        <button class="btn btn-primary" type="submit"
            [disabled]="formSubmitted && !form.valid"
            [class.btn-secondary]="formSubmitted && form.invalid">
```

```
                Create
            </button>
        </form>
</div>

<div class="col-xs-6">
    <table class="table table-sm table-bordered table-striped">
        <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
        <tr *ngFor="let item of getProducts(); let i = index">
            <td>{{i + 1}}</td>
            <td>{{item.name}}</td>
            <td>{{item.category}}</td>
            <td>{{item.price}}</td>
        </tr>
    </table>
</div>
```

This listing uses the Bootstrap grid layout to position the form and the table side by side. Listing 15-2 removes the jsonProperty property and updates the component's addProduct method so that it adds a new object to the data model.

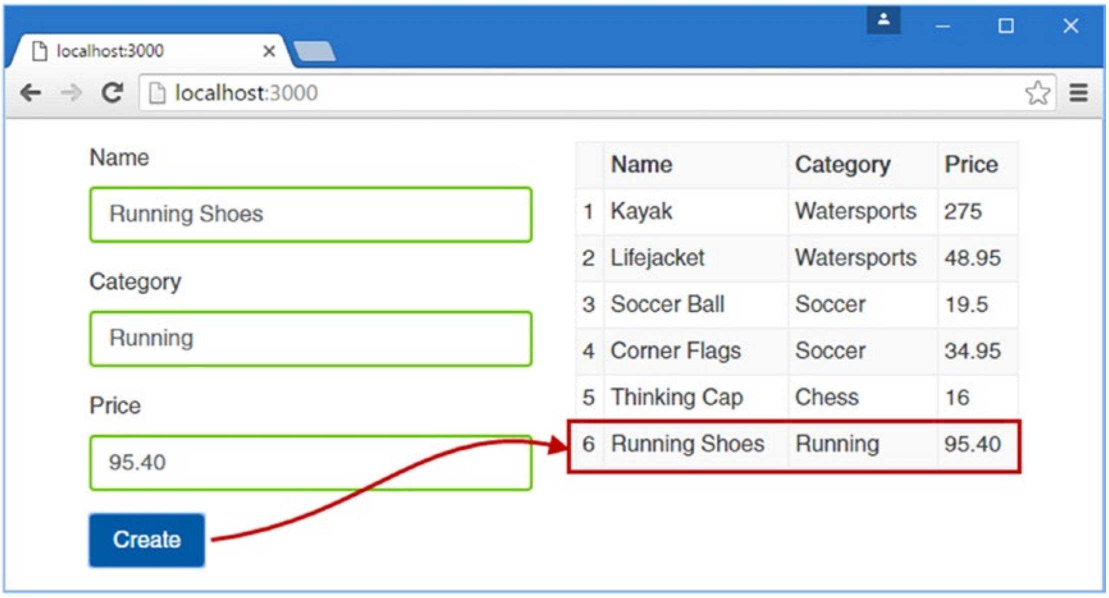
Listing 15-2. Modifying the Data Model in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();
    form: ProductFormGroup = new ProductFormGroup();

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }

    newProduct: Product = new Product();

    addProduct(p: Product) {
        this.model.saveProduct(p);
    }
    formSubmitted: boolean = false;

    submitForm(form: NgForm) {
        this.formSubmitted = true;
        if (form.valid) {
            this.addProduct(this.newProduct);
            this.newProduct = new Product();
            form.reset();
            this.formSubmitted = false;
        }
    }
}
```

To start the application, navigate to the project folder and run the following command:

```
npm start
```

The development web server will start and open a new browser window that will show the form in Figure 15-1. When you submit the form, the data will be validated, and either error messages will be displayed or a new item will be added to the data model and displayed in the table.



	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16
6	Running Shoes	Running	95.40

***Figure 15-1.** Running the example application*

Creating a Simple Attribute Directive

The best place to start is to jump in and create a directive to see how they work. I added a file called `attr.directive.ts` to the app folder with the code shown in Listing 15-3. The name of the file indicates that it contains a directive. I set the first part of the file name to `attr` to indicate that this is an example of an attribute directive.

Listing 15-3. The Contents of the attr.directive.ts File in the app Folder

```
import { Directive, ElementRef } from "@angular/core";

@Directive({
    selector: "[pa-attr]",
})
export class PaAttrDirective {

    constructor(element: ElementRef) {
        element.nativeElement.classList.add("bg-success");
    }
}
```

Directives are classes to which the `@Directive` decorator has been applied. The decorator requires the `selector` property, which is used to specify how the directive is applied to elements, expressed using a standard CSS style selector. The selector I used is `[pa-attr]`, which will match any element that has an attribute called `pa-attr`, regardless of the element type or the value assigned to the attribute.

Custom directives are given a distinctive prefix so they can be easily recognized. The prefix can be anything that is meaningful to your application. I have chosen the prefix `Pa` for my directive, reflecting the title of this book, and this prefix is used in the attribute specified by the `selector` decorator property and the name of the attribute class. The case of the prefix is changed to reflect its use so that an initial lowercase character is used for the selector attribute name (`pa-attr`) and an initial uppercase character is used in the name of the directive class (`PaAttrDirective`).

■ **Note** The prefix `Ng`/`ng` is reserved for use for built-in Angular features and should not be used.

The directive constructor defines a single `ElementRef` parameter, which Angular provides when it creates a new instance of the directive and which represents the host element.

The `ElementRef` class defines a single property, `nativeElement`, which returns the object used by the browser to represent the element in the Domain Object Model. This object provides access to the methods and properties that manipulate the element and its contents, including the `classList` property, which can be used to manage the class membership of the element, like this:

```
...
element.nativeElement.classList.add("bg-success");
...
```

To summarize, the `PaAttrDirective` class is a directive that is applied to elements that have a `pa-attr` attribute, and adds those elements to the `bg-success` class, which the Bootstrap CSS library uses to assign a background color to elements.

Applying a Custom Directive

There are two steps to apply a custom directive. The first is to update the template so that there are one or more elements that match the `selector` that the directive uses. In the case of the example directive, this means adding the `pa-attr` attribute to an element, as shown in Listing 15-4.

Listing 15-4. Adding a Directive Attribute in the template.html File

```
...
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index" pa-attr>
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
...
```

The directive's selector matches any element with the attribute, regardless of whether a value has been assigned to it or what that value is.

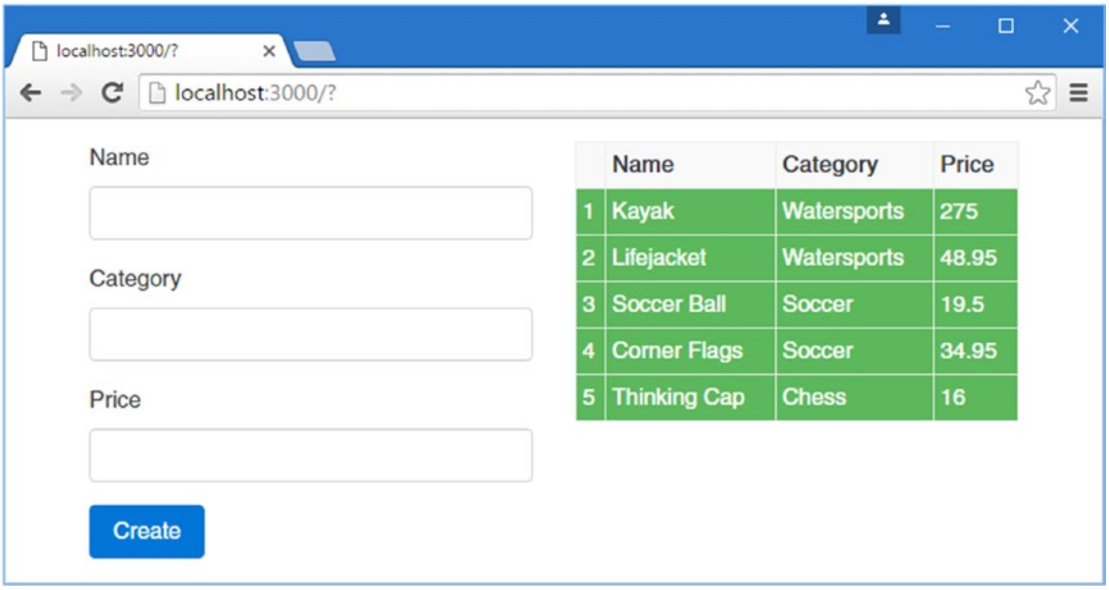
The second step to applying a directive is to change the configuration of the Angular module, as shown in Listing 15-5.

Listing 15-5. Configuring the Component in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

The `declarations` property of the `NgModule` decorator declares the directives and components that the application will use. Don't worry if the relationship and differences between directives and components seem muddled at the moment; it will become clear in Chapter 17.

Once both steps have been completed, the effect is that the `pa-attr` attribute applied to the `tr` element in the template will trigger the custom directive, which uses the DOM API to add the element to the `bg-success` class. Since the `tr` element is part of the micro-template used by the `ngFor` directive, all the rows in the table are affected, as shown in Figure 15-2.



	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 15-2. *Applying a custom directive*

Accessing Application Data in a Directive

The example in the previous section shows the basic structure of a directive, but it doesn't do anything that couldn't be performed just by using a `class` property binding on the `tr` element. Directives become useful when they can interact with the host element and with the rest of the application.

Reading Host Element Attributes

The simplest way to make a directive more useful is to configure it using attributes applied to the host element, which allows each instance of the directive to be provided with its own configuration information and to adapt its behavior accordingly.

As an example, Listing 15-6 applies the directive to some of the `td` elements in the template table and adds an attribute that specifies the class that the host element should be added to. The directive's selector means that it will match any element that has the `pa-attr` attribute, regardless of the tag type, and will work as well on `td` elements as it does on `tr` elements.

Listing 15-6. Adding Attributes in the template.html File

```
...
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index" pa-attr>
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td pa-attr pa-attr-class="bg-warning">{{item.category}}</td>
        <td pa-attr pa-attr-class="bg-info">{{item.price}}</td>
    </tr>
</table>
...
```

The pa-attr attribute has been applied to two of the td elements, along with a new attribute called pa-attr-class, which has been used to specify the class to which the directive should add the host element. Listing 15-7 shows the changes required to the directive to get the value of the pa-attr-class attribute and use it to change the element.

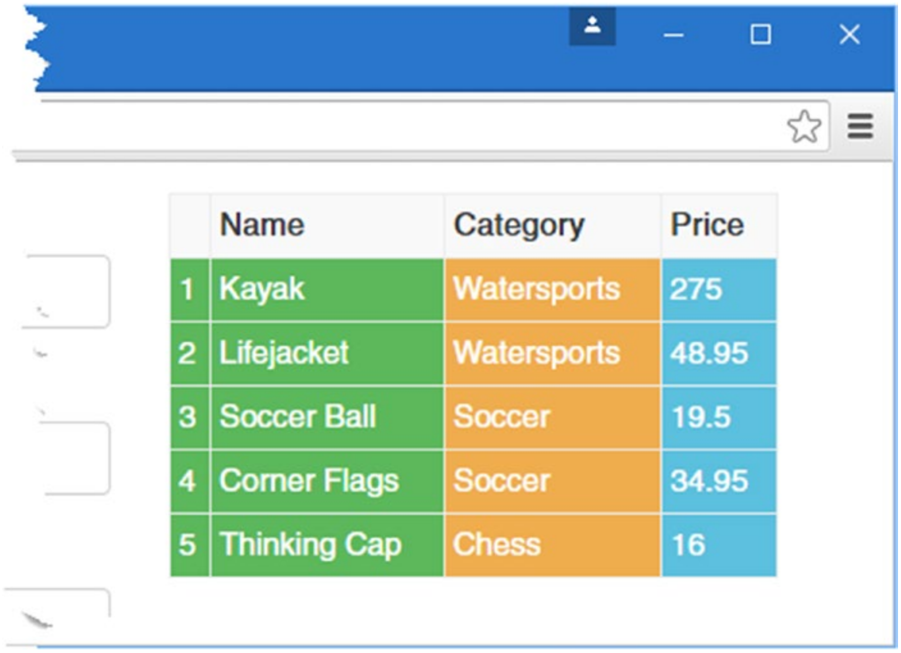
Listing 15-7. Reading an Attribute in the attr.directive.ts File

```
import { Directive, ElementRef, Attribute } from "@angular/core";

@Directive({
    selector: "[pa-attr]",
})
export class PaAttrDirective {

    constructor(element: ElementRef, @Attribute("pa-attr-class") bgClass: string) {
        element.nativeElement.classList.add(bgClass || "bg-success");
    }
}
```

To receive the value of the pa-attr-class attribute, I added a new constructor parameter called bgClass, to which the @Attribute decorator has been applied. This decorator is defined in the @angular/core module, and it specifies the name of the attribute that should be used to provide a value for the constructor parameter when a new instance of the directive class is created. Angular creates a new instance of the decorator for each element that matches the selector and uses that element's attributes to provide the values for the directive constructor arguments that have been decorated with @Attribute.

Within the constructor, the value of the attribute is passed to the classList.add method, with a default value that allows the directive to be applied to elements that have the pa-attr attribute but not the pa-attr-class attribute.

The result is that the class to which elements are added can now be specified using an attribute, producing the result shown in Figure 15-3.



	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 15-3. *Configuring a directive using a host element attribute*

Using a Single Host Element Attribute

Using one attribute to apply a directive and another to configure it is redundant, and it makes more sense to make a single attribute do double duty, as shown in Listing 15-8.

Listing 15-8. Reusing an Attribute in the attr.directive.ts File

```
import { Directive, ElementRef, Attribute } from "@angular/core";

@Directive({
    selector: "[pa-attr]",
})
export class PaAttrDirective {

    constructor(element: ElementRef, @Attribute("pa-attr") bgClass: string) {
        element.nativeElement.classList.add(bgClass || "bg-success");
    }
}
```

The `@Attribute` decorator now specifies the `pa-attr` attribute as the source of the `bgClass` parameter value. In Listing 15-9, I have updated the template to reflect the dual-purpose attribute.

Listing 15-9. Applying a Directive in the template.html File

```
...
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index" pa-attr>
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td pa-attr="bg-warning">{{item.category}}</td>
        <td pa-attr="bg-info">{{item.price}}</td>
    </tr>
</table>
...
```

There is no visual change in the result produced by this example, but it has simplified the way that the directive is applied in the HTML template.

Creating Data-Bound Input Properties

The main limitation of reading attributes with `@Attribute` is that the values are static. The real power in Angular directives comes through support for expressions that are updated to reflect changes in the application state and that can respond by changing the host element.

Directives receive expressions using *data-bound input properties*, also known as *input properties* or, simply, *inputs*. Listing 15-10 changes the application's template so that the `pa-attr` attributes applied to the `tr` and `td` elements contain expressions, rather than just static class names.

Listing 15-10. Using Expressions in the template.html File

```
...
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
        [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
            {{item.category}}
        </td>
        <td [pa-attr]="'bg-info'">{{item.price}}</td>
    </tr>
</table>
...
```

There are three expressions in the listing. The first, which is applied to the `tr` element, uses the number of objects returned by the component's `getProducts` method to select a class.

```
...
<tr *ngFor="let item of getProducts(); let i = index"
    [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'">
...
```

The second expression, which is applied to the `td` element for the `Category` column, specifies the `bg-info` class for `Product` objects whose `Category` property returns `Soccer` and `null` for all other values.

```
...
<td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
...
```

The third and final expression returns a fixed string value, which I have enclosed in single quotes, since this is an expression and not a static attribute value.

```
...
<td [pa-attr]="'bg-info'">{{item.price}}</td>
...
```

Notice that the attribute name is enclosed in square brackets. That's because the way to receive an expression in a directive is to create a data binding, just like the built-in directives that are described in Chapters 13 and 14.

■ **Tip** Forgetting to use the square brackets is a common mistake. Without them, Angular will just pass the raw text of the expression to the directive without evaluating it. This is the first thing to check if you encounter an error when applying a custom directive.

Implementing the other side of the data binding means creating an input property in the directive class and telling Angular how to manage its value, as shown in Listing 15-11.

Listing 15-11. Defining an Input Property in the attr.directive.ts File

```
import { Directive, ElementRef, Attribute, Input } from "@angular/core";

@Directive({
    selector: "[pa-attr]"
})
export class PaAttrDirective {

    constructor(private element: ElementRef) {}

    @Input("pa-attr")
    bgClass: string;

    ngOnInit() {
        this.element.nativeElement.classList.add(this.bgClass || "bg-success");
    }
}
```

Input properties are defined by applying the `@Input` decorator to a property and using it to specify the name of the attribute that contains the expression. This listing defines a single input property, which tells Angular to set the value of the directive's `bgClass` property to the value of the expression contained in the `pa-attr` attribute.

■ **Tip** You don't need to provide an argument to the `@Input` decorator if the name of the property corresponds to the name of the attribute on the host element. So, if you apply `@Input()` to a property called `myVal`, then Angular will look for a `myVal` attribute on the host element.

The role of the constructor has changed in this example. When Angular creates a new instance of a directive class, the constructor is invoked to create a new directive object and only then is the value of the input property set. This means that the constructor cannot access the input property value because its value will not be set by Angular until after the constructor has completed and the new directive object has been produced. To address this, directives can implement *lifecycle hook methods*, which Angular uses to provide directives with useful information after they have been created and while the application is running, as described in Table 15-3.

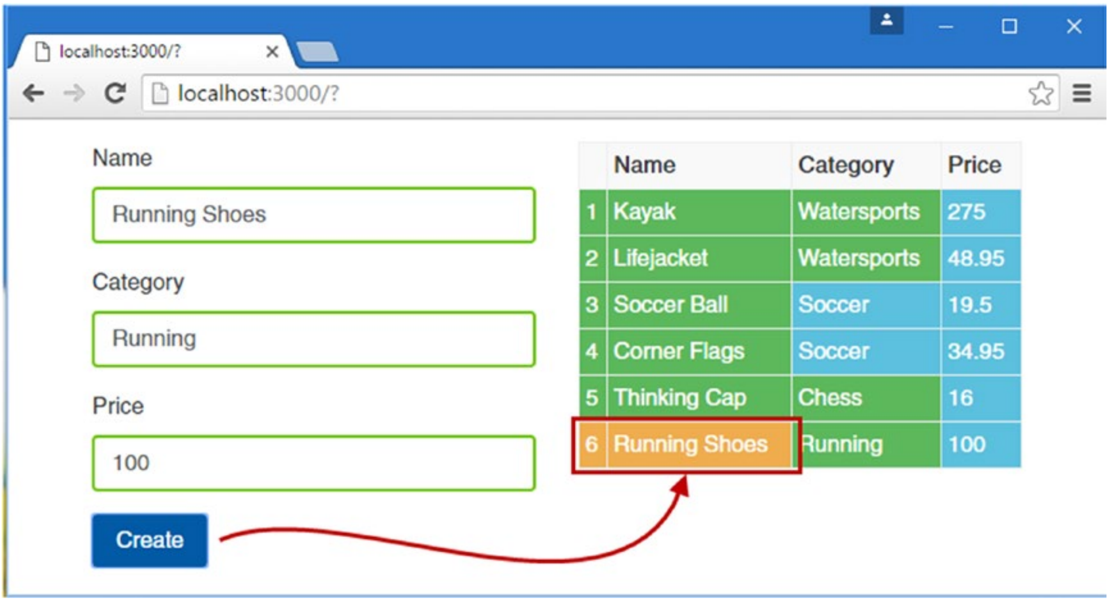
Table 15-3. *The Directive Lifecycle Hook Methods*

Name	Description
ngOnInit	This method is called after Angular has set the initial value for all the input properties that the directive has declared.
ngOnChanges	This method is called when the value of an input property has changed and also just before the `ngOnInit` method is called.
ngDoCheck	This method is called when Angular runs its change detection process so that directives have an opportunity to update any state that isn't directly associated with an input property.
ngAfterContentInit	This method is called when the directive's content has been initialized. See the "Receiving Query Change Notifications" section in Chapter 16 for an example that uses this method.
ngAfterContentChecked	This method is called after the directive's content has been inspected as part of the change detection process.
ngOnDestroy	This method is called immediately before Angular destroys a directive.

To set the class on the host element, the directive in Listing 15-11 implements the `ngOnInit` method, which is called after Angular has set the value of the `bgClass` property. The constructor is still needed to receive the `ElementRef` object that provides access to the host element, which is assigned to a property called `element`.

The result is that Angular will create a directive object for each `tr` element, evaluate the expressions specified in the `pa-attr` attribute, use the results to set the value of the input properties, and then call the `ngOnInit` methods, which allows the directives to respond to the new input property values.

To see the effect, use the form to add a new product to the example application. Since there are initially five items in the model, the expression for the `tr` element will select the `bg-success` class. When you add a new item, Angular will create another instance of the directive class and evaluate the expression to set the value of the input property; since there are now six items in the model, the expression will select the `bg-warning` class, which provides the new row with a different background color, as shown in Figure 15-4.



Name: Running Shoes

Category: Running

Price: 100

	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16
6	Running Shoes	Running	100

Figure 15-4. *Using an input property in a custom directive*

Responding to Input Property Changes

Something odd happened in the previous example: adding a new item affected the appearance of the new elements only and not the existing elements. Behind the scenes, Angular has updated the value of the bgClass property for each of the directives that it created—one for each td element in the table column—but the directives didn't notice because changing a property value doesn't automatically cause directives to respond.

To handle changes, a directive must implement the ngOnChanges method to receive notifications when the value of an input property changes, as shown in Listing 15-12.

Listing 15-12. Receiving Change Notifications in the attr.directive.ts File

```
import { Directive, ElementRef, Attribute, Input,
         SimpleChange } from "@angular/core";

@Directive({
    selector: "[pa-attr]"
})
export class PaAttrDirective {

    constructor(private element: ElementRef) {}

    @Input("pa-attr")
    bgClass: string;

    ngOnChanges(changes: {[property: string]: SimpleChange }) {
        let change = changes["bgClass"];
        let classList = this.element.nativeElement.classList;
```

```
            if (!change.isFirstChange() && classList.contains(change.previousValue)) {
                classList.remove(change.previousValue);
            }
            if (!classList.contains(change.currentValue)) {
                classList.add(change.currentValue);
            }
        }
    }
```

The ngOnChanges method is called once before the ngOnInit method and then called again each time there are changes to any of a directive's input properties. The ngOnChanges parameter is an object whose property names refer to each changed input property and whose values are SimpleChange objects, which are defined in the @angular/core module. TypeScript represents this data structure as follows:

```
...
ngOnChanges(changes: {[property: string]: SimpleChange }) {
...
```

The SimpleChange class defines the members shown in Table 15-4.

Table 15-4. *The Properties and Method of the SimpleChange Class*

Name	Description
previousValue	This property returns the previous value of the input property.
currentValue	This property returns the current value of the input property
isFirstChange()	This method returns true if this is the call to the ngOnChanges method that occurs before the ngOnInit method.

The easiest way to understand the way that changes are presented to the ngOnChanges method is to serialize the object as JSON and look at it then.

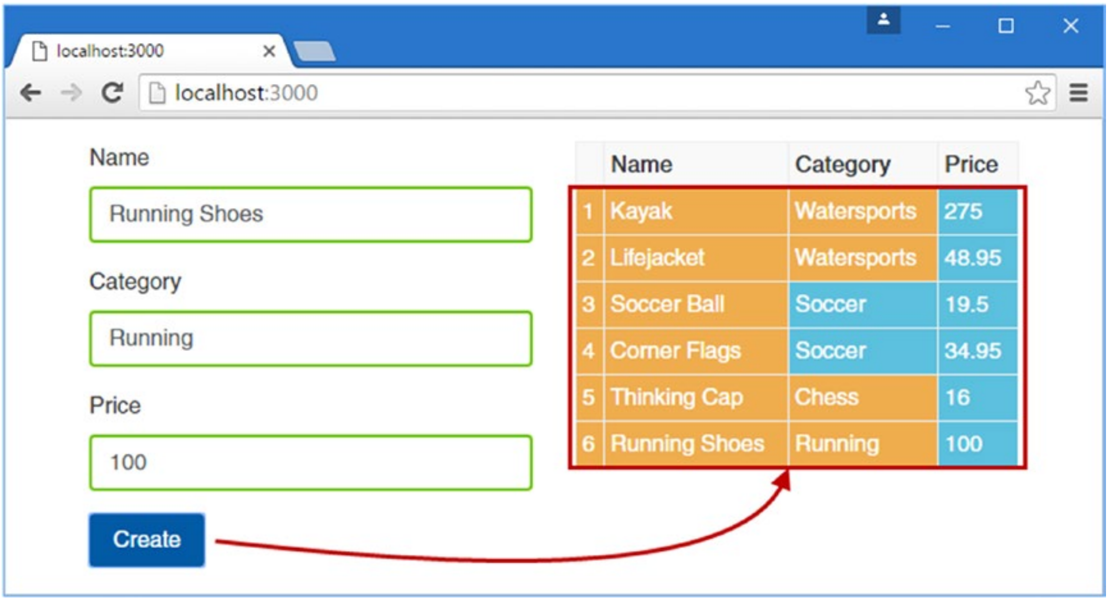
```
...
{
    "target": {
        "previousValue":"bg-success",
        "currentValue":"bg-warning"
    }
}
...
```

This strips out the isFirstChange method, but it does help show the way that each property in the argument object is used to indicate a change to an input property.

When responding to changes to the input property value, a directive has to make sure to undo the effect of previous updates. In the case of the example directive, this means removing the element from the previousValue class and adding it to the currentValue class instead.

It is important to use the isFirstChange method so that you don't undo a value that hasn't actually been applied, since the ngOnChanges method is called the first time a value is assigned to the input property.

The result of handling these change notifications is that the directive responds when Angular reevaluates the expressions and updates the input properties. Now when you add a new product to the application, the background colors for all the `tr` elements are updated, as shown in Figure 15-5.



Name: Running Shoes

Category: Running

Price: 100

	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16
6	Running Shoes	Running	100

Figure 15-5. *Responding to input property changes*

Creating Custom Events

Output properties are the Angular feature that allows directives to add custom events to their host elements, through which details of important changes can be sent to the rest of the application. Output properties are defined using the `@Output` decorator, which is defined in the `@angular/core` module, as shown in Listing 15-13.

Listing 15-13. Defining an Output Property in the attr.directive.ts File

```
import { Directive, ElementRef, Attribute, Input,
         SimpleChange, Output, EventEmitter } from "@angular/core";
import { Product } from "./product.model";

@Directive({
    selector: "[pa-attr]"
})
export class PaAttrDirective {

    constructor(private element: ElementRef) {
        this.element.nativeElement.addEventListener("click", e => {
            if (this.product != null) {
                this.click.emit(this.product.category);
            }
        });
    }
    @Input("pa-attr")
    bgClass: string;

    @Input("pa-product")
    product: Product;

    @Output("pa-category")
    click = new EventEmitter<string>();

    ngOnChanges(changes: {[property: string]: SimpleChange }) {
        let change = changes["bgClass"];
        let classList = this.element.nativeElement.classList;
        if (!change.isFirstChange() && classList.contains(change.previousValue)) {
            classList.remove(change.previousValue);
        }
        if (!classList.contains(change.currentValue)) {
            classList.add(change.currentValue);
        }
    }
}
```

The `EventEmitter` class provides the event mechanism for Angular directives. The listing creates an `EventEmitter` object and assigns it to a variable called `click`, like this:

```
...
@Output("pa-category")
click = new EventEmitter<string>();
...
```

The `string` type parameter indicates that listeners to the event will receive a string when the event is triggered. Directives can provide any type of object to their event listeners, but common choices are `string` and `number` values, data model objects, and JavaScript `Event` objects.

The custom event in the listing is triggered when the mouse button is clicked on the host element, and the event provides its listeners with the `category` of the `Product` object that was used to create the table row using the `ngFor` directive. The effect is that the directive is responding to a DOM event on the host element and generating its own custom event in response. The listener for the DOM event is set up in the directive class constructor using the browser's standard `addEventListener` method, like this:

```
...
constructor(private element: ElementRef) {
    this.element.nativeElement.addEventListener("click", e => {
        if (this.product != null) {
            this.click.emit(this.product.category);
        }
    });
}
...
```

The directive defines an input property to receive the `Product` object whose category will be sent in the event. (The directive is able to refer to the value of the input property value in the constructor because Angular will have set the property value before the function assigned to handle the DOM event is invoked.)

The most important statement in the listing is the one that uses the EventEmitter object to send the event, which is done using the EventEmitter.emit method, which is described in Table 15-5 for quick reference. The argument to the emit method is the value that you want the event listeners to receive, which is the value of the category property for this example.

Table 15-5. *The EventEmitter Method*

Name	Description
emit(value)	This method triggers the custom event associated with the EventEmitter, providing the listeners with the object or value received as the method argument.

Tying everything together is the @Output decorator, which creates a mapping between the directive class EventEmitter property and the name that will be used to bind to the event in the template, like this:

```
...
@Output("pa-category")
click = new EventEmitter<string>();
...
```

The argument to the decorator specifies the attribute name that will be used in event bindings applied to the host element. You can omit the argument if the TypeScript property name is also the name you want for the custom event. I have specified pa-category in the listing, which allows me to refer to the event as click within the directive class but require a more meaningful name externally.

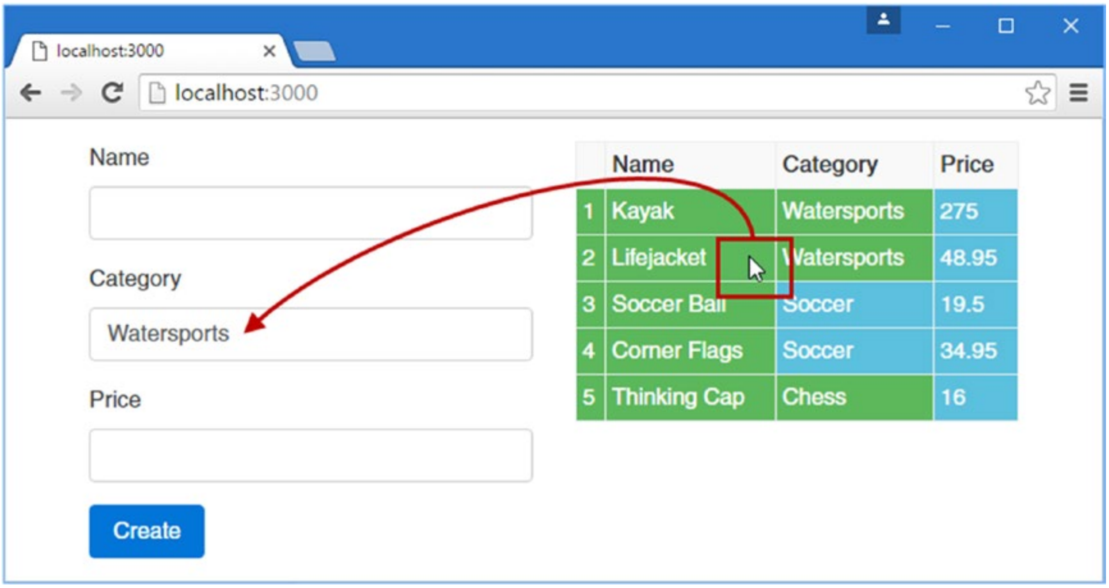
Binding to a Custom Event

Angular makes it easy to bind to custom events in templates by using the same binding syntax that is used for built-in events, which was described in Chapter 14. Listing 15-14 adds the pa-product attribute to the tr element in the template to provide the directive with its Product object and adds a binding for the pa-category event.

Listing 15-14. Binding to a Custom Event in the template.html File

```
...
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
            [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'"
            [pa-product]="item" (pa-category)="newProduct.category=$event">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
            {{item.category}}
        </td>
        <td [pa-attr]="'bg-info'">{{item.price}}</td>
    </tr>
</table>
...
```

The term `$event` is used to access the value the directive passed to the `EventEmitter.emit` method. That means `$event` will be a `string` value containing the product category in this example. The value received from the event is assigned to the component's `newProduct.category` property, which causes the data binding for one of the `input` elements to be updated, meaning that clicking a row in the table displays the product's category in the form, as shown in Figure 15-6.



Name

Category

Watersports

Price

	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 15-6. *Defining and receiving a custom event using an output property*

Creating Host Element Bindings

The example directive relies on the browser's DOM API to manipulate its host element, both to add and remove class memberships and to receive the `click` event. Working with the DOM API in an Angular application is a useful technique, but it does mean that your directive can be used only in applications that are run in a web browser. Angular is intended to be run in a range of different execution environments, and not all of them can be assumed to provide the DOM API.

Even if you are sure that a directive will have access to the DOM, the same results can be achieved in a more elegant way using standard Angular directive features: property and event bindings. Rather than use the DOM to add and remove classes, a class binding can be used on the host element. And rather than use the `addEventListener` method, an event binding can be used to deal with the mouse click.

Behind the scenes, Angular implements these features using the DOM API when the directive is used in a web browser—or some equivalent mechanism when the directive is used in a different environment.

Bindings on the host element are defined using two decorators, `@HostBinding` and `@HostListener`, both of which are defined in the `@angular/core` module, as shown in Listing 15-15.

Listing 15-15. Creating Host Bindings in the attr.directive.ts File

```
import { Directive, ElementRef, Attribute, Input,
         SimpleChange, Output, EventEmitter, HostListener, HostBinding }
            from "@angular/core";
 import { Product } from "./product.model";
```

```
@Directive({
    selector: "[pa-attr]"
})
export class PaAttrDirective {

    @Input("pa-attr")
    @HostBinding("class")
    bgClass: string;

    @Input("pa-product")
    product: Product;

    @Output("pa-category")
    click = new EventEmitter<string>();

    @HostListener("click")
    triggerCustomEvent() {
        if (this.product != null) {
            this.click.emit(this.product.category);
        }
    }
}
```

The @HostBinding decorator is used to set up a property binding on the host element and is applied to a directive property. The listing sets up a binding between the class property on the host element and the decorator's bgClass property.

■ **Tip** If you want to manage the contents of an element, you can use the @HostBinding decorator to bind to the textContent property. See Chapter 19 for an example.

The @HostListener decorator is used to set up an event binding on the host element and is applied to a method. The listing creates an event binding for the click event that invokes the triggerCustomEvent method when the mouse button is pressed and released. As its name suggests, the triggerCustomEvent method uses the EventEmitter.emit method to dispatch the custom event through the output property.

Using the host element bindings means that the directive constructor can be removed since there is no longer any need to access the HTML element via the ElementRef object. Instead, Angular takes care of setting up the event listener and setting the element's class membership through the property binding.

Although the directive code is much simpler, the effect of the directive is the same: clicking a table row sets the value of one of the input elements, and adding a new item using the form triggers a change in the background color of the table cells for products that are not part of the Soccer category.

Creating a Two-Way Binding on the Host Element

Angular provides special support for creating directives that support two-way bindings so they can be used with the banana-in-a-box bracket style that ngModel uses and can bind to a model property in both directions.

The two-way binding feature relies on a naming convention. To demonstrate how it works, Listing 15-16 adds some new elements and bindings to the template.html file.

Listing 15-16. Applying a Directive in the template.html File

```
...
<div class="col-xs-6">

    <div class="form-group bg-info p-a-1">
        <label>Name:</label>
        <input class="bg-primary" [paModel]="newProduct.name"
                                  (paModelChange)="newProduct.name=$event" />
    </div>

    <table class="table table-sm table-bordered table-striped">
        <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
        <tr *ngFor="let item of getProducts(); let i = index"
                [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'"
                [pa-product]="item" (pa-category)="newProduct.category=$event">
            <td>{{i + 1}}</td>
            <td>{{item.name}}</td>
            <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
                {{item.category}}
            </td>
            <td [pa-attr]="'bg-info'">{{item.price}}</td>
        </tr>
    </table>
</div>
...
```

I am going to create a directive that supports two one-way bindings. The binding whose target is `paModel` will be updated when the value of the `newProduct.name` property changes, which provides a flow of data from the application to the directive and will be used to update the contents of the `input` element. The custom event, `paModelChange`, will be triggered when the user changes the contents of the input element and will provide a flow of data from the directive to the rest of the application.

To implement the directive, I added a file called `twoway.directive.ts` to the app folder and used it to define the directive shown in Listing 15-17.

Listing 15-17. The Contents of the twoway.directive.ts File in the app Folder

```
import { Input, Output, EventEmitter, Directive,
         HostBinding, HostListener, SimpleChange } from "@angular/core";

@Directive({
    selector: "input[paModel]"
})
export class PaModel {

    @Input("paModel")
    modelProperty: string;

    @HostBinding("value")
    fieldValue: string = "";
    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        let change = changes["modelProperty"];
        if (change.currentValue != this.fieldValue) {
            this.fieldValue = changes["modelProperty"].currentValue || "";
        }
    }

    @Output("paModelChange")
    update = new EventEmitter<string>();

    @HostListener("input", ["$event.target.value"])
    updateValue(newValue: string) {
        this.fieldValue = newValue;
        this.update.emit(newValue);
    }
}
```

This directive uses features that have been described previously. The `selector` property for this directive specifies that it will match `input` elements that have a `paModel` attribute. The built-in `ngModel` two-way directive has support for a range of form elements and knows which events and properties each of them uses, but I want to keep this example simple, so I am going to support just `input` elements, which define a `value` property that gets and sets the element content.

The `paModel` binding is implemented using an input property and the `ngOnChanges` method, which responds to changes in the expression value by updating the contents of the input element through a host binding on the `input` element's `value` property.

The `paModelChange` event is implemented using a host listener on the `input` event, which then sends an update through an output property. Notice that the method invoked by the event is able to receive the event object by specifying an additional argument to the `@HostListener` decorator, like this:

```
...
@HostListener("input", ["$event.target.value"])
updateValue(newValue: string) {
...
```

The first argument to the `@HostListener` decorator specifies the name of the event that will be handled by the listener. The second argument is an array that will be used to provide the decorated methods with arguments. In this example, the `input` event will be handled by the listener, and when the `updateValue` method is invoked, its `newValue` argument will be set to the `target.value` property of the `Event` object, which is referred to using `$event`.

To enable the directive, I added it to the Angular module, as shown in Listing 15-18.

Listing 15-18. Registering the Directive in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
```

```
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

When you save the changes and the browser has reloaded, you will see a new `input` element that responds to changes to a model property and updates the model property if its host element's content is changed. The expressions in the bindings specify the same model property used by the Name field in the form on the left side of the HTML document, which provides a convenient way to test the relationship between them, as shown in Figure 15-7.

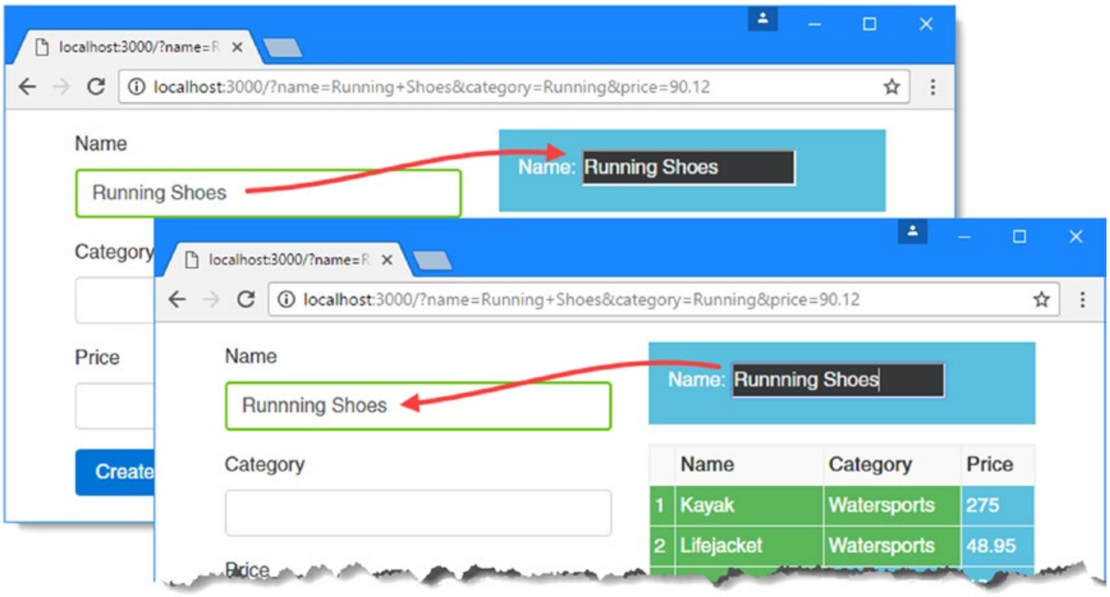


Figure 15-7. *Testing the two-way flow of data*

The final step is to simplify the bindings and apply the banana-in-a-box style of brackets, as shown in Listing 15-19.

Listing 15-19. Simplifying the Bindings in the template.html File

```
...
<div class="col-xs-6">

    <div class="form-group bg-info p-a-1">
        <label>Name:</label>
        <input class="bg-primary" [(paModel)]="newProduct.name" />
    </div>

    <table class="table table-sm table-bordered table-striped">
        <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
        <tr *ngFor="let item of getProducts(); let i = index"
                [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'"
                [pa-product]="item" (pa-category)="newProduct.category=$event">
            <td>{{i + 1}}</td>
            <td>{{item.name}}</td>
            <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
                {{item.category}}
            </td>
            <td [pa-attr]="'bg-info'">{{item.price}}</td>
        </tr>
    </table>
</div>
...
```

When Angular encounters the [()] brackets, it expands the binding to match the format used in Listing 15-16, targeting the paModel input property and setting up the paModelChange event. As long as a directive exposes these to Angular, it can be targeted using the banana-in-a-box brackets, producing a simpler template syntax.

Exporting a Directive for Use in a Template Variable

In earlier chapters, I used template variables to access functionality provided by built-in directives, such as ngForm. As an example, here is an element from Chapter 14:

```
...
<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)">
...
```

The form template variable is assigned ngForm, which is then used to access validation information for the HTML form. This is an example of how a directive can provide access to its properties and methods so they can be used in data bindings and expressions.

Listing 15-20 modifies the directive from the previous section so that it provides details of whether it has expanded the text in its host element.

Listing 15-20. Exporting a Directive in the twoway.directive.ts File

```
import { Input, Output, EventEmitter, Directive,
    HostBinding, HostListener, SimpleChange } from "@angular/core";

@Directive({
    selector: "input[paModel]",
    exportAs: "paModel"
})
export class PaModel {

    direction: string = "None";

    @Input("paModel")
    modelProperty: string;
    @HostBinding("value")
    fieldValue: string = "";

    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        let change = changes["modelProperty"];
        if (change.currentValue != this.fieldValue) {
            this.fieldValue = changes["modelProperty"].currentValue || "";
            this.direction = "Model";
        }
    }

    @Output("paModelChange")
    update = new EventEmitter<string>();

    @HostListener("input", ["$event.target.value"])
    updateValue(newValue: string) {
        this.fieldValue = newValue;
        this.update.emit(newValue);
        this.direction = "Element";
    }
}
```

The exportAs property of the @Directive decorator specifies a name that will be used to refer to the directive in template variables. This example uses paModel as the value for the exportAs property, and you should try to use names that make it clear which directive is providing the functionality.

The listing adds a property called direction to the directive, which used to indicate when data is flowing from the model to the element or from the element to the model.

When you use the exportAs decorator, you are providing access to all the methods and properties defined by the directive to be used in template expressions and data bindings. Some developers prefix the names of the methods and properties that are not for use outside of the directive with an underscore (the _ character) or to apply the private keyword. This is an indication to other developers that some methods and properties should not be used but isn't enforced by Angular.

Listing 15-21 creates a template variable for the directive's exported functionality and uses it in a style binding.

Listing 15-21. Using Exported Directive Functionality in the template.html File

```
...
<div class="col-xs-6">

    <div class="form-group bg-info p-a-1">
        <label>Name:</label>
        <input class="bg-primary" [(paModel)]="newProduct.name" #paModel="paModel" />
        <div class="bg-primary">Direction: {{paModel.direction}}</div>
    </div>

    <table class="table table-sm table-bordered table-striped">
        <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
        <tr *ngFor="let item of getProducts(); let i = index"
                [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'"
                [pa-product]="item" (pa-category)="newProduct.category=$event">
            <td>{{i + 1}}</td>
            <td>{{item.name}}</td>
            <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
                {{item.category}}
            </td>
            <td [pa-attr]="'bg-info'">{{item.price}}</td>
        </tr>
    </table>
</div>
...
```

The template variable is called `paModel`, and its value is the name used in the directive's `exportAs` property.

```
...
#paModel="paModel"
...
```

■ **Tip** You don't have to use the same names for the variable and the directive, but it does help to make the source of the functionality clear.

Once the template variable has been defined, it can be used in interpolation bindings or as part of a binding expression. I opted for a string interpolation binding whose expression uses the value of the directive's `direction` property.

```
...
<div class="bg-primary">Direction: {{paModel.direction}}</div>
...
```

The result is that you can see the effect of typing text into the two `input` elements that are bound to the `newProduct.name` model property. When you type into the one that uses the `ngModel` directive, then the string interpolation binding will display `Model`. When you type into the element that uses the `paModel` directive, the string interpolation binding will display `Element`, as shown in Figure 15-8.

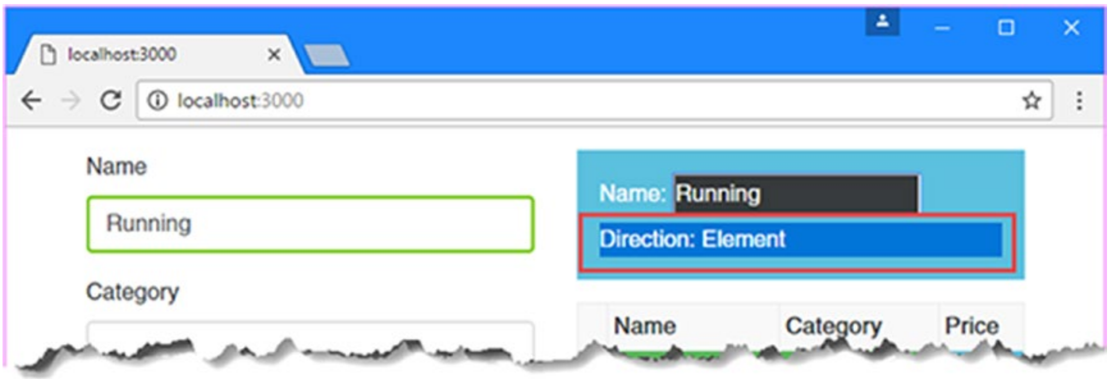


***Figure 15-8.** Exporting functionality from a directive*

Summary

In this chapter, I described how to define and use attribute directives, including the use of input and output properties and host bindings. In the next chapter, I explain how structural directives work and how they can be used to change the layout or structure of the HTML document.

CHAPTER 16

Creating Structural Directives

Structural directives change the layout of the HTML document by adding and removing elements. They build on the core features available for attribute directives, described in Chapter 15, with additional support for micro-templates, which are small fragments of contents defined within the templates used by components. You can recognize when a structural directive is being used because its name will be prefixed with an asterisk, such as `*ngIf` and `*ngFor`. In this chapter, I explain how structural directives are defined and applied, how they work, and how they respond to changes in the data model. Table 16-1 puts structural directives in context.

Table 16-1. *Putting Structural Directives in Context*

Question	Answer
What are they?	Structural directives use micro-templates to add content to the HTML document.
Why are they useful?	Structural directives allow content to be added conditionally based on the result of an expression or for the same content to be repeated for each object in a data source, such as an array.
How are they used?	Structural directives are applied to a `template` element, which contains the content and bindings that comprise its micro-template. The template class uses objects provided by Angular to control the inclusion of the content or to repeat the content.
Are there any pitfalls or limitations?	Unless care is taken, structural directives can make a lot of unnecessary changes to the HTML document, which can ruin the performance of a web application. It is important only to make changes when they are required, as explained in the "Dealing with Collection-Level Data Changes" section later in the chapter.
Are there any alternatives?	You can use the built-in directives for common tasks, but writing custom structural directives provides the ability to tailor behavior to your application.

Table 16-2 summarizes the chapter.

Table 16-2. *Chapter Summary*

Problem	Solution	Listing
Create a structural directive	Apply the `@Directive` decorator to a class that receives view container and template constructor parameters	1–6
Create an iterating structural directive	Define a `ForOf` input property in a structural directive class and iterate over its value	7–12
Handle data changes in a structural directive	Use a differ to detect changes in the ngDoCheck method	13–19
Query the content of the host element to which a structural directive has been applied	Use the `@ContentChild` or `@ContentChildren` decorators	20–25

Preparing the Example Project

In this chapter, I continue working with the `example` project that I created in Chapter 11 and have been using ever since. To prepare for this chapter, I have simplified the template to remove the form, leaving only the table shown in Listing 16-1. (I'll add the form back in later in the chapter.)

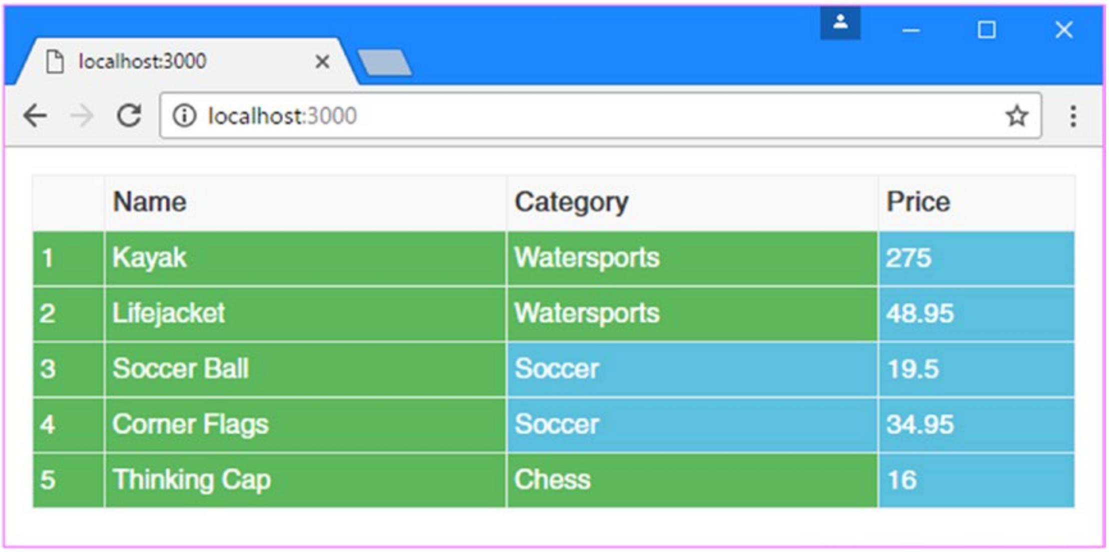
Listing 16-1. Simplifying the Template in the template.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
            [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'"
            [pa-product]="item" (pa-category)="newProduct.category=$event">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
            {{item.category}}
        </td>
        <td [pa-attr]="'bg-info'">{{item.price}}</td>
    </tr>
</table>
```

Run the following command in the `example` folder to start the development server and the TypeScript compiler and to load the Angular application in the browser:

```
npm start
```

Figure 16-1 shows the initial content displayed in the browser.



	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 16-1. *Running the example application*

Creating a Simple Structural Directive

A good place to start with structural directives is to re-create the functionality provided by the `ngIf` directive, which is relatively simple, is easy to understand, and provides a good foundation for explaining how structural directives work.

The best way to start is by making changes to the template and working back to write the code that supports it. Listing 16-2 shows the template changes.

Listing 16-2. Applying a Structural Directive in the template.html File

```
<div class="checkbox">
    <label>
        <input type="checkbox" [(ngModel)]="showTable" />
        Show Table
    </label>
</div>

<template [paIf]="showTable">
    <table class="table table-sm table-bordered table-striped">
        <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
        <tr *ngFor="let item of getProducts(); let i = index"
            [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'"
            [pa-product]="item" (pa-category)="newProduct.category=$event">
            <td>{{i + 1}}</td>
            <td>{{item.name}}</td>
            <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
                {{item.category}}
            </td>
            <td [pa-attr]="'bg-info'">{{item.price}}</td>
        </tr>
    </table>
</template>
```

This listing uses the full template syntax, in which the directive is applied to a `template` element, which contains the content that will be used by the directive. In this case, the `template` element contains the `table` element and all its contents, including bindings, directives, and expressions. There is also a concise syntax, which I use later in the chapter.

The `template` element has a standard one-way data binding, which targets a directive called `paIf`, like this:

```
...
<template [paIf]="showTable">
...
```

The expression for this binding uses the value of a property called `showTable`. This is the same property that is used in the other new binding in the template, which has been applied to a checkbox, as follows:

```
...
<input type="checkbox" checked="true" [(ngModel)]="showTable" />
...
```

The objectives in this section are to create a structural directive that will add the contents of the `template` element to the HTML document when the `showTable` property is `true`, which will happen when the checkbox is checked, and to remove the contents of the `template` element when the `showTable` property is `false`, which will happen when the checkbox is unchecked.

Implementing the Structural Directive Class

You know from the template what the directive should do. To implement the directive, I added a file called `paif.directive.ts` in the app folder and added the code shown in Listing 16-3.

Listing 16-3. The Contents of the structure.directive.ts File in the app Folder

```
import {
    Directive, SimpleChange, ViewContainerRef, TemplateRef, Input
} from "@angular/core";

@Directive({
    selector: "[paIf]"
})
export class PaStructureDirective {

    constructor(private container: ViewContainerRef,
        private template: TemplateRef<Object>) { }

    @Input("paIf")
    expressionResult: boolean;

    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        let change = changes["expressionResult"];
        if (!change.isFirstChange() && !change.currentValue) {
            this.container.clear();
        } else if (change.currentValue) {
            this.container.createEmbeddedView(this.template);
        }
    }
}
```

The selector property of the @Directive decorator is used to match host elements that have the paIf attribute, corresponding to the template additions that I made in Listing 16-1.

There is an input property called expressionResult, which the directive uses to receive the results of the expression from the template. The directive implements the ngOnChanges method to receive change notifications so that it can respond to changes in the data model.

The first indication that this is a structural directive comes from the constructor, which asks Angular to provide parameters using some new types.

```
...
constructor(private container: ViewContainerRef,
      private template: TemplateRef<Object>) {}
...
```

The ViewContainerRef object is used to manage the contents of the *view container*, which is the part of the HTML document where the template element appears and for which the directive is responsible.

As its name suggests, the view container is responsible for managing a collection of *views*. A view is a region of HTML elements that contains directives, bindings, and expressions, and they are created and managed using the methods and properties provided by the ViewContainerRef class, the most useful of which are described in Table 16-3.

Table 16-3. *Useful ViewContainerRef Methods and Properties*

Name	Description
element	This property returns an ElementRef object that represents the container element.
createEmbeddedView(template)	This method uses a template to create a new view. See the text after the table for details. This method also accepts optional arguments for context data (as described in the "Creating Iterating Structural Directives" section) and an index position that specifies where the view should be inserted. The result is a ViewRef object that can be used with the other methods in this table.
clear()	This method removes all the views from the container.
length	This property returns the number of views in the container.
get(index)	This method returns the ViewRef object representing the view at the specified index.
indexOf(view)	This method returns the index of the specified ViewRef object.
insert(view, index)	This method inserts a view at the specified index.
remove(Index)	This method removes and destroys the view at the specified index.
detach(index)	This method detaches the view from the specified index without destroying it so that it can be repositioned with the insert method.

Two of the methods from Table 16-3 are required to re-create the `ngIf` directive's functionality: `createEmbeddedView` to show the `template` element's content to the user and `clear` to remove it again.

The `createEmbeddedView` method adds a view to the view container. This method's argument is a `TemplateRef` object, which represents the content of the `template` element.

The directive receives the `TemplateRef` object as one of its constructor arguments, for which Angular will provide a value automatically when creating a new instance of the directive class.

Putting everything together makes it easy to understand how the directive works. When Angular processes the `template.html` file, it discovers the `template` element and its binding and determines that it needs to create a new instance of the `PaStructureDirective` class. Angular examines the `PaStructureDirective` constructor and can see that it needs to provide it with `ViewContainerRef` and `TemplateRef` objects.

```
...
constructor(private container: ViewContainerRef,
    private template: TemplateRef<Object>) {}
...
```

The `ViewContainerRef` represents the place in the HTML document occupied by the `template` element, and the `TemplateRef` represents the `template` element's contents. Angular passes these objects to the constructor and creates a new instance of the directive class.

Angular then starts processing the expressions and data bindings. As described in Chapter 15, Angular invokes the `ngOnChanges` method during initialization (just before the `ngOnInit` method is invoked) and again whenever the value of the directive's expression changes.

The `PaStructureDirective` class's implementation of the `ngOnChanges` method uses the `SimpleChange` object that it receives to show or hide the contents of the `template` element based on the current value of the expression. When the expression is `true`, the directive displays the `template` element's content by adding them to the container view.

```
...
this.container.createEmbeddedView(this.template);
...
```

When the result of the expression is `false`, the directive clears the view container, which removes the elements from the HTML document.

```
...
this.container.clear();
...
```

The directive doesn't have any insight into the contents of the `template` element and is responsible only for managing its visibility.

Enabling the Structural Directive

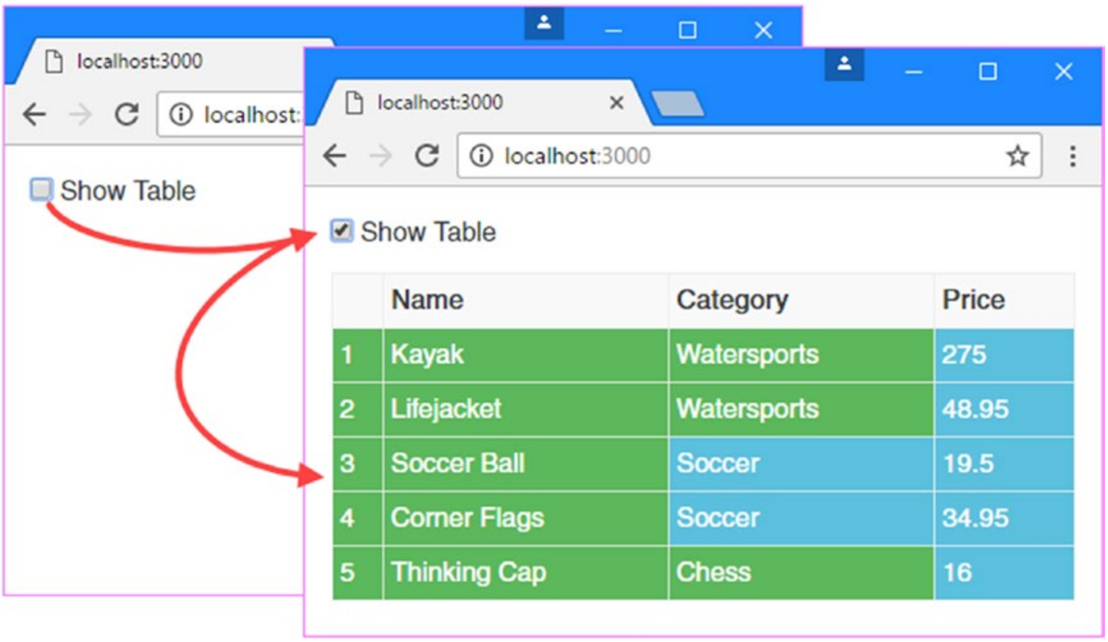
The directive must be enabled in the Angular module before it can be used, as shown in Listing 16-4.

Listing 16-4. Enabling the Directive in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel, PaStructureDirective],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

Structural directives are enabled in the same way as attribute directives and are specified in the module's `declarations` array.

Once you save the changes, the browser will reload the HTML document, and you can see the effect of the new directive: the `table` element, which is the content of the `template` element, will be shown only when the checkbox is checked, as shown in Figure 16-2.



	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

***Figure 16-2.** Creating a structural directive*

■ **Note** The contents of the `template` element are being destroyed and re-created, not simply hidden and revealed. If you want to show or hide content without removing it from the HTML document, then you can use a style binding to set the `display` or `visibility` property.

Setting the Initial Expression Value

The contents of the template element are not shown initially because the directive's expression relies on a variable that has not been previously defined.

```
...
<template [paIf]="showTable">
...
```

The variable showTable won't be defined until the user checks the checkbox element, at which point it will be created with a value of true. This is an example of how templates can dynamically create JavaScript variables described in Chapter 14. I mention it again here because it is easy to get confused about where the variable is created. If you want to define an initial value for the showTable variable, then you must do so in the component, as shown in Listing 16-5, and not in the structural directive.

Listing 16-5. Defining a Variable in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();
    form: ProductFormGroup = new ProductFormGroup();

    // ...other members omitted for brevity...

    showTable: boolean = true;
}
```

The structural directive receives the value of its expression through its input property and has no insight into what the expression is, and the component provides the context for Angular to evaluate the expression. The change in Listing 16-5 gives an initial true value to the showTable property, which means that the template element's content is visible when the application first starts.

Using the Concise Structural Directive Syntax

The use of the template element helps illustrate the role of the view container in structural directives. The concise syntax does away with the template element and applies the directive and its expression to the outermost element that it would contain, as shown in Listing 16-6.

■ **Tip** The concise structural directive syntax is intended to be easier to use and read, but it is just a matter of preference as to which syntax you use.

Listing 16-6. Using the Concise Structural Directive Syntax in the template.html File

```
<div class="checkbox">
    <label>
        <input type="checkbox" [(ngModel)]="showTable" />
        Show Table
    </label>
</div>

<table *paIf="showTable"
        class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *ngFor="let item of getProducts(); let i = index"
        [pa-attr]="getProducts().length < 6 ? 'bg-success' : 'bg-warning'"
        [pa-product]="item" (pa-category)="newProduct.category=$event">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td [pa-attr]="item.category == 'Soccer' ? 'bg-info' : null">
            {{item.category}}
        </td>
        <td [pa-attr]="'bg-info'">{{item.price}}</td>
    </tr>
</table>
```

The template element has been removed, and the directive has been applied to the table element, like this:

```
...
<table *paIf="showTable" class="table table-sm table-bordered table-striped">
...
```

The directive's name is prefixed with an asterisk (the * character) to tell Angular that this is a structural directive that uses the concise syntax. When Angular parses the template.html file, it discovers the directive and the asterisk and handles the elements as though there were a template element in the document. No changes are required to the directive class to support the concise syntax.

Creating Iterating Structural Directives

Angular provides special support for directives that need to iterate over a data source. The best way to demonstrate this is to re-create another of the built-in directives: ngFor.

To prepare for the new directive, I have removed the ngFor directive from the template.html file, inserted a template element, and applied a new directive attribute and expression, as shown in Listing 16-7.

Listing 16-7. Preparing for a New Structural Directive in the template.html File

```
<div class="checkbox">
    <label>
        <input type="checkbox" [(ngModel)]="showTable" />
        Show Table
    </label>
</div>
```

```
<table *paIf="showTable"
        class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <template [paForOf]="getProducts()" let-item>
        <tr><td colspan="4">{{item.name}}</td></tr>
    </template>
</table>
```

The full syntax for iterating structural directives is a little odd. In the listing, the `template` element has two attributes that are used to apply the directive. The first is a standard binding whose expression obtains the data required by the directive, bound to an attribute called `paForOf`.

```
...
<template [paForOf]="getProducts()" let-item>
...
```

The name of this attribute is important. When using a `template` element, the name of the data source attribute must end with `Of` in order to support the concise syntax, which I will introduce shortly.

The second attribute is used to define the *implicit value*, which allows the currently processed object to be referred to within the `template` element as the directive iterates through the data source. Unlike other template variables, the implicit variable isn't assigned a value and its purpose is only to define the variable name.

```
...
<template [paForOf]="getProducts()" let-item>
...
```

In this example, I have used `let-item` to tell Angular that I want the implicit value to be assigned to a variable called `item`, which is then used within a string interpolation binding to display the `name` property of the current data item.

```
...
<td colspan="4">{{item.name}}</td>
...
```

Looking at the `template` element, you can see that the purpose of the new directive is to iterate through the component's `getProducts` method and generate a table row for each of them that displays the `name` property. To implement this functionality, I created a file called `iterator.directive.ts` in the `app` folder and defined the directive shown in Listing 16-8.

Listing 16-8. The Contents of the iterator.directive.ts File in the app Folder

```
import { Directive, ViewContainerRef, TemplateRef,
             Input, SimpleChange } from "@angular/core";

@Directive({
    selector: "[paForOf]"
})
export class PaIteratorDirective {

    constructor(private container: ViewContainerRef,
        private template: TemplateRef<Object>) {}
    @Input("paForOf")
    dataSource: any;

    ngOnInit() {
        this.container.clear();
        for (let i = 0; i < this.dataSource.length; i++) {
            this.container.createEmbeddedView(this.template,
                 new PaIteratorContext(this.dataSource[i]));
        }
    }
}

class PaIteratorContext {
    constructor(public $implicit: any) {}
}
```

The `selector` property in the `@Directive` decorator matches elements with the `paForOf` attribute, which is also the source of the data for the `dataSource` input property and which provides the source of objects that will be iterated.

The `ngOnInit` method will be called once the value of the input property has been set, and the directive empties the view container using the `clear` method and adds a new view for each object using the `createEmbeddedView` method.

When calling the `createEmbeddedView` method, the directive provides two arguments: the `TemplateRef` object received through the constructor and a context object. The `TemplateRef` provides the content to insert into the container, and the context object provides the data for the implicit value, which is specified using a property called `$implicit`. It is this object, with its `$implicit` property, that is assigned to the `item` template variable and that is referred to in the string interpolation binding. To provide templates with the context object in a type-safe way, I defined a class called `PaIteratorContext`, whose only property is called `$implicit`.

The `ngOnInit` method reveals some important aspects of working with view containers. First, a view container can be populated with multiple views—in this case, one view per object in the data source. The `ViewContainerRef` class provides the functionality required to manage these views once they have been created, as you will see in the sections that follow.

Second, a template can be reused to create multiple views. In this example, the contents of the template element will be used to create identical `tr` and `td` elements for each object in the data source. The `td` element contains a data binding, which is processed by Angular when each view is created and is used to tailor the content to its data object.

Third, the directive has no special knowledge about the data it is working with and no knowledge of the content that is being generated. Angular takes care of providing the directive with the context it needs from the rest of the application, providing the data source through the input property and providing the content for each view through the `TemplateRef` object.

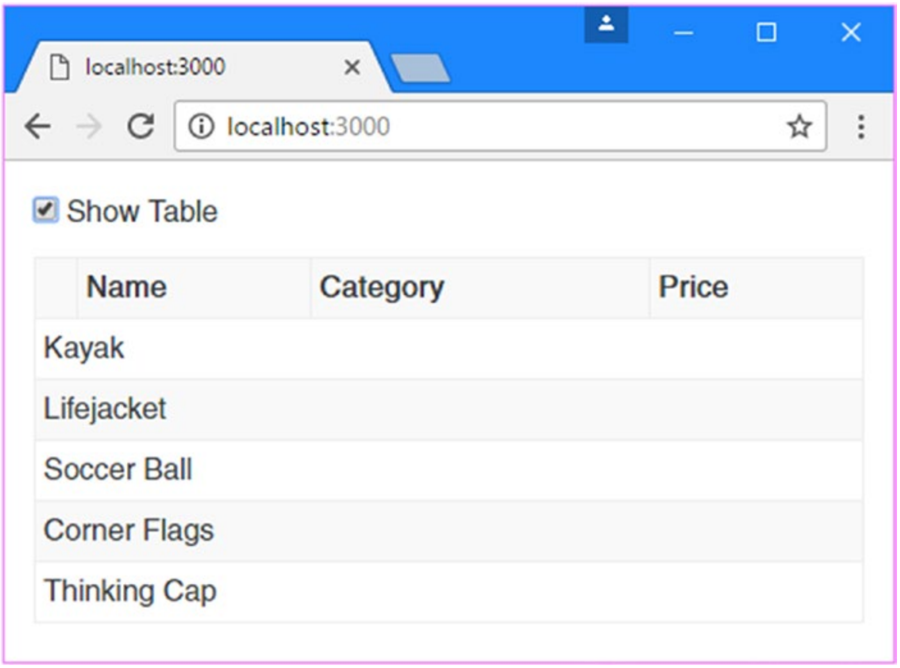
Enabling the directive requires an addition to the Angular module, as shown in Listing 16-9.

Listing 16-9. Adding a Custom Directive in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
```

```
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

The result is that the directive iterates through the objects in its data source and uses the `template` element's content to create a view for each of them, providing rows for the table, as shown in Figure 16-3.



	Name	Category	Price
Kayak			
Lifejacket			
Soccer Ball			
Corner Flags			
Thinking Cap			

Figure 16-3. *Creating an iterating structural directive*

Providing Additional Context Data

Structural directives can provide templates with additional values to be assigned to template variables and used in bindings. For example, the `ngFor` directive provides `odd`, `even`, `first`, and `last` values. Context values are provided through the same object that defines the `$implicit` property, and in Listing 16-10, I have re-created the same set of values that `ngFor` provides.

Listing 16-10. Providing Context Data in the iterator.directive.ts File

```
import { Directive, ViewContainerRef, TemplateRef,
             Input, SimpleChange } from "@angular/core";

@Directive({
    selector: "[paForOf]"
})
```

```
export class PaIteratorDirective {

    constructor(private container: ViewContainerRef,
        private template: TemplateRef<Object>) {}

    @Input("paForOf")
    dataSource: any;

    ngOnInit() {
        this.container.clear();
        for (let i = 0; i < this.dataSource.length; i++) {
            this.container.createEmbeddedView(this.template,
                 new PaIteratorContext(this.dataSource[i],
                     i, this.dataSource.length));
        }
    }
}

class PaIteratorContext {
    odd: boolean; even: boolean;
    first: boolean; last: boolean;

    constructor(public $implicit: any,
            public index: number, total: number ) {

        this.odd = index % 2 == 1;
        this.even = !this.odd;
        this.first = index == 0;
        this.last = index == total - 1;
    }
}
```

This listing defines additional properties in the PaIteratorContext class and expands its constructor so that it receives additional parameters, which are used to set the produce the property values.

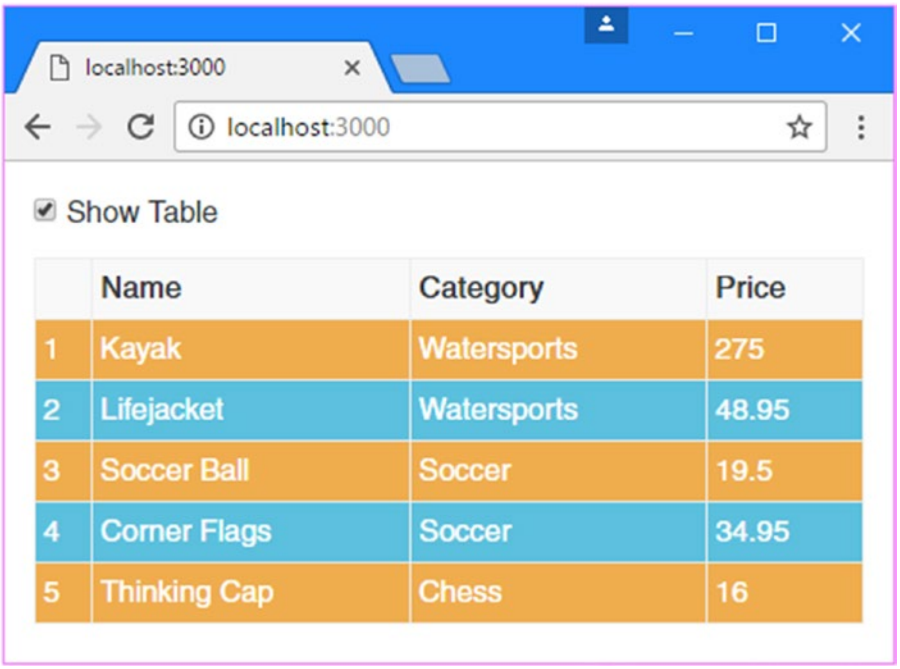
The effect of these additions is that context object properties can be used to create template variables, which can then be referred to in binding expressions, as shown in Listing 16-11.

Listing 16-11. Using Structural Directive Context Data in the template.html File

```
<div class="checkbox">
    <label>
        <input type="checkbox" [(ngModel)]="showTable" />
        Show Table
    </label>
</div>

<table *paIf="showTable"
    class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <template [paForOf]="getProducts()" let-item let-i="index"
            let-odd="odd" let-even="even">
        <tr [class.bg-info]="odd" [class.bg-warning]="even">
```

```
            <td>{{i + 1}}</td>
            <td>{{item.name}}</td>
            <td>{{item.category}}</td>
            <td>{{item.price}}</td>
        </tr>
    </template>
</table>
```

Template variables are created using the `let-<name>` attribute syntax and assigned one of the context data values. In this listing, I used the `odd` and `even` context values to create template variables of the same name, which are then incorporated into class bindings on the `tr` element, resulting in striped table rows, as shown in Figure 16-4. The listing also adds additional table cells to display all the `Product` properties.



	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 16-4. *Using directive context data*

Using the Concise Structure Syntax

Iterating structural directives support the concise syntax and omit the `template` element, as shown in Listing 16-12.

Listing 16-12. Using the Concise Syntax in the template.html File

```
<div class="checkbox">
    <label>
        <input type="checkbox" [(ngModel)]="showTable" />
        Show Table
    </label>
</div>
```

```
<table *paIf="showTable"
    class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td>{{i + 1}}</td>
        <td>{{item.name}}</td>
        <td>{{item.category}}</td>
        <td>{{item.price}}</td>
    </tr>
</table>
```

This is a more substantial change than the one required for attribute directives. The biggest change is in the attribute used to apply the directive. When using the full syntax, the directive was applied to the `template` element using the attribute specified by its selector, like this:

```
...
<template [paForOf]="getProducts()" let-item let-i="index" let-odd="odd"
    let-even="even">
...
```

When using the concise syntax, the `Of` part of the attribute is omitted, the name is prefixed with an asterisk, and the brackets are omitted.

```
...
<tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
...
```

The other change is to incorporate all the context values into the directive's expression, replacing the individual `let-` attributes. The main data value becomes part of the initial expression, with additional context values separated by semicolons.

No changes are required to the directive to support the concise syntax, whose selector and input property still specify an attribute called `paForOf`. Angular takes care of expanding the concise syntax, and the directive doesn't know or care whether a `template` element has been used.

Dealing with Property-Level Data Changes

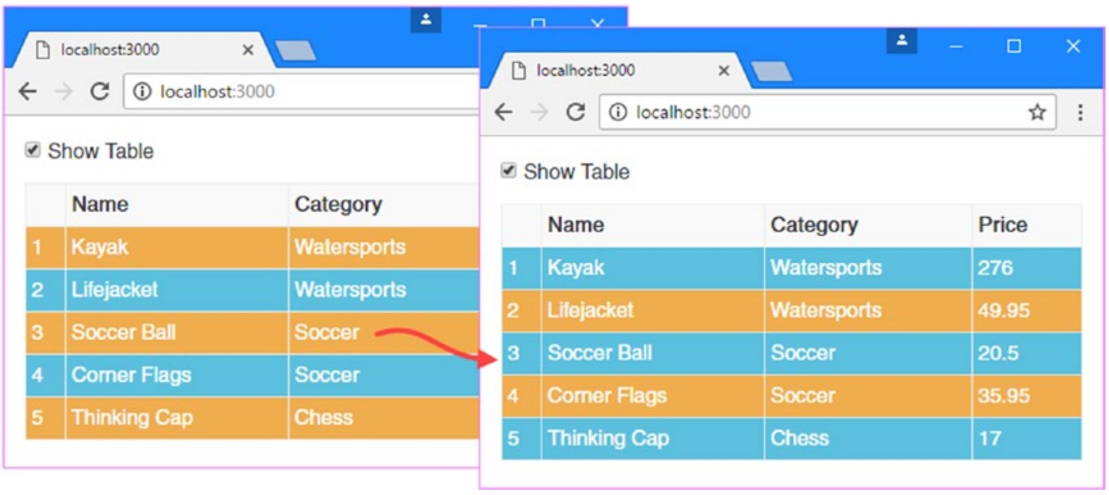
There are two kinds of changes that can occur in the data sources used by iterating structural directives. The first kind happens when the properties of an individual object change. This has a knock-on effect on the data bindings contained within the `template` element, either directly through a change in the implicit value or indirectly through the additional context values provided by the directive. Angular takes care of these changes automatically, reflecting any changes in the context data in the bindings that depend on them.

To demonstrate, in Listing 16-13 I have added a call to the standard JavaScript `setInterval` function in the constructor of the context class. The function passed to `setInterval` alters the `odd` and `even` properties and changes the value of the `price` property of the `Product` object that is used as the implicit value.

Listing 16-13. Modifying Individual Objects in the iterator.directive.ts File

```
...
class PaIteratorContext {
    odd: boolean; even: boolean;
    first: boolean; last: boolean;

    constructor(public $implicit: any,
            public index: number, total: number ) {

        this.odd = index % 2 == 1;
        this.even = !this.odd;
        this.first = index == 0;
        this.last = index == total - 1;

        setInterval(() => {
            this.odd = !this.odd; this.even = !this.even;
            this.$implicit.price++;
        }, 2000);
    }
}
...
```

Once every two seconds, the values of the odd and even properties are inverted, and the `price` value is incremented. When you save the changes, you will see that the colors of the table rows change and the prices slowly increase, as illustrated in Figure 16-5.



	Name	Category
1	Kayak	Watersports
2	Lifejacket	Watersports
3	Soccer Ball	Soccer
4	Corner Flags	Soccer
5	Thinking Cap	Chess

	Name	Category	Price
1	Kayak	Watersports	276
2	Lifejacket	Watersports	49.95
3	Soccer Ball	Soccer	20.5
4	Corner Flags	Soccer	35.95
5	Thinking Cap	Chess	17

Figure 16-5. *Automatic change detection for individual data source objects*

Dealing with Collection-Level Data Changes

The second type of change occurs when the objects within the collection are added, removed, or replaced. Angular doesn't detect this kind of change automatically, which means the iterating directive's ngOnChanges method won't be invoked.

Receiving notifications about collection-level changes is done by implementing the ngDoCheck method, which is called whenever a data change is detected in the application, regardless of where that change occurs or what kind of change it is. The ngDoCheck method allows a directive to respond to changes even when they are not automatically detected by Angular. Implementing the ngDoCheck method requires caution, however, because it represents a pitfall that can destroy the performance of a web application. To demonstrate the problem, Listing 16-14 implements the ngDoCheck method so that the directive updates the content it displays when there is a change.

Listing 16-14. Implementing the ngDoCheck Methods in the iterator.directive.ts File

```
import { Directive, ViewContainerRef, TemplateRef,
             Input, SimpleChange } from "@angular/core";

@Directive({
    selector: "[paForOf]"
})
export class PaIteratorDirective {

    constructor(private container: ViewContainerRef,
        private template: TemplateRef<Object>) {}

    @Input("paForOf")
    dataSource: any;

    ngOnInit() {
        this.updateContent();
    }

    ngDoCheck() {
        console.log("ngDoCheck Called");
        this.updateContent();
    }

    private updateContent() {
        this.container.clear();
        for (let i = 0; i < this.dataSource.length; i++) {
            this.container.createEmbeddedView(this.template,
                 new PaIteratorContext(this.dataSource[i],
                     i, this.dataSource.length));
        }
    }
}

class PaIteratorContext {
    odd: boolean; even: boolean;
    first: boolean; last: boolean;
    constructor(public $implicit: any,
            public index: number, total: number ) {

        this.odd = index % 2 == 1;
        this.even = !this.odd;
        this.first = index == 0;
        this.last = index == total - 1;

        // setInterval(() => {
        //     this.odd = !this.odd; this.even = !this.even;
        //     this.$implicit.price++;
        // }, 2000);
    }
}
```

The ngOnInit and ngDoCheck methods both call a new updateContent method that clears the contents of the view container and generates new template content for each object in the data source. I have also commented out the call to the setInterval function in the PaIteratorContext class.

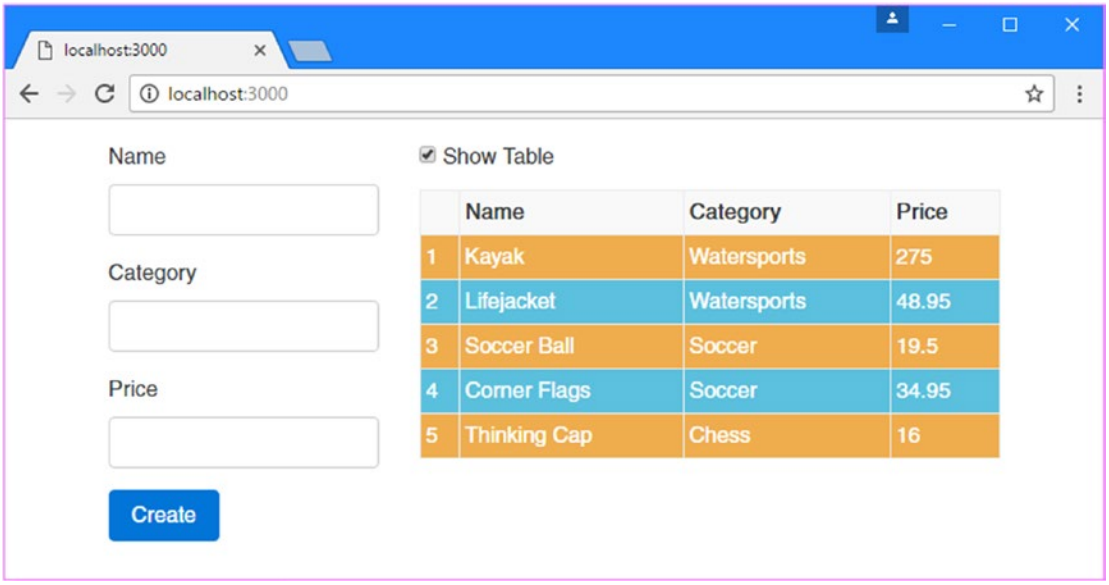
To understand the problem with collection-level changes and the ngDoCheck method, I need to restore the form to the component's template, as shown in Listing 16-15.

Listing 16-15. Restoring the HTML Form in the template.html File

```
<style>
    input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
    input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
</style>

<div class="col-xs-4">
    <form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">
        <div class="form-group" *ngFor="let control of form.productControls">
            <label>{{control.label}}</label>
            <input class="form-control"
                [(ngModel)]="newProduct[control.modelProperty]"
                name="{{control.modelProperty}}"
                formControlName="{{control.modelProperty}}" />
            <ul class="text-danger list-unstyled"
                    *ngIf="(formSubmitted || control.dirty) && !control.valid">
                <li *ngFor="let error of control.getValidationMessages()">
                    {{error}}
                </li>
            </ul>
        </div>
        <button class="btn btn-primary" type="submit"
            [disabled]="formSubmitted && !form.valid"
            [class.btn-secondary]="formSubmitted && !form.valid">
                Create
        </button>
    </form>
</div>
```

```
<div class="col-xs-8">
    <div class="checkbox">
        <label>
            <input type="checkbox" [(ngModel)]="showTable" />
            Show Table
        </label>
    </div>

    <table *paIf="showTable"
        class="table table-sm table-bordered table-striped">
        <tr><th></th><th>Name</th><th>Category</th><th>Price</th></tr>
        <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
                let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
            <td>{{i + 1}}</td>
            <td>{{item.name}}</td>
            <td>{{item.category}}</td>
            <td>{{item.price}}</td>
        </tr>
    </table>
</div>
```

When you save the changes to the template, the HTML form will be displayed alongside the table of products, as shown in Figure 16-6.



	Name	Category	Price
1	Kayak	Watersports	275
2	Lifejacket	Watersports	48.95
3	Soccer Ball	Soccer	19.5
4	Corner Flags	Soccer	34.95
5	Thinking Cap	Chess	16

Figure 16-6. *Restoring the table in the template*

The problem with the ngDoCheck method is that it is invoked every time Angular detects a change anywhere in the application—and those changes happen more often than you might expect.

To demonstrate how often changes occur, I added a call to the console.log method within the directive's ngDoCheck method in Listing 16-14, so that a message will be displayed in the browser's JavaScript console each time the ngDoCheck method is called.

Now, use the HTML form to create a new product and see how many messages are written out to the browser's JavaScript console, each of which represents a change detected by Angular and which results in a call to the ngDoCheck method.

A new message is displayed each time an input element gets the focus, each time a key event is triggered, each time a validation check is performed, and so on. A quick test adding a Running Shoes product in the Running category with a price of 100 generates 29 messages on my system, although the exact number will vary based on how you navigate between elements, whether you need to correct typos, and so on.

For each of those 29 times, the structural directive destroys and re-creates its content, which means producing new tr and td elements, with new directive and binding objects.

There are only a few rows of data in the example application, but these are expensive operations, and in a real application, the performance of the application can grind to a halt as content is repeatedly destroyed and re-created. The worst part of this problem is that all the changes except one were unnecessary because the content in the table didn't need to be updated until the new Product object was added to the data model. For the other 28 times, the directive destroyed its content and created an identical replacement.

Fortunately, Angular provides some tools for managing updates more efficiently and updating content only when it is required. The ngDoCheck method will still be called for all changes in the application, but the directive can inspect its data to see whether any changes that require new content have occurred, as shown in Listing 16-16.

Listing 16-16. Minimizing Content Changes in the iterator.directive.ts File

```
import { Directive, ViewContainerRef, TemplateRef,
             Input, SimpleChange, IterableDiffer, IterableDiffers,
             ChangeDetectorRef, CollectionChangeRecord } from "@angular/core";

@Directive({
    selector: "[paForOf]"
})
export class PaIteratorDirective {
    private differ: IterableDiffer;

    constructor(private container: ViewContainerRef,
        private template: TemplateRef<Object>,
        private differs: IterableDiffers,
        private changeDetector: ChangeDetectorRef) {
    }

    @Input("paForOf")
    dataSource: any;

    ngOnInit() {
        this.differ = this.differs.find(this.dataSource).create(this.changeDetector);
    }

    ngDoCheck() {
        let changes = this.differ.diff(this.dataSource);
        if (changes != null) {
            console.log("ngDoCheck called, changes detected");
            changes.forEachAddedItem(addition => {
                this.container.createEmbeddedView(this.template,
                    new PaIteratorContext(addition.item,
                        addition.currentIndex, changes.length));
            });
        }
    }
}

class PaIteratorContext {
    odd: boolean; even: boolean;
    first: boolean; last: boolean;

    constructor(public $implicit: any,
            public index: number, total: number ) {

        this.odd = index % 2 == 1;
        this.even = !this.odd;
        this.first = index == 0;
        this.last = index == total - 1;
    }
}
```

The idea is to work out whether there have been objects added, removed, or moved from the collection. This means the directive has to do some work every time the ngDoCheck method is called in order to avoid unnecessary and expensive DOM operations when there are no collection changes to process.

The process starts in the constructor, which receives two new arguments whose values will be provided by Angular when a new instance of the directive class is created. The IterableDiffers and ChangeDetectorRef objects are used to set up change detection on the data source collection in the ngOnInit method, like this:

```
...
ngOnInit() {
    this.differ = this.differs.find(this.dataSource).create(this.changeDetector);
}
...
```

Angular includes built-in classes, known as *differs*, that can detect changes in different types of objects. The IterableDiffers.find method accepts an object and returns an IterableDifferFactory object that is capable of creating a differ class for that object. The IterableDifferFactory class defines a create method that returns an IterableDiffer object that will perform the actual change detection, using the ChangeDetectorRef object that was received in the constructor.

■ **Tip** The IterableDifferFactory.create method accepts an optional argument that specifies a tracking function, which is how the ngFor directive implements its trackBy feature, as described in Chapter 13.

The important part of this incantation is the IterableDiffer object, which was assigned to a property called differ so that it can be used when the ngDoCheck method is called.

```
...
ngDoCheck() {
    let changes = this.differ.diff(this.dataSource);
    if (changes != null) {
        console.log("ngDoCheck called, changes detected");
        changes.forEachAddedItem(addition => {
            this.container.createEmbeddedView(this.template,
                new PaIteratorContext(addition.item,
                    addition.currentIndex, changes.length));
        });
    }
}
...
```

The `IterableDiffer.diff` method accepts an object for comparison and returns a list of the changes or `null` if there have been no changes. Checking for the `null` result allows the directive to avoid unnecessary work when the `ngDoCheck` method is called for changes elsewhere in the application. The object returned by the `IterableDiffer.diff` method provides the properties and methods described in Table 16-4 for processing changes.

Table 16-4. *The IterableDiffer.Diff Results Methods and Properties*

Name	Description
`collection`	This property returns the collection of objects that has been inspected for changes.
`length`	This property returns the number of objects in the collection.
`forEachItem(func)`	This method invokes the specified function for each object in the collection.
`forEachPreviousItem(func)`	This method invokes the specified function for each object in the previous version of the collection.
`forEachAddedItem(func)`	This method invokes the specified function for each new object in the collection.
`forEachMovedItem(func)`	This method invokes the specified function for each object whose position has changed.
`forEachRemovedItem(func)`	This method invokes the specified function for each object that was removed from the collection.
`forEachIdentityChange(func)`	This method invokes the specified function for each object whose identity has changed.

The functions that are passed to the methods described in Table 16-4 will receive a `CollectionChangeRecord` object that describes an item and how it has changed, using the properties shown in Table 16-5.

Table 16-5. *The CollectionChangeRecord Properties*

Name	Description
`item`	This property returns the data item.
`trackById`	This property returns the identity value if a `trackBy` function is used.
`currentIndex`	This property returns the current index of the item in the collection.
`previousIndex`	This property returns the previous index of the item in the collection.

The code in Listing 16-16 only needs to deal with new objects in the data source, since that is the only change that the rest of the application can perform. If the result of the `IterableDiffer.diff` method isn't `null`, then I use the `forEachAddedItem` method to invoke a fat arrow function for each new object that has been detected. The function is called once for each new object and uses the properties in Table 16-5 to create new views in the view container.

The changes in Listing 16-16 included a new console message that is written to the browser's JavaScript console only when there has been a data change detected by the directive. If you repeat the process of adding a new product, you will see that the message is displayed only when the application first starts and when the Create button is clicked. The `ngDoCheck` method is still being called, and the directive has to check for data changes every time, so there is still unnecessary work going on. But these operations are much less expensive and time-consuming than destroying and then re-creating HTML elements.

■ **Tip** Angular also provides change tracking for key/value pairs, which makes it possible to monitor `Map` objects and objects that use properties as map keys. See Chapter 19 for an example.

Keeping Track of Views

Handling change detection is simple when you are handling the creation of new data items. Other operations—such as dealing with deletions or modifications—are more complex and require the directive to keep track of which view is associated with which data object.

To demonstrate, I am going to add support for deleting a `Product` object from the data model. First, Listing 16-17 adds a method to the component to delete a product using its key. This isn't a requirement because the template could access the repository through the component's `model` property, but it can help make applications easier to understand, when all of the data is accessed and used in the same way.

Listing 16-17. Adding a Delete Method in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();
    form: ProductFormGroup = new ProductFormGroup();
    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }

    newProduct: Product = new Product();

    addProduct(p: Product) {
        this.model.saveProduct(p);
    }

    deleteProduct(key: number) {
        this.model.deleteProduct(key);
    }

    formSubmitted: boolean = false;

    submitForm(form: NgForm) {
        this.formSubmitted = true;
        if (form.valid) {
            this.addProduct(this.newProduct);
            this.newProduct = new Product();
            form.reset();
            this.formSubmitted = false;
        }
    }

    showTable: boolean = true;
}
```

Listing 16-18 updates the template so that the content generated by the structural directive contains a column of button elements that will delete the data object associated with the row that contains it.

Listing 16-18. Adding a Delete Button in the template.html File

```
...
<table *paIf="showTable"
    class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">{{item.price}}</td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
...
```

The button elements have click event bindings that call the component's deleteProduct method. I also set the value of the CSS style property vertical-align on the existing td elements so the text in the table is aligned with the button text. The final step is to process the data changes in the structural directive so that it responds when an object is removed from the data source, as shown in Listing 16-19.

Listing 16-19. Responding to a Removed Item in the iterator.directive.ts File

```
import { Directive, ViewContainerRef, TemplateRef,
         Input, SimpleChange, IterableDiffer, IterableDiffers,
         ChangeDetectorRef, CollectionChangeRecord, ViewRef } from "@angular/core";

@Directive({
    selector: "[paForOf]"
})
export class PaIteratorDirective {
    private differ: IterableDiffer;
    private views: Map<any, PaIteratorContext> = new Map<any, PaIteratorContext>();

    constructor(private container: ViewContainerRef,
        private template: TemplateRef<Object>,
        private differs: IterableDiffers,
        private changeDetector: ChangeDetectorRef) {
    }

    @Input("paForOf")
    dataSource: any;

    ngOnInit() {
        this.differ = this.differs.find(this.dataSource).create(this.changeDetector);
    }

    ngDoCheck() {
        let changes = this.differ.diff(this.dataSource);
        if (changes != null) {
            changes.forEachAddedItem(addition => {
                let context = new PaIteratorContext(addition.item,
                    addition.currentIndex, changes.length);
                context.view = this.container.createEmbeddedView(this.template,
                    context);
                this.views.set(addition.trackById, context);
            });
            let removals = false;
            changes.forEachRemovedItem(removal => {
                removals = true;
                let context = this.views.get(removal.trackById);
                if (context != null) {
                    this.container.remove(this.container.indexOf(context.view));
                    this.views.delete(removal.trackById);
                }
            });
            if (removals) {
                let index = 0;
                this.views.forEach(context =>
                    context.setData(index++, this.views.size));
            }
        }
    }
}

class PaIteratorContext {
    index: number;
    odd: boolean; even: boolean;
    first: boolean; last: boolean;
    view: ViewRef;

    constructor(public $implicit: any,
            public position: number, total: number ) {
        this.setData(position, total);
    }

    setData(index: number, total: number) {
        this.index = index;
        this.odd = index % 2 == 1;
        this.even = !this.odd;
        this.first = index == 0;
        this.last = index == total - 1;
    }
}
```

Two tasks are required to handle removed objects. The first task is updating the set of views by removing the ones that correspond to the items provided by the `forEachRemovedItem` method. This means keeping track of the mapping between the data objects and the views that represent them, which I have done by adding a `ViewRef` property to the `PaIteratorContext` class and using a `Map` to collect them, indexed by the value of the `CollectionChangeRecord.trackById` property.

WORKING WITH MAPS

The `Map` class is a collection that stores key/value pairs and is defined as part of the ES6 specification. TypeScript has built-in support for managing key/value pairs if the key is a `string` or a `number`, which isn't useful for this example. When using a `Map`, you can provide TypeScript type annotations for the key and value types, like this:

```
...
private views: Map<any, PaIteratorContext> = new Map<any, PaIteratorContext>();
...
```

This example uses `any` to specify that the key can be any JavaScript object, which allows item tracking IDs to be used to store context objects in the `Map`. Setting a key/value pair is done through the `set` method, like this:

```
...
this.views.set(addition.trackById, context);
...
```

Items are retrieved through the `get` method and removed from the `Map` using the `delete` method.

```
...
let context = this.views.get(removal.trackById);
...
this.views.delete(removal.trackById);
...
```

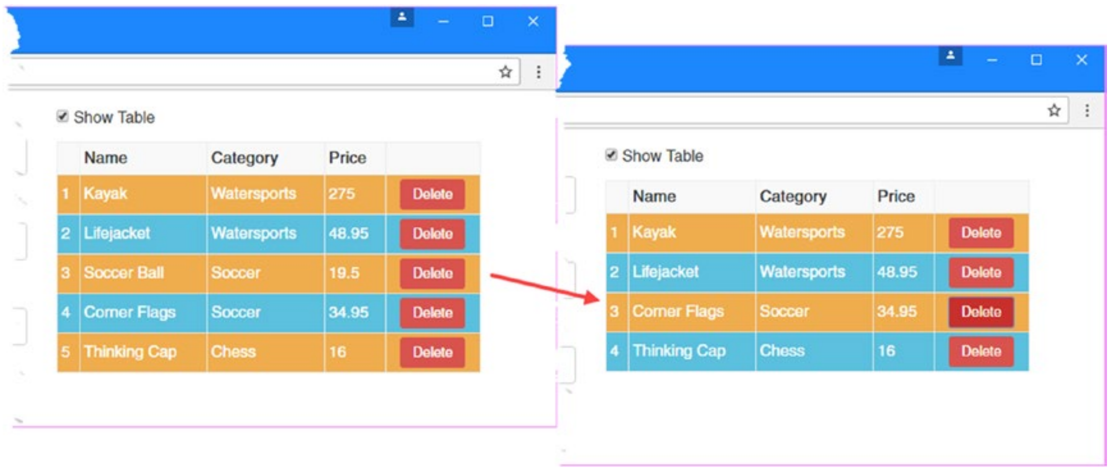
The contents of the `Map` can be processed using the `forEach` method, which invokes a callback function for each key/value pair. As explained in the SportsStore chapters, the `Map` doesn't work well as a source of data for data bindings.

The full set of `Map` features is described at `https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/Map`. Older browsers don't have built-in support for the `Map` class and must use a compatibility library, such as `core-js`, as described in Chapter 11.

When processing the collection changes, the directive handles each removed object by retrieving the corresponding `PaIteratorContext` object from the `Map`, getting its `ViewRef` object and passing it to the `ViewContainerRef.remove` element to remove the content associated with the object from the view container.

The second task is to update the context data for those objects that remain so that the bindings that rely on a views position in the view container are updated correctly. The directive calls the `PaIteratorContext.setData` method for each context object left in the `Map` to update the view's position in the container and update the total number of views that are in use. Without these changes, the properties provided by the context object wouldn't accurately reflect the data model, which means that the background colors for the rows wouldn't be striped and the Delete buttons wouldn't target the right objects.

The effect of these changes is that each table row contains a Delete button that removes the corresponding object from the data model, which in turn triggers an update of the table, as shown in Figure 16-7.



☑ Show Table

	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

☑ Show Table

	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Corner Flags	Soccer	34.95	Delete
4	Thinking Cap	Chess	16	Delete

Figure 16-7. *Removing objects from the data model*

Querying the Host Element Content

Directives can query the contents of their host element to access the directives it contains, known as the *content children*, which allows directives to coordinate themselves to work together.

■ **Tip** Directives can also work together by sharing services, which I describe in Chapter 19.

To demonstrate how content can be queried, I added a file called `cellColor.directive.ts` to the app folder and used it to define the directive shown in Listing 16-20.

Listing 16-20. The Contents of the cellColor.directive.ts File in the app Folder

```
import { Directive, HostBinding } from "@angular/core";

@Directive({
    selector: "td"
})
export class PaCellColor {

    @HostBinding("class")
    bgClass: string = "";

    setColor(dark: Boolean) {
        this.bgClass = dark ? "bg-inverse" : "";
    }
}
```

The `PaCellColor` class defines a simple attribute directive that operates on `td` elements and that binds to the `class` property of the host element. The `setColor` method accepts a Boolean parameter that, when the value is `true`, sets the `class` property to `bg-inverse`, which is the Bootstrap class for inverted colors (a dark background with light text).

The PaCellColor class will be the directive that is embedded in the host element's content in this example. The goal is to write another directive that will query its host element to locate the embedded directive and invoke its setColor method. To that end, I added a file called cellColorSwitcher.directive.ts to the app folder and used it to define the directive shown in Listing 16-21.

Listing 16-21. The Contents of the cellColorSwitcher.directive.ts File in the app Folder

```
import { Directive, Input, Output, EventEmitter,
         SimpleChange, ContentChild } from "@angular/core";
import { PaCellColor } from "./cellColor.directive";

@Directive({
    selector: "table"
})
export class PaCellColorSwitcher {

    @Input("paCellDarkColor")
    modelProperty: Boolean;

    @ContentChild(PaCellColor)
    contentChild: PaCellColor;

    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        if (this.contentChild != null) {
            this.contentChild.setColor(changes["modelProperty"].currentValue);
        }
    }
}
```

The PaCellColorSwitcher class defines a directive that operates on table elements and that defines an input property called paCellDarkColor. The important part of this directive is the contentChild property.

```
...
@ContentChild(PaCellColor)
contentChild: PaCellColor;
...
```

The @ContentChild decorator tells Angular that the directive needs to query the host element's content and assign the first result of the query to the property. The argument to the @ContentChild director is one or more directive classes. In this case, the argument to the @ContentChild decorator is PaCellColor, which tells Angular to locate the first PaCellColor object contained within the host element's content and assign it to the decorated property.

■ **Tip** You can also query using template variable names, such that @ContentChild("myVariable") will find the first directive that has been assigned to myVariable.

The query result provides the PaCellColorSwitcher directive with access to the child component and allows it to call the setColor method in response to changes to the input property.

■ **Tip** If you want to include the descendants of children in the results, then you can configure the query, like this: `@ContentChild(PaCellColor, { descendants: true})`.

In Listing 16-22, I added a checkbox to the template that uses the `ngModel` directive to set a variable that is bound to the `PaCellColorSwitcher` directive's input property.

Listing 16-22. Applying the Directives in the template.html File

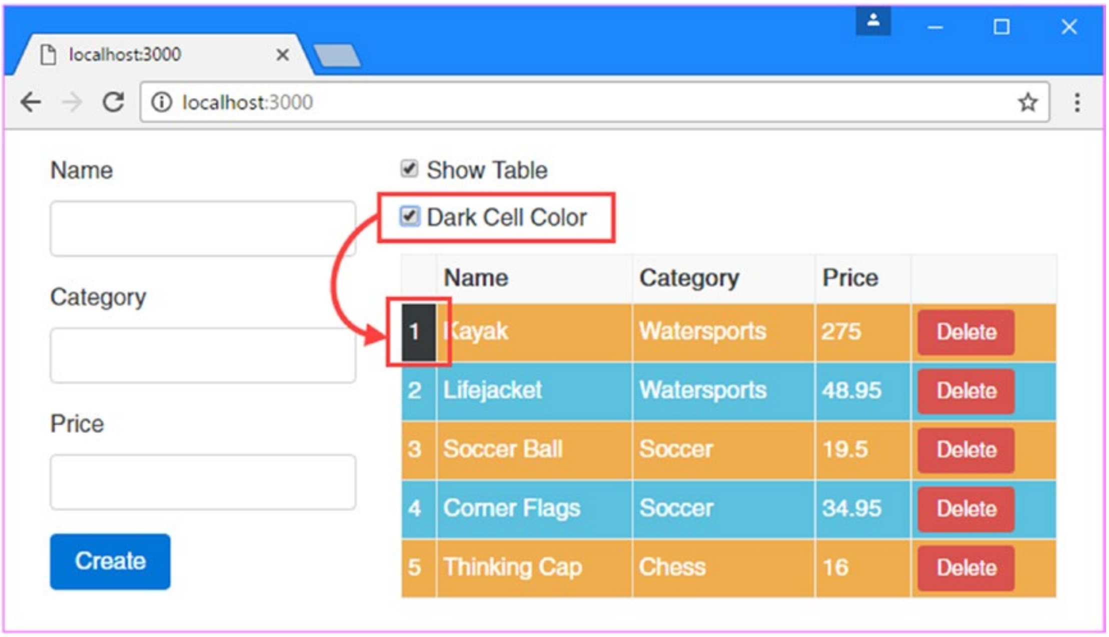
```
...
<div class="col-xs-8">
    <div class="checkbox">
        <label>
            <input type="checkbox" [(ngModel)]="showTable" />
            Show Table
        </label>
    </div>

    <div class="checkbox">
        <label>
            <input type="checkbox" [(ngModel)]="darkColor" />
            Dark Cell Color
        </label>
    </div>

    <table *paIf="showTable" [paCellDarkColor]="darkColor"
            class="table table-sm table-bordered table-striped">
        <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
        <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
                let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
            <td style="vertical-align:middle">{{i + 1}}</td>
            <td style="vertical-align:middle">{{item.name}}</td>
            <td style="vertical-align:middle">{{item.category}}</td>
            <td style="vertical-align:middle">{{item.price}}</td>
            <td class="text-xs-center">
                <button class="btn btn-danger btn-sm" (click)="deleteProduct(i)">
                    Delete
                </button>
            </td>
        </tr>
    </table>
</div>
...
```

The final step is to register the new directives with the Angular module's `declarations` property, as shown in Listing 16-23.

Listing 16-23. Registering New Directives in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

When you save the changes, you will see a new checkbox above the table. When you check the box, the ngModel directive will cause the PaCellColorSwitcher directive's input property to be updated, which will call the setColor method of the PaCellColor directive object that was found using the @ContentChild decorator. The visual effect is small because only the first PaCellColor directive is affected, which is the cell that displays the number 1, at the top-left corner of the table, as shown in Figure 16-8.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 16-8. *Operating on a content child*

Querying Multiple Content Children

The @ContentChild decorator finds the first directive object that matches the argument and assigns it to the decorated property. If you want to receive all the directive objects that match the argument, then you can use the @ContentChildren decorator instead, as shown in Listing 16-24.

Listing 16-24. Querying Multiple Content Children in the cellColorSwitcher.directive.ts File

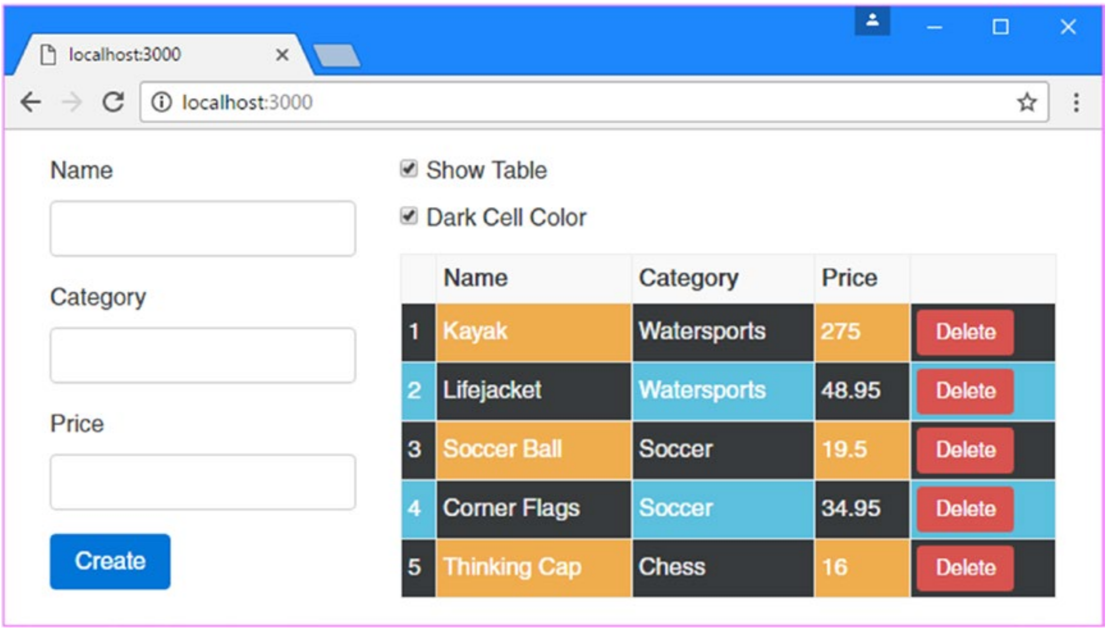
```
import { Directive, Input, Output, EventEmitter,
         SimpleChange, ContentChildren, QueryList } from "@angular/core";
import { PaCellColor } from "./cellColor.directive";

@Directive({
    selector: "table"
})
export class PaCellColorSwitcher {

    @Input("paCellDarkColor")
    modelProperty: Boolean;

    @ContentChildren(PaCellColor)
    contentChildren: QueryList<PaCellColor>;

    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        this.updateContentChildren(changes["modelProperty"].currentValue);
    }

    private updateContentChildren(dark: Boolean) {
        if (this.contentChildren != null && dark != undefined) {
            this.contentChildren.forEach((child, index) => {
                child.setColor(index % 2 ? dark : !dark);
            });
        }
    }
}
```

When you use the @ContentChildren decorator, the results of the query are provided through a QueryList, which provides access to the directive objects using the methods and properties described in Table 16-6.

***Table 16-6.** The QueryList Members*

Name	Description
`length`	This property returns the number of matched directive objects.
`first`	This property returns the first matched directive object.
`last`	This property returns the last matched directive object.
`map(function)`	This method calls a function for each matched directive object in order to create a new array, equivalent to the `Array.map` method.
`filter(function)`	This method calls a function for each matched directive object in order to create an array containing the objects for which the function returns true, equivalent to the `Array.filter` method.
`reduce(function)`	This method calls a function for each matched directive object in order to create a single value, equivalent to the `Array.reduce` method.
`forEach(function)`	This method calls a function for each matched directive object, equivalent to the `Array.forEach` method.
`some(function)`	This method calls a function for each matched directive object and returns `true` if the function returns `true` at least once, equivalent to the `Array.some` method.
`changes`	This property is used to monitor the results for changes, as described in the upcoming "Receiving Query Change Notifications" section.

In the listing, the directive responds to changes in the input property value by calling the `updateContentChildren` method, which in turns uses the `forEach` method on the `QueryList` and invokes the `setColor` method on every second directive that has matched the query. Figure 16-9 shows the effect when the checkbox is selected.



localhost:3000

Name

Category

Price

Create

☑ Show Table

☑ Dark Cell Color

	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

***Figure 16-9.** Operating on multiple content children*

Receiving Query Change Notifications

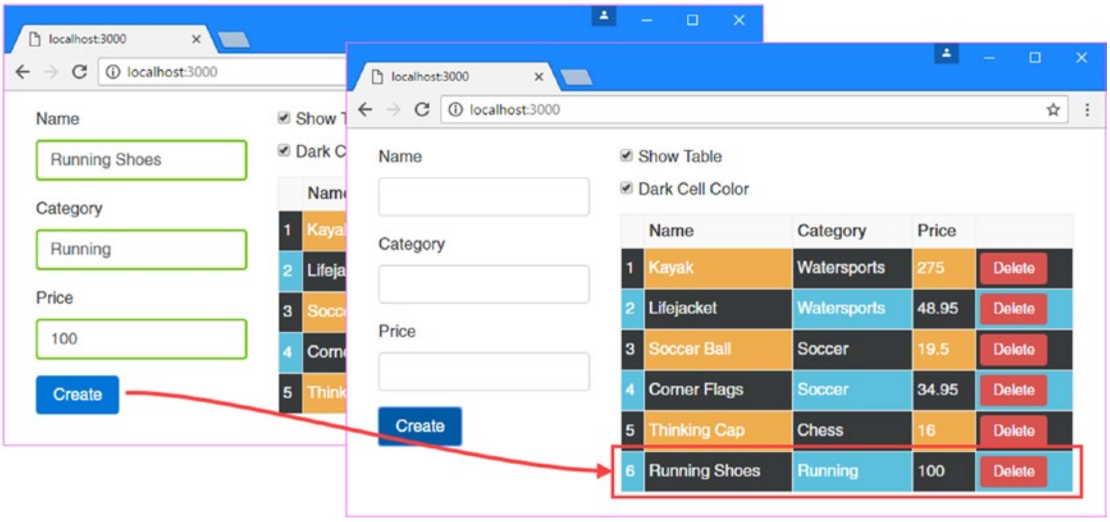
The results of content queries are live, meaning that they are automatically updated to reflect additions, changes, or deletions in the host element's content. Receiving a notification when there is a change in the query results requires using the `Observable` interface, which is provided by the Reactive Extensions package added to the project in Chapter 11. The Reactive Extensions package provides features for distributing change events through a JavaScript application. I explain how `Observable` objects work in more detail in Chapter 23, but for now, it is enough to know that they are used internally by Angular to manage changes.

In Listing 16-25, I have updated the `PaCellColorSwitcher` directive so that it receives notifications when the set of content children in the `QueryList` changes.

Listing 16-25. Receiving Change Notifications in the cellColorSwitcher.directive.ts File

```
import { Directive, Input, Output, EventEmitter,
         SimpleChange, ContentChildren, QueryList } from "@angular/core";
import { PaCellColor } from "./cellColor.directive";

@Directive({
    selector: "table"
})
export class PaCellColorSwitcher {

    @Input("paCellDarkColor")
    modelProperty: Boolean;

    @ContentChildren(PaCellColor)
    contentChildren: QueryList<PaCellColor>;

    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        this.updateContentChildren(changes["modelProperty"].currentValue);
    }

    ngAfterContentInit() {
        this.contentChildren.changes.subscribe(() => {
            setTimeout(() => this.updateContentChildren(this.modelProperty), 0);
        });
    }

    private updateContentChildren(dark: Boolean) {
        if (this.contentChildren != null && dark != undefined) {
            this.contentChildren.forEach((child, index) => {
               child.setColor(index % 2 ? dark : !dark);
            });
        }
    }
}
```

The value of a content child query property isn't set until the `ngAfterContentInit` lifecycle method is invoked, so I use this method to set up the change notification. The `QueryList` class defines a changes method that returns a Reactive Extensions `Observable` object, which defines a `subscribe` method. This method accepts a function that is called when the contents of the `QueryList` change, meaning that there is some change in the set of directives matched by the argument to the `@ContentChildren` decorator. The function that I passed to the `subscribe` method calls the `updateContentChildren` method to set the colors, but it does so within a call to the `setTimeout` function, which delays the execution of the method call until after the `subscribe` callback function has completed. Without the call to `setTimeout`, Angular will report an error because the directive tries to start a new content update before the existing one has been fully processed. The result of these changes is that the dark coloring is automatically applied to new table cells that are created when the HTML form is used, as shown in Figure 16-10.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete
6	Running Shoes	Running	100	Delete

Figure 16-10. *Acting on content query change notifications*

Summary

In this chapter, I explained how structural directives work by re-creating the functionality of the built-in `ngIf` and `ngFor` directives. I explained the use of view containers and templates, described the full and concise syntax for applying structural directives, and showed you how to create a directive that iterates over a collection of data objects and how directives can query the content of their host element. In the next chapter, I introduce components and explain how they differ from directives.

CHAPTER 17

Understanding Components

Components are directives that have their own templates, rather than relying on content provided from elsewhere. Components have access to all the directive features described in earlier chapters and still have a host element, can still define input and output properties, and so on. But they also define their own content.

It can be easy to underestimate the importance of the template, but attribute and structural directives have limitations. Directives can do useful and powerful work, but they don't have much insight into the elements they are applied to. Directives are at their most useful when they are general-purpose tools, such the `ngModel` directive, which can be applied to any data model property and any form element, without regard to what the data or the element is being used for.

Components, by contrast, are closely tied to the contents of their templates. Components provide the data and logic that will be used by the data bindings that are applied to the HTML elements in the template, which provide the context used to evaluate data binding expressions and act as the glue between the directives and the rest of the application. Components are also a useful tool in allowing large Angular projects to be broken up into manageable chunks.

In this chapter, I explain how components work and explain how to restructure an application by introducing some additional components. Table 17-1 puts components in context.

Table 17-1. *Putting Components in Context*

Question	Answer
What are they?	Components are directives that define their own HTML content and, optionally, CSS styles.
Why are they useful?	Components make it possible to define self-contained blocks of functionality, which makes projects more manageable and allows for functionality to be more readily reused.
How are they used?	The `@Component` decorator is applied to a class, which is registered in the application's Angular module.
Are there any pitfalls or limitations?	No. Components provide all the functionality of directives, with the addition of providing their own templates.
Are there any alternatives?	An Angular application must contain at least one component, which is used in the bootstrap process. Aside from this, you don't have to add additional components, although the resulting application becomes unwieldy and difficult to manage.

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Table 17-2 summarizes the chapter.

Table 17-2. *Chapter Summary*

Problem	Solution	Listing
Create a component	Apply the `@Component` directive to a class	1–5
Define the content displayed by a component	Create an inline or external template	6–8
Include data in a template	Use a data binding in the component's template	9
Coordinate between components	Use input or output properties	10–16
Display content in an element to which a component has been applied	Project the host element's content	17–21
Style component content	Create component styles	22–30
Query the content in the component's template	Use the `@ViewChildren` decorator	31

Preparing the Example Project

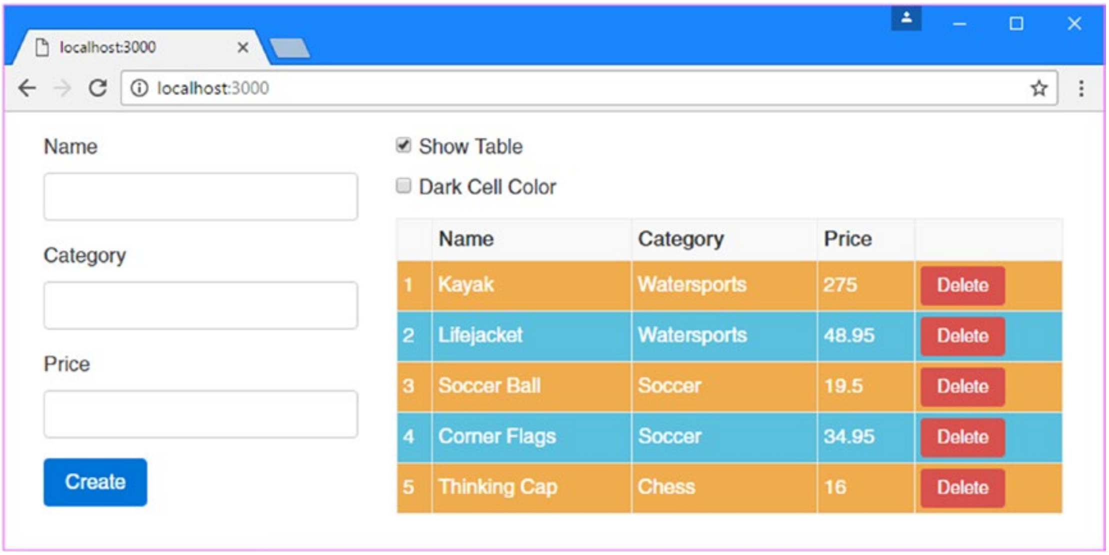
In this chapter, I continue using the `example` project that I created in Chapter 11 and have been modifying since. No changes are required to prepare for this chapter.

■ **Tip** You can get the project as part of the free source code download that accompanies this book and that is available at `apress.com`.

To start the TypeScript compiler and the development HTTP server, run the following command in the `example` folder:

```
npm start
```

The development HTTP server will open a new browser window showing the content in Figure 17-1.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-1. *Running the example project*

Structuring an Application with Components

At the moment, the example project contains only one component and one template. Angular applications require at least one component, known as the *root component*, which is the entry point specified in the Angular module.

The problem with having only one component is that it ends up containing the logic required for all the application's features, with its template containing all the markup required to expose those features to the user. The result is that a single component and its template are responsible for handling a lot of tasks. The component in the example application is responsible for the following:

- Providing Angular with an entry point into the application, as the root component
- Providing access to the application's data model so that it can be used in data bindings
- Defining the HTML form used to create new products
- Defining the HTML table used to display products
- Defining the layout that contains the form and the table
- Checking that the form data is valid when a new product is created
- Maintaining state information used to prevent invalid data being used to create data
- Maintaining state information about whether the table should be displayed

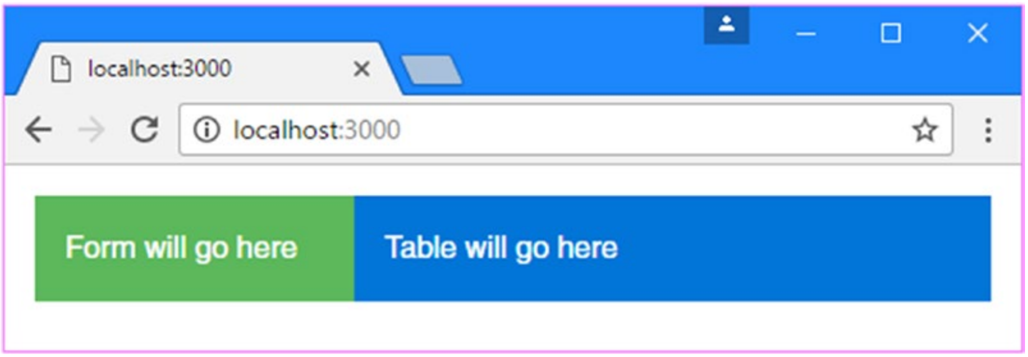
There is a lot going on for such a simple application, and not all of these tasks are related. This effect tends to creep up gradually as development proceeds, but it means that the application is harder to test because individual features can't be isolated effectively and is harder to enhance and maintain because the code and markup become increasingly complex.

Adding components to the application allows features to be teased apart into building blocks that can be used repeatedly in different parts of the application. In the sections that follow, I will create components that break up the functionality contained in the example application into manageable, reusable, and self-contained units. Along the way, I'll explain the different features that components provide above and beyond those available to directives. To prepare for these changes, I have simplified the existing component's template, as shown in Listing 17-1.

Listing 17-1. Simplifying the Content of the template.html File

```
<div class="col-xs-4 p-a-1 bg-success">
    Form will go here
</div>
<div class="col-xs-8 p-a-1 bg-primary">
    Table will go here
</div>
```

When you save the changes to the template, you will see the content in Figure 17-2. The placeholders will be replaced with application functionality as I develop the new components and add them to the application.



Form will go here
Table will go here

Figure 17-2. *Simplifying the existing template*

Creating New Components

To create a new component, I added a file called `productTable.component.ts` to the app folder and used it to define the component shown in Listing 17-2.

Listing 17-2. The Contents of the productTable.component.ts File in the app Folder

```
import { Component } from "@angular/core";

@Component({
    selector: "paProductTable",
    template: "<div>This is the table component</div>"
})
export class ProductTableComponent {

}
```

A component is a class to which the `@Component` decorator has been applied. This is as simple as a component can get, and it provides just enough functionality to count as a component, without yet doing anything useful.

The naming convention for the files that define components is to use a descriptive name that suggests the purpose of the component, followed by a period and then `component.ts`. For this component, which will be used to generate the table of products, the file name is `productTable.component.ts`. The name of the class should be equally descriptive. This component's class is named `ProductTableComponent`.

The `@Component` decorator describes and configures the component. The most useful decorator properties are described by Table 17-3, which also includes details of where they are described (not all of them are covered in this chapter).

Table 17-3. *The Component Decorator Properties*

Name	Description
`animations`	This property is used to configuration animations, as described in Chapter 28.
`encapsulation`	This property is used to change the view encapsulation settings, which control how component styles are isolated from the rest of the HTML document. See the "Setting View Encapsulation" section for details.
`moduleId`	This property is used to specify the module that the component is defined within and is used in conjunction with the `templateUrl` property, as described in Chapter 12.
`selector`	This property is used to specify the CSS selector used to match host elements, as described after the table.
`styles`	This property is used to define CSS styles that are applied only to the component's template. The styles are defined inline, as part of the TypeScript file. See the "Using Component Styles" section for details.
`styleUrls`	This property is used to define CSS styles that are applied only to the component's template. The styles are defined in separate CSS files. See the "Using Component Styles" section for details.
`template`	This property is used to specify an inline template, as described in the "Defining Templates" section.
`templateUrl`	This property is used to specify an external template, as described in the "Defining Templates" section.
`providers`	This property is used to create local providers for services, as described in Chapter 19.
`viewProviders`	This property is used to create local providers for services that are available only to view children, as described in Chapter 20.

For the second component, I created a file called `productForm.component.ts` in the `app` folder and added the code shown in Listing 17-3.

Listing 17-3. The Contents of the productForm.component.ts File in the app Folder

```
import { Component } from "@angular/core";

@Component({
    selector: "paProductForm",
    template: "<div>This is the form component</div>"
})
export class ProductFormComponent {

}
```

This component is equally simple and is just a placeholder for the moment. Later in the chapter, I'll add some more useful features. To enable the components, they must be declared in the application's Angular module, as shown in Listing 17-4.

Listing 17-4. Enabling New Components in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

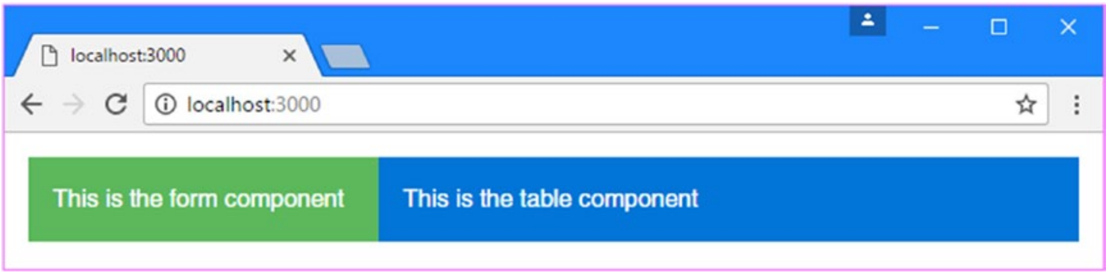
The component class is brought into scope using an `import` statement and added to the `NgModule` decorator's `declarations` array.

The final step is to add an HTML element that matches the component's selector property, as shown in Listing 17-5, which will provide the component with its host element.

Listing 17-5. Adding a Host Element in the template.html File

```
<div class="col-xs-4 p-a-1 bg-success">
    <paProductForm></paProductForm>
</div>
<div class="col-xs-8 p-a-1 bg-primary">
    <paProductTable></paProductTable>
</div>
```

When all the changes have been saved, the browser will display the content shown in Figure 17-3, which shows that parts of the HTML document are now under the management of the new components.



This is the form component This is the table component

Figure 17-3. Adding new components

Understanding the New Application Structure

The new components have changed the structure of the application. Previously, the root component was responsible for all the HTML content displayed by the application. Now, however, there are three components, and responsibility for some of the HTML content has been delegated to the new additions, as illustrated by Figure 17-4.

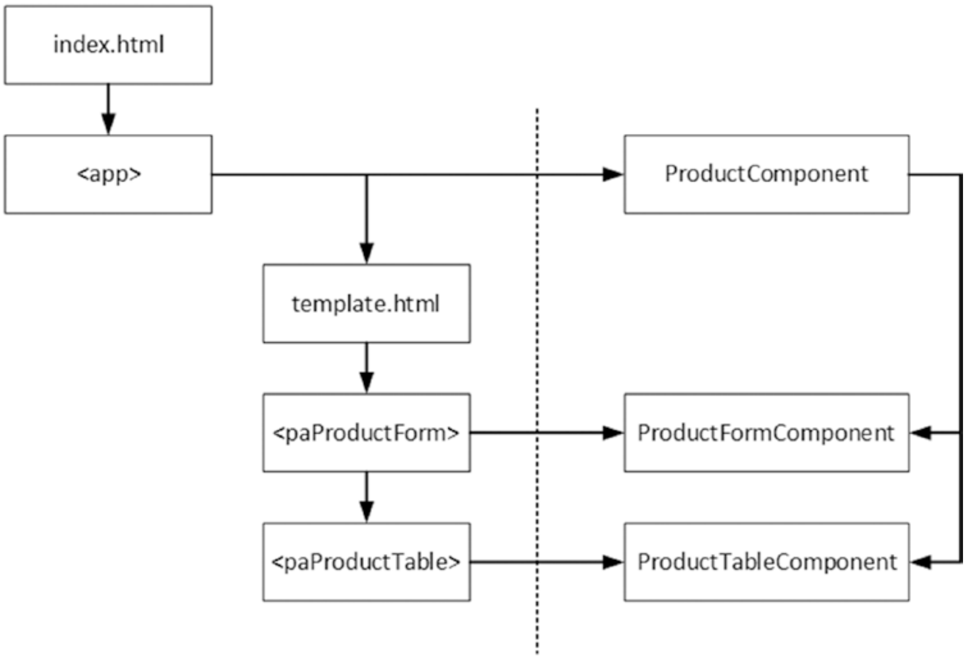


Figure 17-4. The new application structure

When the browser loads the `index.html` file, the Angular bootstrap process starts, and Angular processes the application's module, which provides a list of the components that the application requires. Angular inspects the decorator for each component in its configuration, including the value of the `selector` property, which is used to identify which elements will be hosts.

Angular then begins processing the body of the `index.html` file and finds the `app` element, which is specified by the `selector` property of the `ProductComponent` component. Angular populates the `app` element with the component's template, which is contained in the `template.html` file. Angular inspects the contents of the `template.html` file and finds the `paProductForm` and `paProductTable` elements, which match the selector properties of the newly added components. Angular populates these elements with each component's template, producing the placeholder content shown in Figure 17-3.

There are some important new relationships to understand. First, the HTML content that is displayed in the browser window is now composed of several templates, each of which is managed by a component. Second, the `ProductComponent` is now the parent component to the `ProductFormComponent` and `ProductTableComponent` objects, a relationship that is formed by the fact that the host elements for the new components are defined in the `template.html` file, which is the `ProductComponent` template. Equally, the new components are children of the `ProductComponent`. The parent/child relationship is an important one when it comes to Angular components, as you will see as I describe how components work in later sections.

Defining Templates

Although there are new components in the application, they don't have much impact at the moment because they display only placeholder content. Each component has its own template, which defines the content that will be used to replace its host element in the HTML document. There are two different ways to define templates: inline within the `@Component` decorator or externally in an HTML file.

The new components that I added templates, where a fragment of HTML is assigned to the `template` property of the `@Component` decorator, like this:

```
...
template: "<div>This is the form component</div>"
...
```

The advantage of this approach is simplicity: the component and the template are defined in a single file, and there is no way that the relationship between them can be confused. The drawback of inline templates is that they can get out of control and be hard to read if they contain more than a few HTML elements.

Another problem is that editors that highlight syntax errors as you type usually rely on the file extension to figure out what type of checking should be performed and won't realize that the value of the `template` property is HTML and will simply treat it as a string.

If you are using TypeScript, then you can use multiline strings to make inline templates more readable. Multiline strings are denoted with the backtick character (the ` character, which is also known as the *grave accent*), and they allow strings to spread over multiple lines, as shown in Listing 17-6.

Listing 17-6. Using a Multiline String for an Inline Template in the productTable.component.ts File

```
import { Component } from "@angular/core";

@Component({
    selector: "paProductTable",
    template: `<div class='bg-info p-a-1'>
                   This is a multiline template
               </div>`
})
export class ProductTableComponent {

}
```

Multiline strings allow the structure of the HTML elements in a template to be preserved, which make it easier to read and increase the size of template that can be practically included inline before it becomes too unwieldly to manage. Figure 17-5 shows the effect of the template in Listing 17-6.

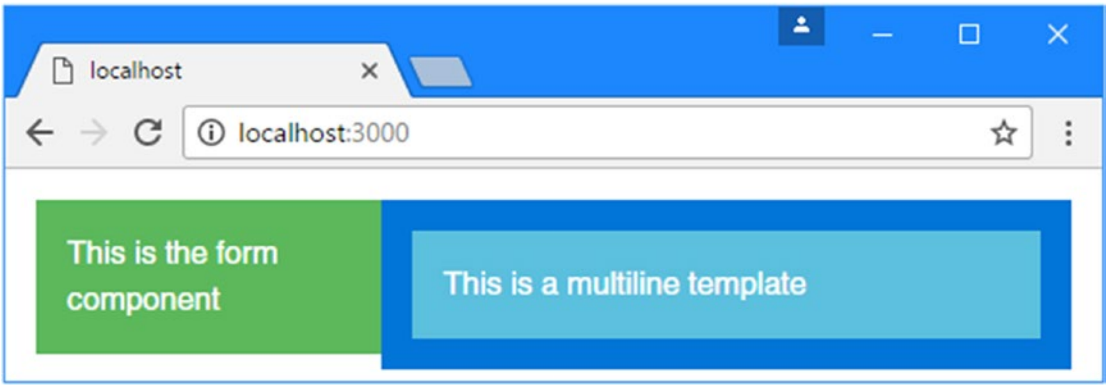


***Figure 17-5.** Using a multiline inline template*

■ **Tip** My advice is to use external templates (explained in the next section) for any template that contains more than two or three simple elements, largely to take advantage of the HTML editing and syntax highlighting features that modern editors provide, which can go a long way to reduce the number of errors you discover when running the application.

Defining External Templates

External templates are defined in a different file from the rest of the component. The advantage of this approach is that the code and HTML are not mixed together, which makes both easier to read and unit test, and it also means that code editors will know they are working with HTML content when you are working on a template file, which can help reduce coding-time errors by highlighting errors.

The drawback of external templates is that you have to manage more files in the project and ensure that each component is associated with the correct template file. The best way to do this is to follow a consistent file naming strategy so that it is immediately obvious that a file contains a template for a given component. The convention for Angular is to create pairs of files using the convention `<componentname>.component.<type>` so that when you see a file called `productTable.component.ts`, you know it contains a component called `Products` written in TypeScript, and when you see a file called `productTable.component.html`, you know that it contains an external template for the `Products` component.

■ **Tip** The syntax and features for both types of template are the same, and the only difference is where the content is stored, either in the same file as the component code or in a separate file.

To define an external template using the naming convention, I created a file called `productTable.component.html` in the app folder and added the markup shown in Listing 17-7.

Listing 17-7. The Contents of the productTable.component.html File in the app Folder

```
<div class="bg-info p-a-1">
    This is an external template
</div>
```

This is the kind of template that I have been using for the root component since Chapter 11. To specify an external template, the `templateURL` property is used in the `@Component` decorator, as shown in Listing 17-8.

Listing 17-8. Using an External Template in the productTable.component.html File

```
import { Component } from "@angular/core";

@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {

}
```

Notice that different properties are used: `template` is for inline templates, and `templateUrl` is for external templates. Figure 17-6 shows the effect of using an external template.

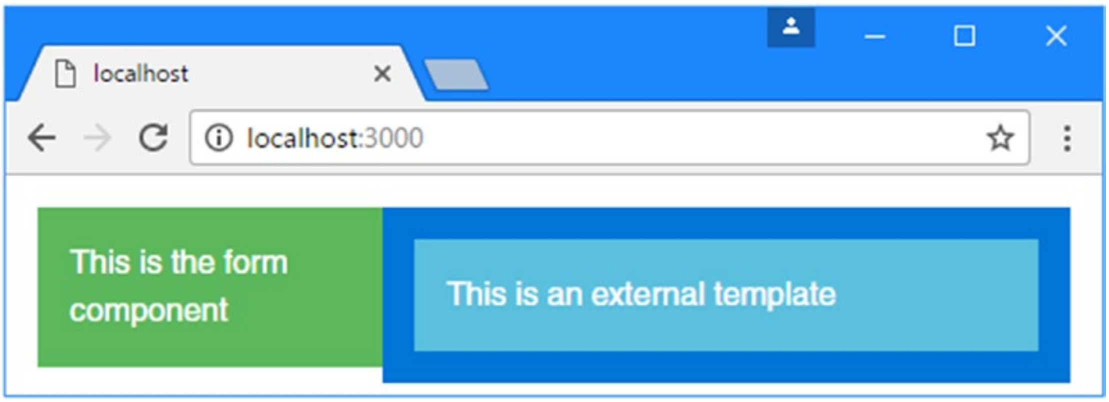


Figure 17-6. *Using an external template*

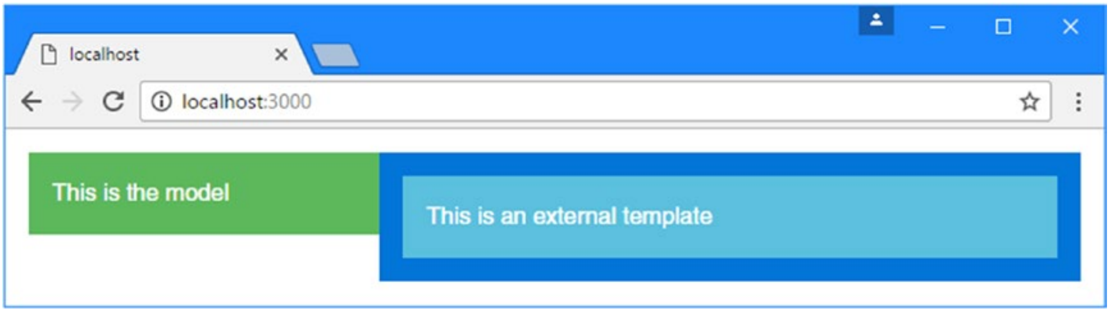
Using Data Bindings in Component Templates

A component's template can contain the full range of data bindings and target any of the built-in directives or custom directives that have been registered in the application's Angular module. Each component class provides the context for evaluating the data binding expressions in its template, and, by default, each component is isolated from the others. This means that the component doesn't have to worry about using the same property and method names that other components use and can rely on Angular to keep everything separate. As an example, Listing 17-9 shows the addition of a property called `model` to the form child component, which would conflict with the property of the same name in the root component were they not kept separate.

Listing 17-9. Adding a Property and a Model Binding Expression in the productForm.component.ts File

```
import { Component } from "@angular/core";

@Component({
    selector: "paProductForm",
    template: "<div>{{model}}</div>"
})
export class ProductFormComponent {

    model: string = "This is the model";
}
```

The component class uses the `model` property to store a message that is displayed in the template using a string interpolation binding. Figure 17-7 shows the result.



This is the model

This is an external template

Figure 17-7. *Using a data binding in a child component*

Using Input Properties to Coordinate Between Components

Few components exist in isolation and need to share data with other parts of the application. Components can define input properties to receive the value of data binding expressions on their host elements. The expression will be evaluated in the context of the parent component, but the result will be passed to the child component's property.

To demonstrate, Listing 17-10 adds an input property to the table component, which it will use to receive the model data that it should display.

Listing 17-10. Defining an Input Property in the productTable.component.ts File

```
import { Component, Input } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
```

```
@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {

    @Input("model")
    dataModel: Model;

    getProduct(key: number): Product {
        return this.dataModel.getProduct(key);
    }

    getProducts(): Product[] {
        return this.dataModel.getProducts();
    }

    deleteProduct(key: number) {
        this.dataModel.deleteProduct(key);
    }

    showTable: boolean = true;
}
```

The component now defines an input property that will be assigned the value expression assigned to the `model` attribute on the host element. The `getProduct`, `getProducts`, and `deleteProduct` methods use the input property to provide access to the data model to bindings in the component's template, which is modified in Listing 17-11. The `showTable` property is used when I enhance the template in Listing 17-14 later in the chapter.

Listing 17-11. Adding a Data Binding in the productTable.component.html File

```
There are {{getProducts().length}} items in the model
```

To provide the child component with the data that it requires means adding a binding to its host element, which is defined in the template of the parent component, as shown in Listing 17-12.

Listing 17-12. Adding a Data Binding in the template.html File

```
<div class="col-xs-4 p-a-1 bg-success">
    <paProductForm></paProductForm>
</div>
<div class="col-xs-8 p-a-1 bg-primary">
    <paProductTable [model]="model"></paProductTable>
</div>
```

The effect of this binding is to provide the child component with access to the parent component's model property. This can be a confusing feature because it relies on the fact that the host element is defined in the parent component's template but that the input property is defined by the child component, as illustrated by Figure 17-8.

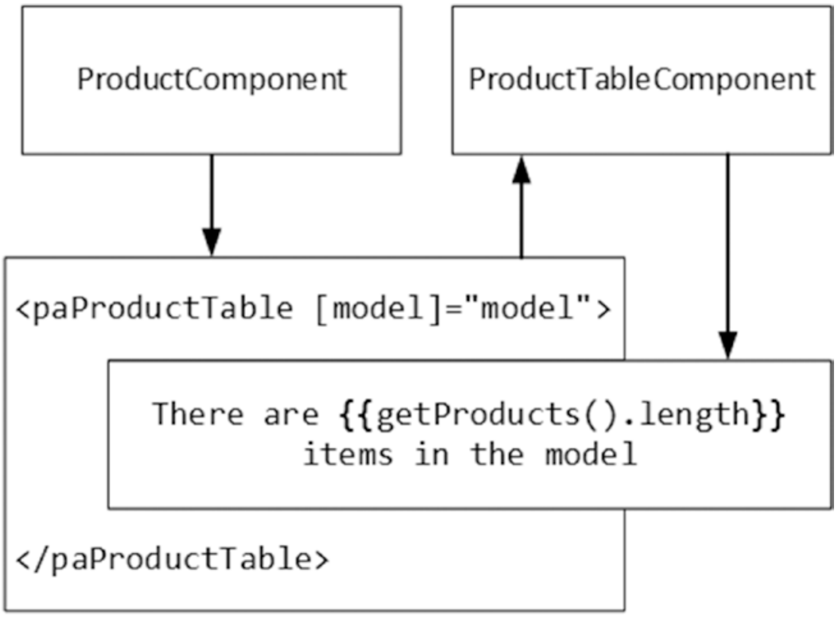
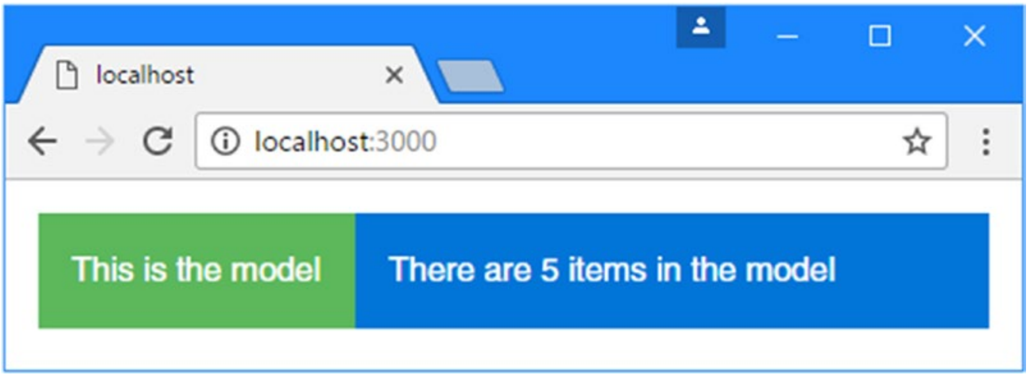

ProductComponent
ProductTableComponent
<paProductTable [model]="model">
There are {{getProducts().length}} items in the model
</paProductTable>

Figure 17-8. *Sharing data between parent and child components*

The child component's host element acts as the bridge between the parent and child components, and the input property allows the component to provide the child with the data it needs, producing the result shown in Figure 17-9.



This is the model

There are 5 items in the model

Figure 17-9. *Sharing data from a parent to a child component*

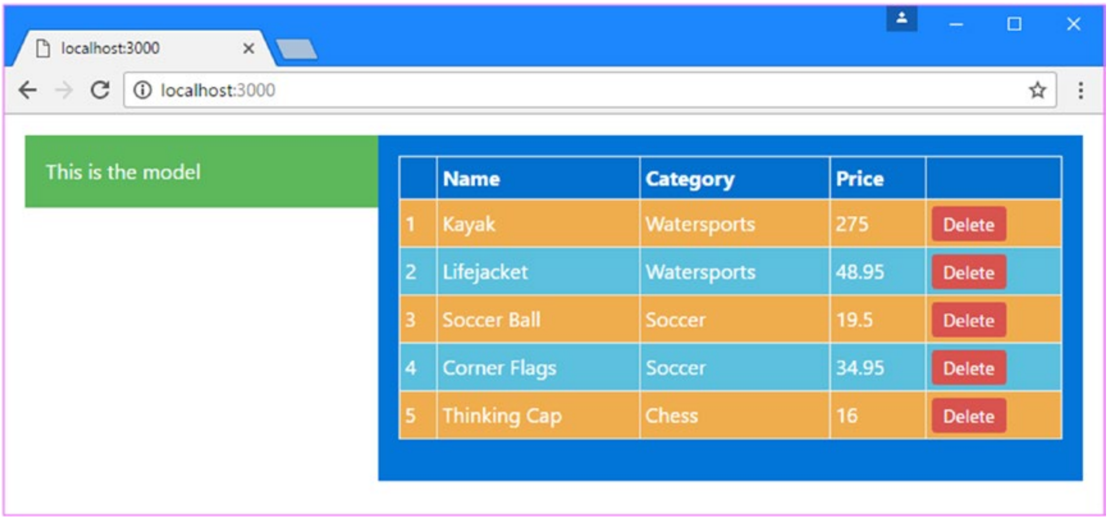
Using Directives in a Child Component Template

Once the input property has been defined, the child component can use the full range of data bindings and directives, either by using the data provided through the parent component or by defining its own. In Listing 17-13, I have restored the original table functionality from earlier chapters that displays a list of the `Product` objects in the data model, along with a checkbox that determines whether the table is displayed. This was functionality that was previously managed by the root component and its template.

Listing 17-13. Restoring the Table Functionality in the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">{{item.price}}</td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

The same HTML elements, data bindings, and directives (including custom directives like `paIf` and `paFor`) are used, producing the result shown in Figure 17-10. The key difference is not in the appearance of the table but in the way that it is now managed by a dedicated component.



This is the model

	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-10. *Restoring the table display*

Using Output Properties to Coordinate Between Components

Child components can use output properties that define custom events that signal important changes and that allow the parent component to respond when they occur. Listing 17-14 shows the addition of an output property to the form component, which will be triggered when the user creates a new `Product` object.

Listing 17-14. Defining an Output Property in the productForm.component.ts File

```
import { Component, Output, EventEmitter } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html"
})
export class ProductFormComponent {
    form: ProductFormGroup = new ProductFormGroup();
    newProduct: Product = new Product();
    formSubmitted: boolean = false;

    @Output("paNewProduct")
    newProductEvent = new EventEmitter<Product>();

    submitForm(form: any) {
        this.formSubmitted = true;
        if (form.valid) {
            this.newProductEvent.emit(this.newProduct);
            this.newProduct = new Product();
            this.form.reset();
            this.formSubmitted = false;
        }
    }
}
```

The output property is called `newProductEvent`, and the component triggers it when the `submitForm` method is called. Aside from the output property, the additions in the listing are based on the logic in the root controller, which previously managed the form. I also removed the inline template and created a file called `productForm.component.html` in the `app` folder, into which I restored the HTML form, as shown in Listing 17-15.

Listing 17-15. The Contents of the productForm.component.html File in the app Folder

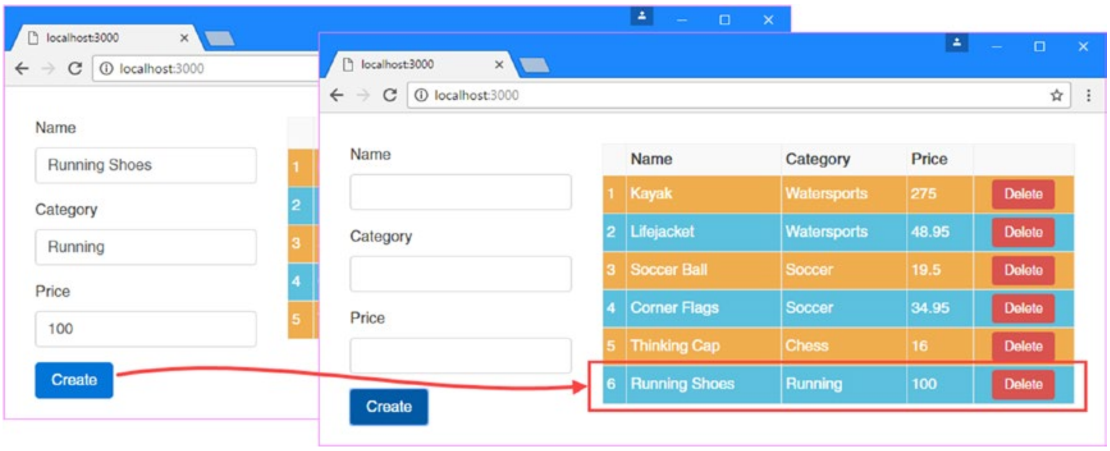
```
<form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">
    <div class="form-group" *ngFor="let control of form.productControls">
        <label>{{control.label}}</label>
        <input class="form-control"
            [(ngModel)]="newProduct[control.modelProperty]"
            name="{{control.modelProperty}}"
            formControlName="{{control.modelProperty}}" />
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || control.dirty) && !control.valid">
            <li *ngFor="let error of control.getValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>
    <button class="btn btn-primary" type="submit"
        [disabled]="formSubmitted && !form.valid"
        [class.btn-secondary]="formSubmitted && !form.valid">
            Create
    </button>
</form>
```

No changes are need to the markup used to define the form. As with the input property, the child component's host element acts as the bridge to the parent component, which can register interest in the custom event, as shown in Listing 17-16.

Listing 17-16. Registering for the Custom Event in the template.html File

```
<div class="col-xs-4 p-a-1">
    <paProductForm (paNewProduct)="addProduct($event)"></paProductForm>
</div>
<div class="col-xs-8 p-a-1">
    <paProductTable [model]="model"></paProductTable>
</div>
```

The new binding handles the custom event by passing the event object to the `addProduct` method. The child component is responsible for managing the form elements and validating their contents. When the data passes validation, the custom event is triggered, and the data binding expression is evaluated in the context of the parent component, whose `addProduct` method adds the new object to the model. Since the model has been shared with the table child component through its input property, the new data is displayed to the user, as shown in Figure 17-11.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete
6	Running Shoes	Running	100	Delete

Figure 17-11. *Using a custom event in a child component*

Projecting Host Element Content

If the host element for a component contains content, it can be included in the template using the special `ng-content` element. This is known as *content projection*, and it allows components to be created that combine the content in their template with the content in the host element. To demonstrate, I added a file called `toggleView.component.ts` to the app folder and used it to define the component shown in Listing 17-17.

Listing 17-17. The Contents of the toggleView.component.ts File in the app Folder

```
import { Component } from "@angular/core";

@Component({
    selector: "paToggleView",
    templateUrl: "app/toggleView.component.html"
})
export class PaToggleView {

    showContent: boolean = true;
}
```

This component defines a `showContent` property that will be used to determine whether the host element's content will be displayed within the template. To provide the template, I added a file called `toggleView.component.html` to the app folder and added the elements shown in Listing 17-18.

Listing 17-18. The Contents of the toggleView.component.html File in the app Folder

```
<div class="checkbox">
    <label>
        <input type="checkbox" [(ngModel)]="showContent" />
        Show Content
    </label>
</div>
<ng-content *ngIf="showContent"></ng-content>
```

The important element is `ng-content`, which Angular will replace with the content of the host element. The `ngIf` directive has been applied to the `ng-content` element so that it will be visible only if the checkbox in the template is checked. Listing 17-19 registers the component with the Angular module.

Listing 17-19. Registering the Component in the app.module.ts File

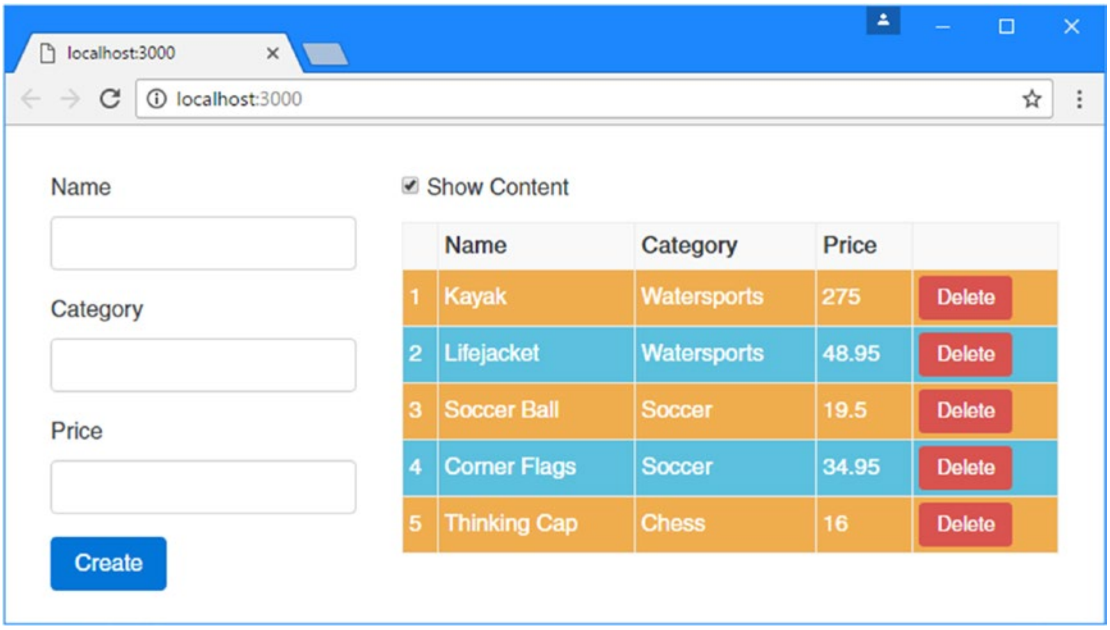
```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaToggleView } from "./toggleView.component";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaToggleView],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

The final step is to apply the new component to a host element that contains content, as shown in Listing 17-20.

Listing 17-20. Adding a Host Element with Content in the template.html File

```
<div class="col-xs-4 p-a-1">
    <paProductForm (paNewProduct)="addProduct($event)"></paProductForm>
</div>
<div class="col-xs-8 p-a-1">
    <paToggleView>
        <paProductTable [model]="model"></paProductTable>
    </paToggleView>
</div>
```

The `paToggleView` element is the host for the new component, and it contains the `paProductTable` element, which applies the component that creates the product table. The result is that there is a checkbox that controls visibility of the table, as shown in Figure 17-12. The new component has no knowledge of the content of its host element, and its inclusion in the template is possible only through the `ng-content` element.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-12. *Including host element content in the template*

Completing the Component Restructure

The functionality that was previously contained in the root component has been distributed to the new child components. All that remains is to tidy up the root component to remove the code that is no longer required, as shown in Listing 17-21.

Listing 17-21. Removing Obsolete Code in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    model: Model = new Model();

    addProduct(p: Product) {
        this.model.saveProduct(p);
    }
}
```

Many of the responsibilities of the root component have been moved elsewhere in the application. Of the original list from the start of the chapter, only the following remain the responsibility of the root component:

- Providing Angular with an entry point into the application, as the root component
- Providing access to the application's data model so that it can be used in data bindings

The child components have assumed the rest of the responsibilities, providing self-contained blocks of functionality that are simpler, easier to develop, and easier to maintain and that can be reused as required.

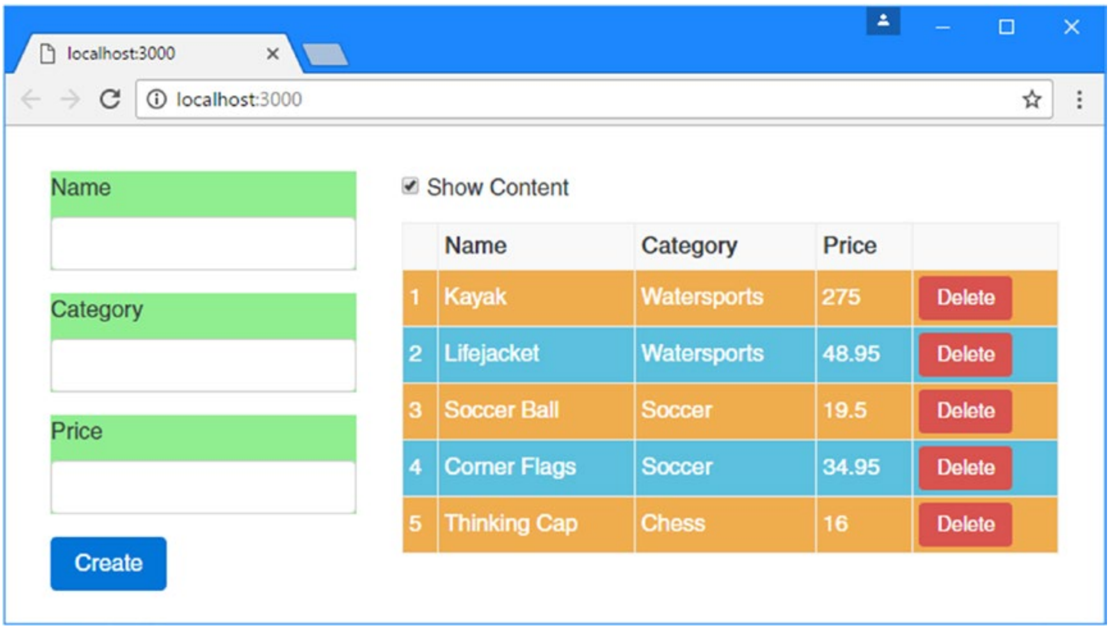
Using Component Styles

Components can define styles that apply only to the content in their templates, which allows content to be styled by a component without it being affected by the styles defined by its parents or other antecedents and without affecting the content in its child and other descendant components. Styles can be defined inline using the `styles` property of the `@Component` decorator, as shown in Listing 17-22.

Listing 17-22. Defining Inline Styles in the productForm.component.ts File

```
import { Component, Output, EventEmitter } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    styles: ["div { background-color: lightgreen"]
})
export class ProductFormComponent {
    form: ProductFormGroup = new ProductFormGroup();
    newProduct: Product = new Product();
    formSubmitted: boolean = false;

    @Output("paNewProduct")
    newProductEvent = new EventEmitter<Product>();

    submitForm(form: any) {
        this.formSubmitted = true;
        if (form.valid) {
            this.newProductEvent.emit(this.newProduct);
            this.newProduct = new Product();
            this.form.reset();
            this.formSubmitted = false;
        }
    }
}
```

The `styles` property is set to an array, where each item contains a CSS selector and one or more properties. In the listing I have specified styles that set the background color of `div` elements to `lightgreen`. Even though there are `div` elements throughout the combined HTML document, this style will affect only the elements in the template of the component that defines them, which is the form component in this case, as shown in Figure 17-13.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-13. *Defining inline component styles*

■ **Tip** The styles defined in the head section of the HTML document still apply to all elements, even when a component defines its own. This is why the content is still styled using Bootstrap.

Defining External Component Styles

Inline styles offer the same benefits and drawbacks as inline templates: they are simple and keep everything in one file, but they can be hard to read, can be hard to manage, and can confuse code editors.

The alternative is to define styles in a separate file and associate them with a component using the `styleUrls` property in its decorator. External style files follow the same naming convention as templates and code files. I added a file called `productForm.component.css` to the app folder and used it to define the styles shown in Listing 17-23.

Listing 17-23. The Contents of the productForm.component.css File in the app Folder

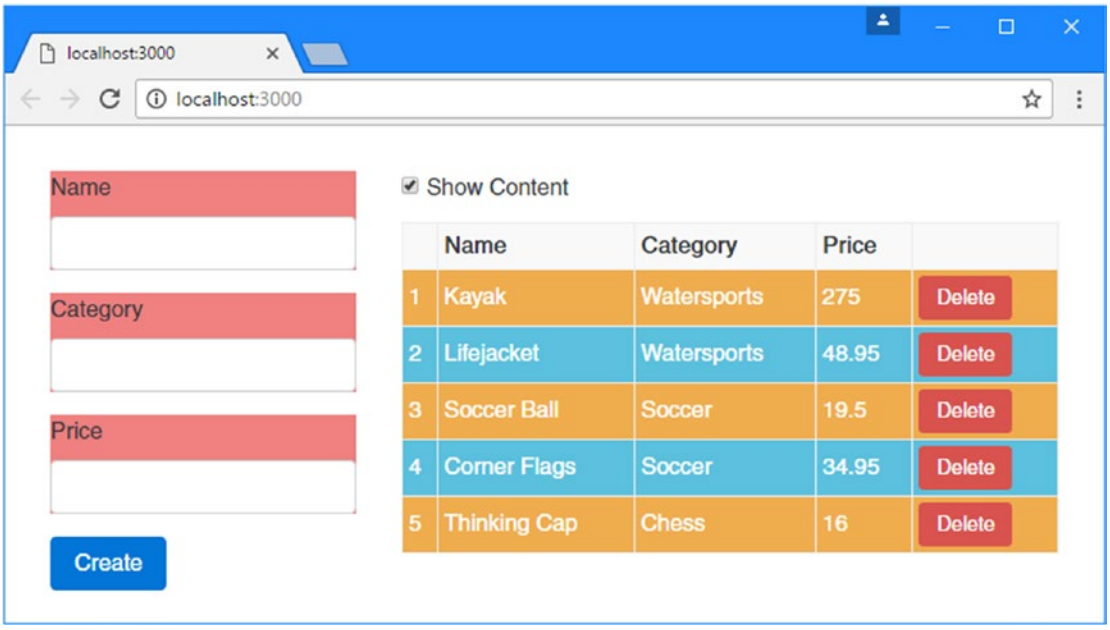
```
div {
    background-color: lightcoral;
}
```

This is the same style that was defined inline but with a different color value to confirm that this is the CSS being used by the component. In Listing 17-24, the component's decorator has been updated to specify the styles file.

Listing 17-24. Using External Component Styles in the productForm.component.ts File

```
import { Component, Output, EventEmitter } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    styleUrls: ["app/productForm.component.css"]
})
export class ProductFormComponent {

    // ...class members omitted for brevity...

}
```

The `styleUrls` property is set to an array of strings, each of which specifies a CSS file. Figure 17-14 shows the effect of adding the external styles file.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-14. *Defining external component styles*

Using Advanced Style Features

Defining styles in components is a useful feature, but you won't always get the results you expect. Some advanced features allow you to take control of how component styles work.

Setting View Encapsulation

By default, component-specific styles are implemented by writing the CSS that has been applied to the component so that it targets special attributes, which Angular then adds to all of the top-level elements contained in the component's template. If you inspect the DOM using the browser's F12 developer tools, you will see that the contents of the external CSS file in Listing 17-23 have been added to the head element of the HTML document and have been rewritten like this:

```
...
<style>
div[_ngcontent-qsg-2] {
    background-color: lightcoral;
}
</style>
...
```

The selector has been modified so that it matches `div` elements with an attribute called `_ngcontent-qsg-2`, although you may see a different name in your browser since the name of the attribute is generated dynamically by Angular.

To ensure that the CSS in the `style` element affects only the HTML elements managed by the component, the elements in the template are modified so they have the same dynamically generated attribute, like this:

```
...
<div _ngcontent-qsg-2="" class="form-group">
        <label _ngcontent-qsg-2="">Name</label>
        <input _ngcontent-qsg-2="" class="form-control ng-untouched ng-pristine
                ng-invalid" ng-reflect-name="name" name="name">
</div>
...
```

This is known as the component's *view encapsulation* behavior, and what Angular is doing is emulating a feature known as the *shadow DOM*, which allows sections of the Domain Object Model to be isolated so they have their own scope, meaning that JavaScript, styles, and templates can be applied to part of the HTML document. The reason that Angular emulates this behavior is that it is implemented by only a small number of browsers (at the time of writing, only Google Chrome and the latest versions of Safari and Opera support the shadow DOM feature), but there are two other encapsulation options, which are set using the `encapsulation` property in the `@Component` decorator.

■ **Tip** You can learn more about the shadow DOM at `http://developer.mozilla.org/en-US/docs/Web/Web_Components/Shadow_DOM`. You can see which browsers support the shadow DOM feature at `http://caniuse.com/#feat=shadowdom`.

The `encapsulation` property is assigned a value from the `ViewEncapsulation` enumeration, which is defined in the `@angular/core` module, and it defines the values described in Table 17-4.

***Table 17-4.** The ViewEncapsulation Values*

Name	Description
`Emulated`	When this value is specified, Angular emulates the shadow DOM by writing content and styles to add attributes, as described earlier. This is the default behavior if no `encapsulation` value is specified in the `@Component` decorator.
`Native`	When this value is specified, Angular uses the browser's shadow DOM feature. This will work only if the browser implements the shadow DOM or if you are using a polyfill.
`None`	When this value is specified, Angular simply adds the unmodified CSS styles to the head section of the HTML document and lets the browser figure out how to apply the styles using the normal CSS precedence rules.

The `Native` and `None` values should be used with caution. Browser support for the shadow DOM feature is so limited that using the `Native` option is sensible only if you are using a polyfill library that provides compatibility for other browsers. There are polyfill libraries available (such as the one at `http://github.com/webcomponents/webcomponentsjs`), but they produce inconsistent results and do not work with all the browsers that Angular supports.

The None option adds all the styles defined by components to the head section of the HTML document and lets the browser figure out how to apply them. This has the benefit of working in all browsers, but the results are unpredictable, and there is no isolation between the styles defined by different components.

For completeness, Listing 17-25 shows the encapsulation property being set to Emulated, which is the default value and which works in all the browsers that Angular supports, without the need for polyfills.

Listing 17-25. Setting View Encapsulation in the productForm.component.ts File

```
import { Component, Output, EventEmitter, ViewEncapsulation } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    styleUrls: ["app/productForm.component.css"],
    encapsulation: ViewEncapsulation.Emulated
})
export class ProductFormComponent {
    form: ProductFormGroup = new ProductFormGroup();
    newProduct: Product = new Product();
    formSubmitted: boolean = false;

    @Output("paNewProduct")
    newProductEvent = new EventEmitter<Product>();

    submitForm(form: any) {
        this.formSubmitted = true;
        if (form.valid) {
            this.newProductEvent.emit(this.newProduct);
            this.newProduct = new Product();
            this.form.reset();
            this.formSubmitted = false;
        }
    }
}
```

Using the Shadow DOM CSS Selectors

Using the shadow DOM means that there are boundaries that regular CSS selectors do not operate across. To help address this, here are a number of special CSS selectors that are useful when using styles that rely on the shadow DOM (even when it is being emulated), as described in Table 17-5 and demonstrated in the sections that follow.

Table 17-5. *The Shadow DOM CSS Selectors*

Name	Description
`:host`	This selector is used to match the component's host element.
`:host-context(classSelector)`	This selector is used to match the ancestors of the host element that are members of a specific class.
`/deep/ or >>>`	This selector is used by a parent component to define styles that affect the elements in child component templates. This selector should be used only when the `@Component` decorator's `encapsulation` property is set to `emulated`, as described in the "Setting View Encapsulation" section.

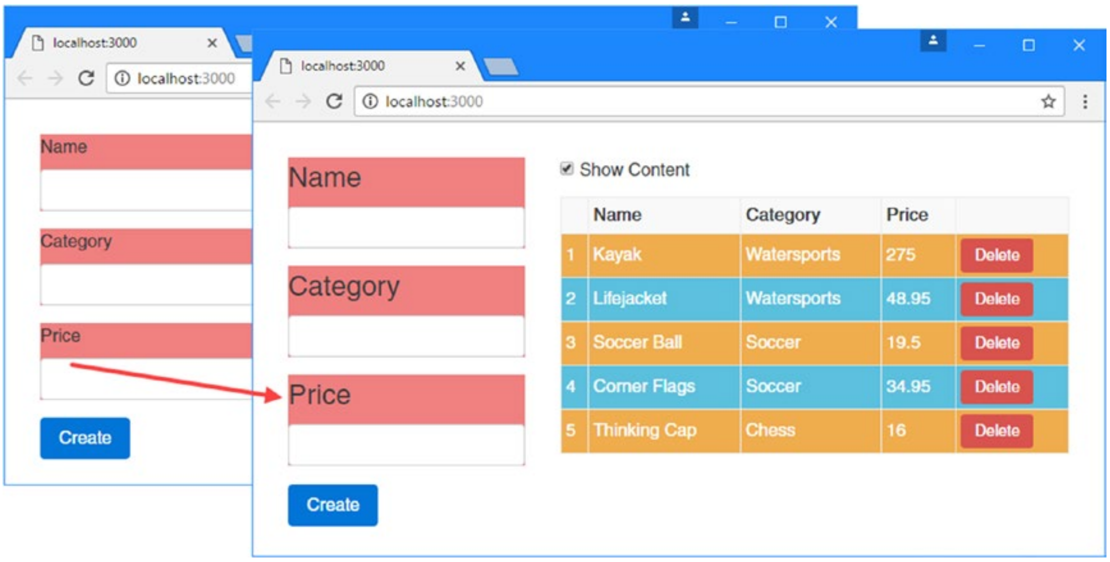
Selecting the Host Element

A component's host element appears outside of its template, which means that the selectors in its styles apply only to elements that the host element contains and not the element itself. This can be addressed by using the `:host` selector, which matches the host element. Listing 17-26 defines a style that is applied only when the mouse pointer is hovering over the host element, which is specified by combining the `:host` and `:hover` selectors.

Listing 17-26. Matching the Component's Host Element in the productForm.component.css File

```
div {
    background-color: lightcoral;
}
:host:hover {
    font-size: 25px;
}
```

When the mouse pointer is over the host element, its `font-size` property will be set to 25px, which increases the text size to 25 points for all the elements in the form, as shown in Figure 17-15.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-15. *Selecting the host element in a component style*

Selecting the Host Element's Ancestors

The `:host-context` selector is used to style elements within the component's template based on the class membership of the host element's ancestors (which are outside the template). This is a more limited selector than `:host` and cannot be used to specify anything other than a class selector, without support for matching tag types, attributes, or any other selector. Listing 17-27 shows the use of the `:host-context` selector.

Listing 17-27. Selecting the Host Element's Ancestors in the productForm.component.css File

```
div {
    background-color: lightcoral;
}
:host:hover {
    font-size: 25px;
}
:host-context(.angularApp) input {
    background-color: lightgray;
}
```

The selector in the listing sets the `background-color` property of `input` elements within the component's template to `lightgrey` only if one of the host element's ancestor elements is a member of a class called `angularApp`. In Listing 17-28, I have added the `app` element in the `index.html` file, which is the host element for the root component, to the `angularApp` class.

Listing 17-28. Adding the Root Component's Host Element to a Class in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title></title>
    <meta charset="utf-8" />
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
</head>
<body class="m-a-1">
    <app class="angularApp"></app>
</body>
</html>
```

Figure 17-16 shows the effect of the selector before and after the changes in Listing 17-28.

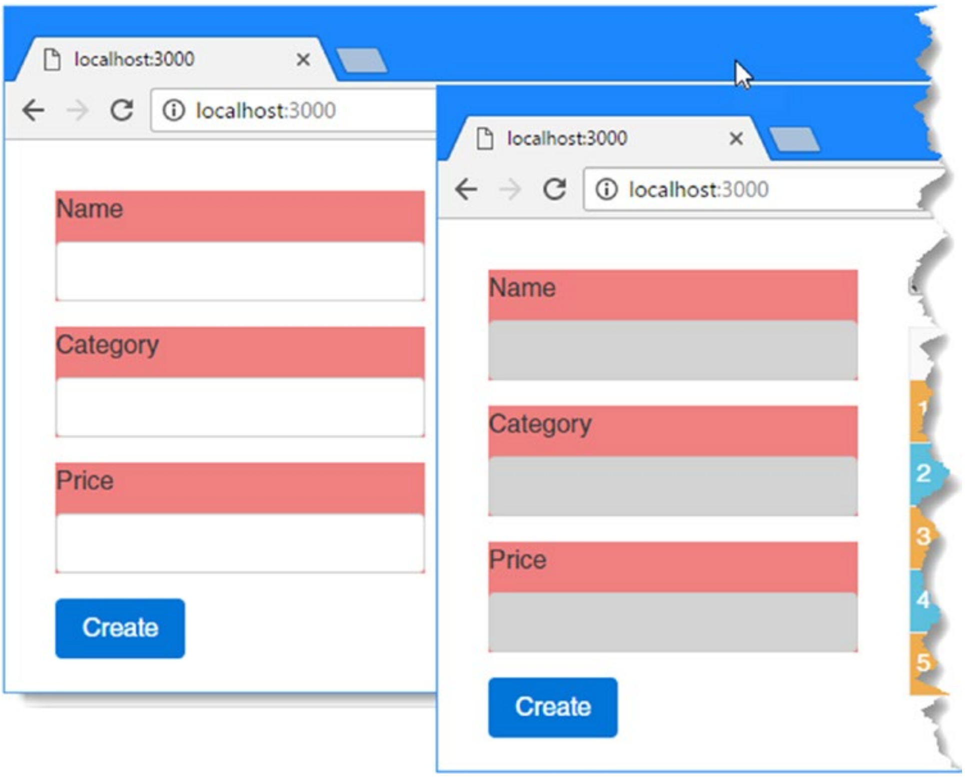


Figure 17-16. *Selecting the host element's ancestors*

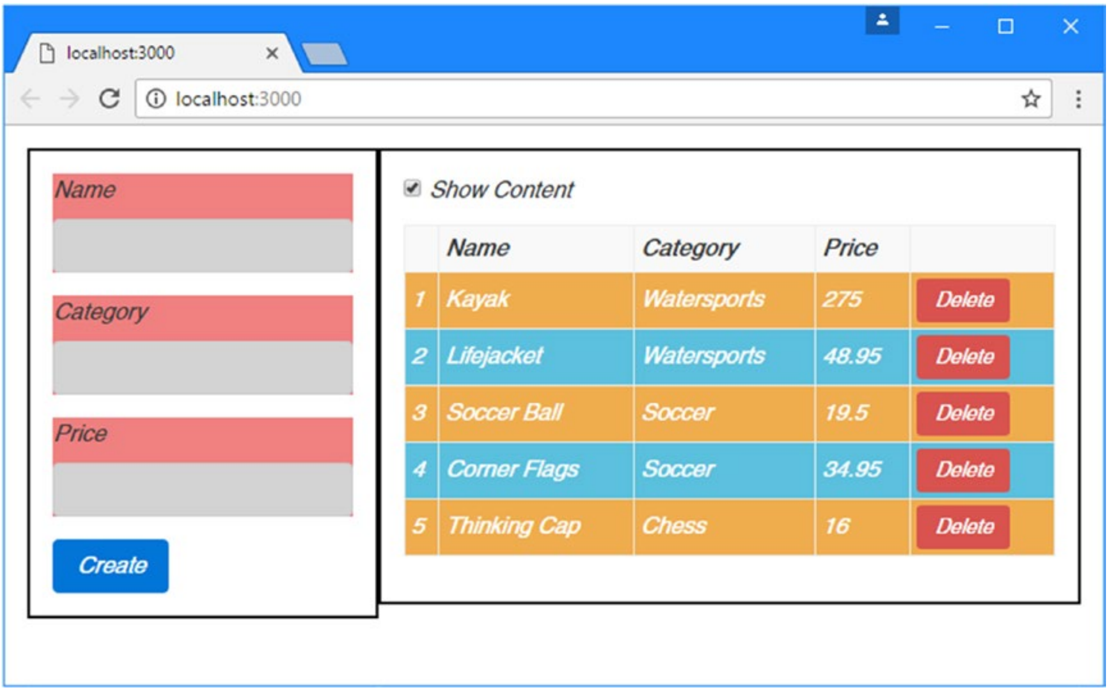
Pushing a Style into the Child Component's Template

Styles defined by a component are not automatically applied to the elements in the child component's templates. As a demonstration, Listing 17-29 adds a style to the `@Component` decorator of the root component.

Listing 17-29. Defining Styles in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html",
    styles: ["div { border: 2px black solid;  font-style:italic }"]
})
export class ProductComponent {
    model: Model = new Model();

    addProduct(p: Product) {
        this.model.saveProduct(p);
    }
}
```

The selector matches all `div` elements and applies a border and changes the font style. Figure 17-17 shows the result.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-17. *Applying regular CSS styles*

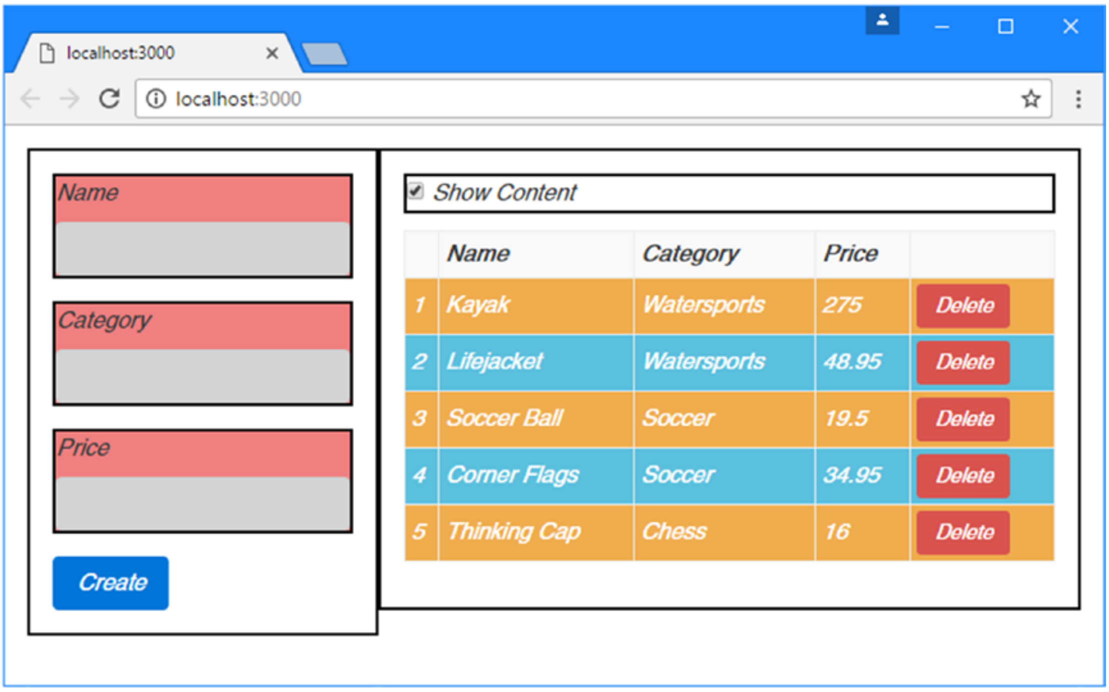
Some CSS style properties, such as `font-style`, are inherited by default, which means that setting such a property in a parent component will affect the elements in child component templates because the browser automatically applies the style.

Other properties, such as `border`, are not inherited by default, and setting such a property in a parent component has no effect on child component templates, unless the `/deep/` or `>>>` selectors are used, as shown in Listing 17-30. (These selectors are aliases of one another and have the same effect.)

Listing 17-30. Pushing a Style into Child Component Templates in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html",
    styles: ["/deep/ div { border: 2px black solid;  font-style:italic }"]
})
export class ProductComponent {
    model: Model = new Model();

    addProduct(p: Product) {
        this.model.saveProduct(p);
    }
}
```

The selector for the style uses `/deep/` to push the styles into the child components' templates, which means that all the `div` elements are given a border, as shown in Figure 17-18.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-18. *Pushing a style into child component templates*

Querying Template Content

Components can query the content of their templates to locate instances of directives or components, which are known as *view children*. These are similar to the directive content children queries that were described in Chapter 16 but with some important differences.

In Listing 17-31, I have added some code to the component that manages the table that queries for the PaCellColor directive that was created to demonstrate directive content queries. This directive is still registered in the Angular module and selects td elements, so Angular will have applied it to the cells in the table component's content.

Listing 17-31. Selecting View Children in the productTable.component.ts File

```
import { Component, Input, ViewChildren, QueryList } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { PaCellColor } from "./cellColor.directive";

@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {

    @Input("model")
    dataModel: Model;
    getProduct(key: number): Product {
        return this.dataModel.getProduct(key);
    }

    getProducts(): Product[] {
        return this.dataModel.getProducts();
    }

    deleteProduct(key: number) {
        this.dataModel.deleteProduct(key);
    }

    showTable: boolean = true;

    @ViewChildren(PaCellColor)
    viewChildren: QueryList<PaCellColor>;

    ngAfterViewInit() {
        this.viewChildren.changes.subscribe(() => {
            this.updateViewChildren();
        });
        this.updateViewChildren();
    }

    private updateViewChildren() {
        setTimeout(() => {
            this.viewChildren.forEach((child, index) => {
                child.setColor(index % 2 ? true : false);
            })
        }, 0);
    }
}
```

There are two property decorators that are used to query for directives or components defined in the template, as described in Table 17-6.

Table 17-6. *The View Children Query Property Decorators*

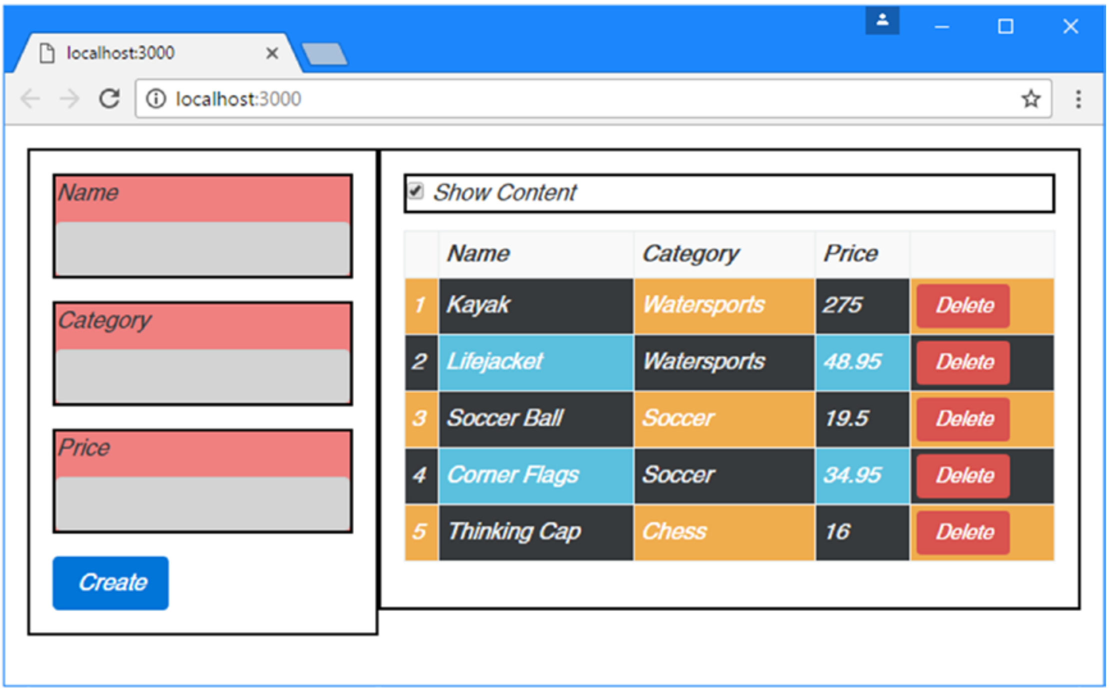
Name	Description
`@ViewChild(class)`	This decorator tells Angular to query for the first directive or component object of the specified type and assign it to the property. The class name can be replaced with a template variable. Multiple classes or templates can be separated by commas.
`@ViewChildren(class)`	This decorator assigns all the directive and component objects of the specified type to the property. Template variables can be used instead of classes, and multiple values can be separated by commas. The results are provided in a `QueryList` object, described in Chapter 16.

In the listing, I used the `@ViewChildren` decorator to select all the `PaCellColor` objects from the component's template. Aside from the different property decorators, components have two different lifecycle methods that are used to provide information about how the template has been processed, as described in Table 17-7.

Table 17-7. *The Additional Component Lifecycle Methods*

Name	Description
`ngAfterViewInit`	This method is called when the component's view has been initialized. The results of the view queries are set before this method is invoked.
`ngAfterViewChecked`	This method is called after the component's view has been checked as part of the change detection process.

In the listing, I implement the `ngAfterViewInit` method to ensure that Angular has processed the component's template and set the result of the query. Within the method I perform the initial call to the `updateViewChildren` method, which operates on the `PaCellColor` objects, and set up the function that will be called when the query results change, using the `QueryList.changes` property, as described in Chapter 16. The view children are updated within a call to the `setTimeout` function, as explained in Chapter 16. The result is that the color of every second table cell is changed, as shown in Figure 17-19.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

Figure 17-19. *Querying for view children*

■ **Tip** You may need to combine view child and content child queries if you have used the `ng-content` element. The content defined in the template is queried using the technique shown in Listing 17-31, but the project content—which replaces the `ng-content` element—is queried using the child queries described in Chapter 16.

Summary

In this chapter, I revisited the topic of components and explained how to combine all of the features of directives with the ability to provide their own templates. I explained how to structure an application to create small module components and how components can coordinate between themselves using input and output properties. I also showed you how components can define CSS styles that are applied only to their templates and no other parts of the application. In the next chapter, I introduce pipes, which are used to prepare data for display in templates.

CHAPTER 18

Using and Creating Pipes

Pipes are small fragments of code that transform data values so they can be displayed to the user in templates. Pipes allow transformation logic to be defined in self-contained classes so that it can be applied consistently throughout an application. Table 18-1 puts pipes in context.

Table 18-1. *Putting Pipes in Context*

Question	Answer
What are they?	Pipes are classes that are used to prepare data for display to the user.
Why are they useful?	Pipes allow preparation logic to be defined in a single class that can be used throughout an application, ensuing that data is presented consistently.
How are they used?	The `@Pipe` decorator is applied to a class and used to specify a name by which the pipe can be used in a template.
Are there any pitfalls or limitations?	Pipes should be simple and focused on preparing data. It can be tempting to let the functionality creep into areas that are the responsibility of other building blocks, such as directives or components.
Are there any alternatives?	You can implement data preparation code in components or directives, but that makes it harder to reuse in other parts of the application.

Table 18-2 summarizes the chapter.

Table 18-2. *Chapter Summary*

Problem	Solution	Listing
Format a data value for inclusion in a template	Use a pipe in a data binding expression	1–8
Create a custom pipe	Apply the `@Pipe` decorator to a class	9–11
Format a data value using multiple pipes	Chain the pipe names together using the bar character	12
Specify when Angular should reevaluate the output from a pipe	Use the `pure` property of the `@Pipe` decorator.	13–16
Format numerical values	Use the `number` pipe	17, 18

(*continued*)

Table 18-2. (*continued*)

Problem	Solution	Listing
Format currency values	Use the `currency` pipe	19, 20
Format percentage values	Use the `percent` pipe	21–24
Change the case of strings	Use the `uppercase` or `lowercase` pipes	25
Serialize objects into the JSON format	Use the `json` pipe	26
Select elements from an array	Use the `slice` pipe	27

Preparing the Example Project

I am going to continue working with the example project that was first created in Chapter 11 and that has been expanded and modified in the chapters since. In the final examples in the previous chapter, component styles and view children queries left the application with a strikingly garish appearance that I am going to tone down for this chapter. In Listing 18-1, I have disabled the inline component styles applied to the form elements.

Listing 18-1. Disabling CSS Styles in the productForm.component.ts File

```
import { Component, Output, EventEmitter, ViewEncapsulation } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    //styleUrls: ["app/productForm.component.css"],
    //encapsulation: ViewEncapsulation.Emulated
})
export class ProductFormComponent {
    form: ProductFormGroup = new ProductFormGroup();
    newProduct: Product = new Product();
    formSubmitted: boolean = false;

    @Output("paNewProduct")
    newProductEvent = new EventEmitter<Product>();

    submitForm(form: any) {
        this.formSubmitted = true;
        if (form.valid) {
            this.newProductEvent.emit(this.newProduct);
            this.newProduct = new Product();
            this.form.reset();
            this.formSubmitted = false;
        }
    }
}
```

To disable the checkerboard coloring of the table cells, I changed the selector for the PaCellColor directive so that it matches an attribute that is not currently applied to the HTML elements, as shown in Listing 18-2.

Listing 18-2. Changing the Selector in the cellColor.directive.ts File

```
import { Directive, HostBinding } from "@angular/core";

@Directive({
    selector: "td[paApplyColor]"
})
export class PaCellColor {

    @HostBinding("class")
    bgClass: string = "";

    setColor(dark: Boolean) {
        this.bgClass = dark ? "bg-inverse" : "";
    }
}
```

Listing 18-3 disables the deep styles defined by the root component.

Listing 18-3. Disabling CSS Styles in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html",
    //styles: ["/deep/ div { border: 2px black solid;  font-style:italic }"]
})
export class ProductComponent {
    model: Model = new Model();

    addProduct(p: Product) {
        this.model.saveProduct(p);
    }
}
```

The next change for the existing code in the example application is to simplify the ProductTableComponent class to remove methods and properties that are no longer required, as shown in Listing 18-4.

Listing 18-4. Simplifying the Code in the productTable.component.ts File

```
import { Component, Input, ViewChildren, QueryList } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
```

```
@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {

    @Input("model")
    dataModel: Model;

    getProduct(key: number): Product {
        return this.dataModel.getProduct(key);
    }

    getProducts(): Product[] {
        return this.dataModel.getProducts();
    }

    deleteProduct(key: number) {
        this.dataModel.deleteProduct(key);
    }
}
```

Finally, I have removed one of the component elements from the root component's template to disable the checkbox that shows and hides the table, as shown in Listing 18-5.

Listing 18-5. Simplifying the Elements in the template.html File

```
<div class="col-xs-4 p-a-1">
    <paProductForm (paNewProduct)="addProduct($event)"></paProductForm>
</div>
<div class="col-xs-8 p-a-1">
    <paProductTable [model]="model"></paProductTable>
</div>
```

Installing the Internationalization Polyfill

Some of the built-in pipes that Angular provides rely on the Internationalization API, which provides location-sensitive string comparisons and formatting for numbers, dates, and times. This API is supported by most recent browsers, but a polyfill library is required for some of the browsers that Angular supports, including older versions of Internet Explorer. At the time of writing, the most complete polyfill for the Internationalization API is `Intl.js`, which I have added to the set of package dependencies in Listing 18-6.

Listing 18-6. Adding a Package to the package.json File

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/forms": "2.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4",
    "intl": "1.2.4"
  },

  "devDependencies": {
      "lite-server": "2.2.2",
      "typescript": "2.0.2",
      "typings": "1.3.2",
      "concurrently": "2.2.0"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

Run the following command in the example folder to download and install the new package:

```
npm install
```

In Listing 18-7, I have added a script element to the main HTML document to load the polyfill library.

Listing 18-7. Adding a Script Element in the index.html File

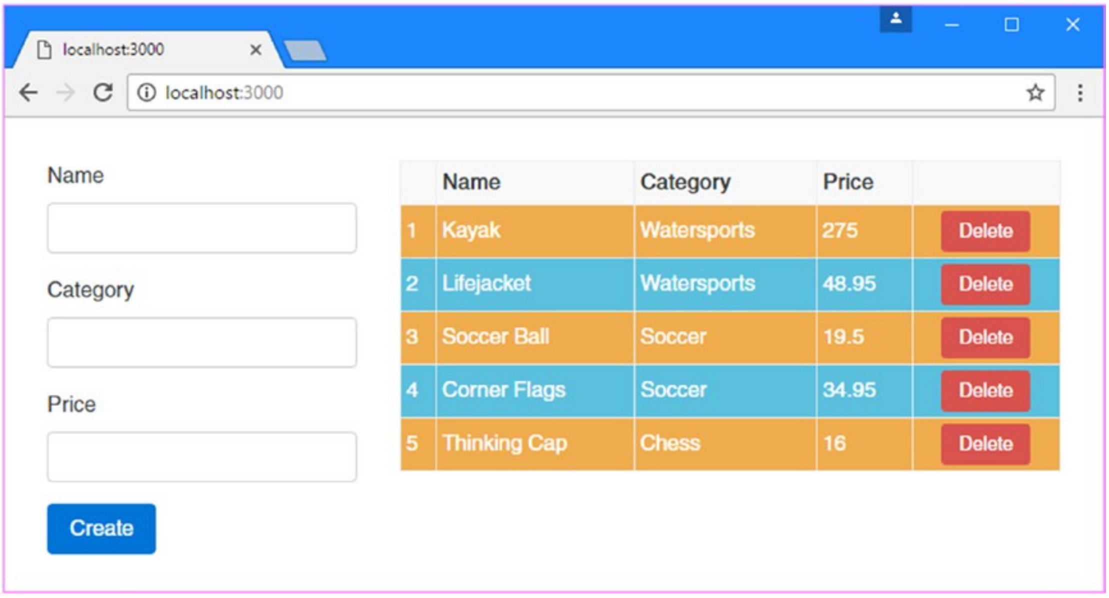
```
<!DOCTYPE html>
<html>
<head>
    <title></title>
    <meta charset="utf-8" />
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/intl/dist/Intl.complete.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
</head>
<body class="m-a-1">
    <app class="angularApp"></app>
</body>
</html>
```

The `Intl.complete.js` file that the `script` element adds in Listing 18-7 includes all of the locale information available in the `Intl.js` library, which is convenient but adds a relatively large file that the browser has to download. See the library home page (`github.com/andyearnshaw/Intl.js`) for instructions about being more selective about the locale data that is loaded.

Run the following command in the `example` folder to start the TypeScript compiler and the development HTTP server:

```
npm start
```

The browser will open a new tab or window and display the content shown in Figure 18-1.



	Name	Category	Price	
1	Kayak	Watersports	275	Delete
2	Lifejacket	Watersports	48.95	Delete
3	Soccer Ball	Soccer	19.5	Delete
4	Corner Flags	Soccer	34.95	Delete
5	Thinking Cap	Chess	16	Delete

***Figure 18-1.** Running the example application*

Understanding Pipes

Pipes are classes that transform data before it is received by a directive or component. That may not sound like an important job, but pipes can be used to perform some of the most commonly required development tasks easily and—most importantly—consistently.

As a quick example to demonstrate how pipes are used, Listing 18-8 applies one of the built-in pipes to transform the values displayed in the `Price` column of the table displayed by the application.

Listing 18-8. Using a Pipe in the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">{{item.price | currency:"USD":true }}</td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

The syntax for applying a pipe is similar to the style used by command prompts, where a value is "piped" for transformation using the vertical bar symbol (the `|` character). Figure 18-2 shows the structure of the data binding that contains the pipe.

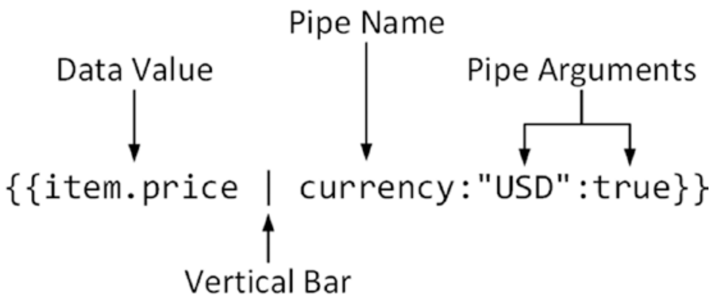
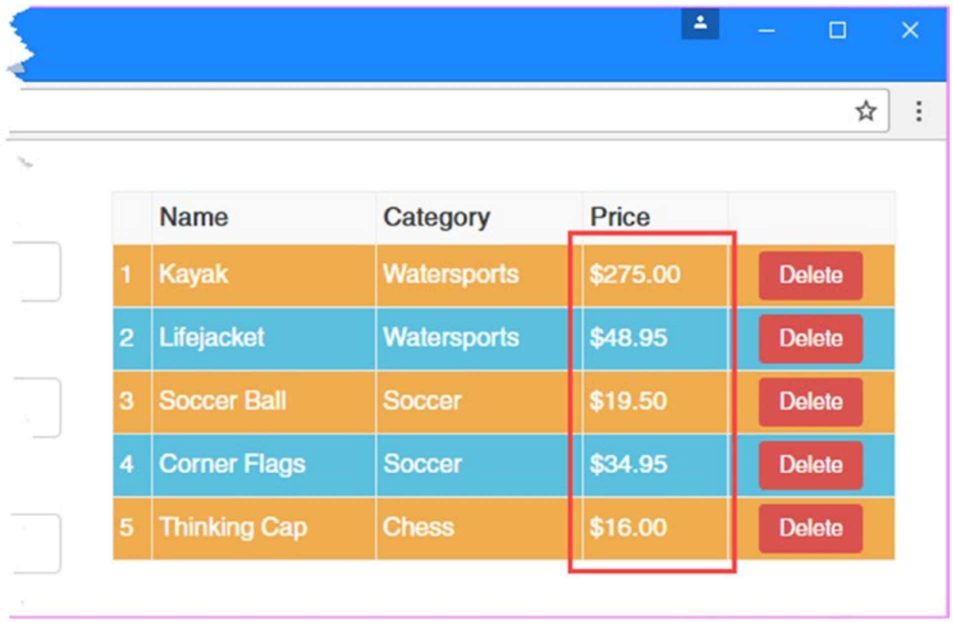


Figure 18-2. *The anatomy of data binding with a pipe*

The name of the pipe used in Listing 18-8 is `currency`, and it formats numbers into currency values. Arguments to the pipe are separated by colons (the `:` character). The first pipe argument specifies the currency code that should be used, which is `USD` in this case, representing US dollars. The second pipe argument, which is `true`, specifies whether the currency symbol, rather than its code, should be displayed.

When Angular processes the expression, it obtains the data value and passes it to the pipe for transformation. The result produced by the pipe is then used as the expression result for the data binding. In the example, the bindings are string interpolations, and the results can be seen in Figure 18-3.



	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete
2	Lifejacket	Watersports	$48.95	Delete
3	Soccer Ball	Soccer	$19.50	Delete
4	Corner Flags	Soccer	$34.95	Delete
5	Thinking Cap	Chess	$16.00	Delete

Figure 18-3. *The effect of using the currency pipe*

Creating a Custom Pipe

I will return to the built-in pipes that Angular provides later in the chapter, but the best way to understand how pipes work and what they are capable of is to create a custom pipe class. I added a file called `addTax.pipe.ts` in the app folder and defined the class shown in Listing 18-9.

Listing 18-9. The Contents of the addTax.pipe.ts File in the app Folder

```
import { Pipe } from "@angular/core";

@Pipe({
    name: "addTax"
})
export class PaAddTaxPipe {

    defaultRate: number = 10;

    transform(value: any, rate?: any): number {
        let valueNumber = Number.parseFloat(value);
        let rateNumber = rate == undefined ?
            this.defaultRate : Number.parseInt(rate);
        return valueNumber + (valueNumber * (rateNumber / 100));
    }
}
```

Pipes are classes to which the `@Pipe` decorator has been applied and that implement a method called `transform`. (Pipes can also implement an interface called `PipeTransform`, but this is optional, and I don't use it in this book.) The `@Pipe` decorator defines two properties, which are used to configure pipes, as described in Table 18-3.

Table 18-3. *The @Pipe Decorator Properties*

Name	Description
`name`	This property specifies the name by which the pipe is applied in templates.
`pure`	When `true`, this pipe is reevaluated only when its input value or its arguments are changed. This is the default value. See the "Creating Impure Pipes" section for details.

The example pipe is defined in a class called `PaAddTaxPipe`, and its decorator `name` property specifies that the pipe will be applied using `addTax` in templates.

The `transform` method must accept at least one argument, which Angular uses to provide the data value that the pipe operates on. The pipe does its work in the transform method, and its result is used by Angular in the binding expression. In this example, the pipe accepts a number value, and its result is the received value plus sales tax.

The transform method can also define additional argument that are used to configure the pipe. In the example, the optional `rate` argument can be used to specify the sales tax rate, which defaults to 10 percent.

■ **Caution** Be careful when dealing with the arguments received by the `transform` method and make sure that you parse or convert them to the types you need. The TypeScript type annotations are not enforced at runtime, and Angular will pass you whatever data values it is working with.

Registering a Custom Pipe

Pipes are registered using the `declarations` property of the Angular module, as shown in Listing 18-10.

Listing 18-10. Registering a Custom Pipe in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaToggleView } from "./toggleView.component";
import { PaAddTaxPipe } from "./addTax.pipe";
```

```
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaToggleView, PaAddTaxPipe],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

Applying a Custom Pipe

Once a custom pipe has been registered, it can be used in data binding expressions. In Listing 18-11, I have applied the pipe to the price value in the tables and added a select element that allows the tax rate to be specified.

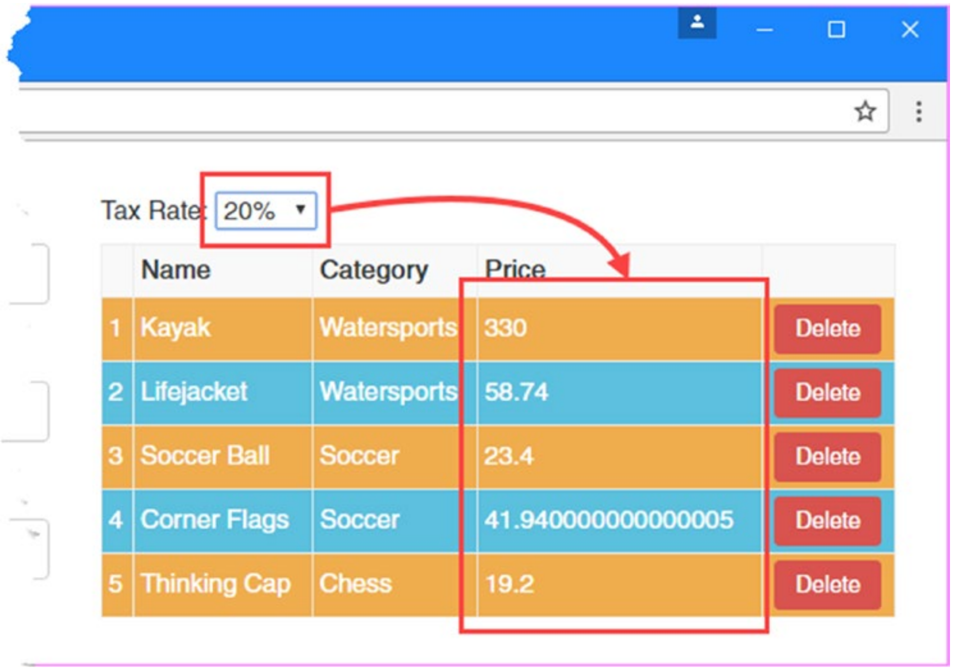
Listing 18-11. Applying the Custom Pipe in the productTable.component.html File

```
<div>
    <label>Tax Rate:</label>
    <select [value]="taxRate || 0" (change)="taxRate=$event.target.value">
        <option value="0">None</option>
        <option value="10">10%</option>
        <option value="20">20%</option>
        <option value="50">50%</option>
    </select>
</div>

<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | addTax:(taxRate || 0) }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

Just for some variety, I have defined the tax rate entirely within the template. The select element has a binding that sets its value property to a component variable called taxRate or defaults to 0 if the property has not been defined. The event binding handles the change event and sets the value of the taxRate property. You cannot specify a fallback value when using the ngModel directive, which is why I have split up the bindings.

In applying the custom pipe, I have used the vertical bar character, followed by the value specified by the `name` property in the pipe's decorator. The name of the pipe is followed by a colon, which is followed by an expression that is evaluated to provide the pipe with its argument. In this case, the `taxRate` property will be used if it has been defined, with a fallback value of zero.

Pipes are part of the dynamic nature of Angular data bindings, and the pipe's `transform` method will be called to get an updated value if the underlying data value changes or if the expression used for the arguments changes. The dynamic nature of pipes can be seen by changing the value displayed by the select element, which will define or change the `taxRate` property, which will, in turn, update the amount added to the `price` property by the custom pipe, as shown in Figure 18-4.



Tax Rate: 20%

	Name	Category	Price	
1	Kayak	Watersports	330	Delete
2	Lifejacket	Watersports	58.74	Delete
3	Soccer Ball	Soccer	23.4	Delete
4	Corner Flags	Soccer	41.940000000000005	Delete
5	Thinking Cap	Chess	19.2	Delete

Figure 18-4. *Using a custom pipe*

Combining Pipes

The `addTax` pipe is applying the tax rate, but the fractional amounts that are produced by the calculation are unsightly—and unhelpful, since few tax authorities insist on accuracy to 15 fractional digits.

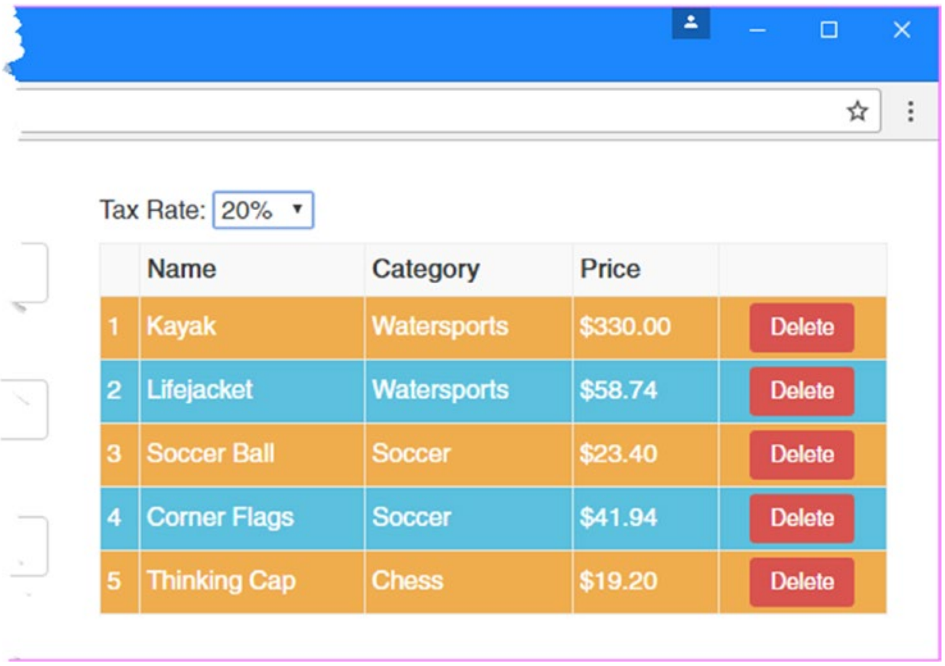
I could fix this by adding support to the custom pipe to format the number values as currencies, but that would require duplicating the functionality of the built-in `currency` pipe that I used earlier in the chapter. A better approach is to combine the functionality of both pipes so that the output from the custom `addTax` pipe is fed into the built-in `currency` pipe, which is then used to produce the value displayed to the user.

Pipes are chained together in this way using the vertical bar character, and the names of the pipes are specified in the order that data should flow, as shown in Listing 18-12.

Listing 18-12. Combining Pipes in the productTable.component.html File

```
...
<td style="vertical-align:middle">
    {{item.price | addTax:(taxRate || 0) | currency:"USD":true  }}
</td>
...
```

The value of the `item.price` property is passed to the `addTax` pipe, which adds the sales tax, and then to the `currency` pipe, which formats the number value into a currency amount, as shown in Figure 18-5.



Tax Rate: 20%

	Name	Category	Price	
1	Kayak	Watersports	$330.00	Delete
2	Lifejacket	Watersports	$58.74	Delete
3	Soccer Ball	Soccer	$23.40	Delete
4	Corner Flags	Soccer	$41.94	Delete
5	Thinking Cap	Chess	$19.20	Delete

Figure 18-5. *Combining the functionality of pipes*

Creating Impure Pipes

The `pure` decorator property is used to tell Angular when to call the pipe's `transform` method. The default value for the `pure` property is `true`, which tells Angular that the pipe's transform method will generate a new value only if the input data value—the data value before the vertical bar character in the template—changes or when one or more of its arguments is modified. This is known as a *pure* pipe because it has no independent internal state and all its dependencies can be managed using the Angular change detection process.

Setting the `pure` decorator property to `false` creates an *impure pipe* and tells Angular that the pipe has its own state data or that it depends on data that may not be picked up in the change detection process when there is a new value.

When Angular performs its change detection process, it treats impure pipes as sources of data values in their own right and invokes the `transform` methods even when there has been no data value or argument changes.

The most common need for impure pipes is when they process the contents of arrays and the elements in the array change. As you saw in Chapter 16, Angular doesn't automatically detect changes that occur within arrays and won't invoke a pure pipe's transform method when an array element is added, edited, or deleted because it just sees the same array object being used as the input data value.

■ **Caution** Impure pipes should be used sparingly because Angular has to call the `transform` method whenever there is any data change or user interaction in the application, just in case it might result in a different result from the `pipe`. If you do create an impure pipe, then keep it as simple as possible. Performing complex operations, such as sorting an array, can devastate the performance of an Angular application.

As a demonstration, I added a file called `categoryFilter.pipe.ts` in the app folder and used it to define the pipe shown in Listing 18-13.

Listing 18-13. The Contents of the categoryFilter.pipe.ts File in the app Folder

```
import { Pipe } from "@angular/core";
import { Product } from "./product.model";

@Pipe({
    name: "filter",
    pure: true
})
export class PaCategoryFilterPipe {

    transform(products: Product[], category: string): Product[] {
        return category == undefined ?
            products : products.filter(p => p.category == category);
    }
}
```

This is a pure filter that receives an array of `Product` objects and returns only the ones whose `category` property matches the `category` argument. Listing 18-14 shows the new pipe registered in the Angular module.

Listing 18-14. Registering a Pipe in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaToggleView } from "./toggleView.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaToggleView, PaAddTaxPipe,
        PaCategoryFilterPipe],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

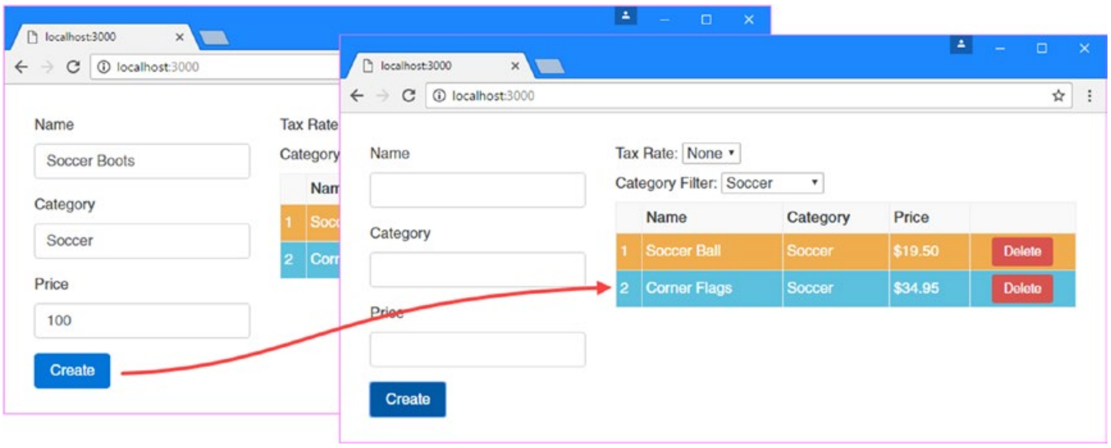
Listing 18-15 shows the application of the new pipe to the binding expression that targets the ngFor directive as well as a new select element that allows the filter category to be selected.

Listing 18-15. Applying a Pipe in the productTable.component.html File

```
<div>
    <label>Tax Rate:</label>
    <select [value]="taxRate || 0" (change)="taxRate=$event.target.value">
        <option value="0">None</option>
        <option value="10">10%</option>
        <option value="20">20%</option>
        <option value="50">50%</option>
    </select>
</div>

<div>
    <label>Category Filter:</label>
    <select [(ngModel)]="categoryFilter">
        <option>Watersports</option>
        <option>Soccer</option>
        <option>Chess</option>
    </select>
</div>

<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts() | filter:categoryFilter;
            let i = index; let odd = odd; let even = even"
            [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | addTax:(taxRate || 0) | currency:"USD":true  }}
        </td>
```

```
            <td class="text-xs-center">
                <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                    Delete
                </button>
            </td>
        </tr>
</table>
```

To see the problem, use the `select` element to filter the products in the table so that only those in the `Soccer` category are shown. Then use the form elements to create a new product in that category. Clicking the Create button will add the product to the data model, but the new product won't be shown in the table, as illustrated in Figure 18-6.



	Name	Category	Price	
1	Soccer Ball	Soccer	$19.50	Delete
2	Corner Flags	Soccer	$34.95	Delete

Figure 18-6. *A problem caused by a pure pipe*

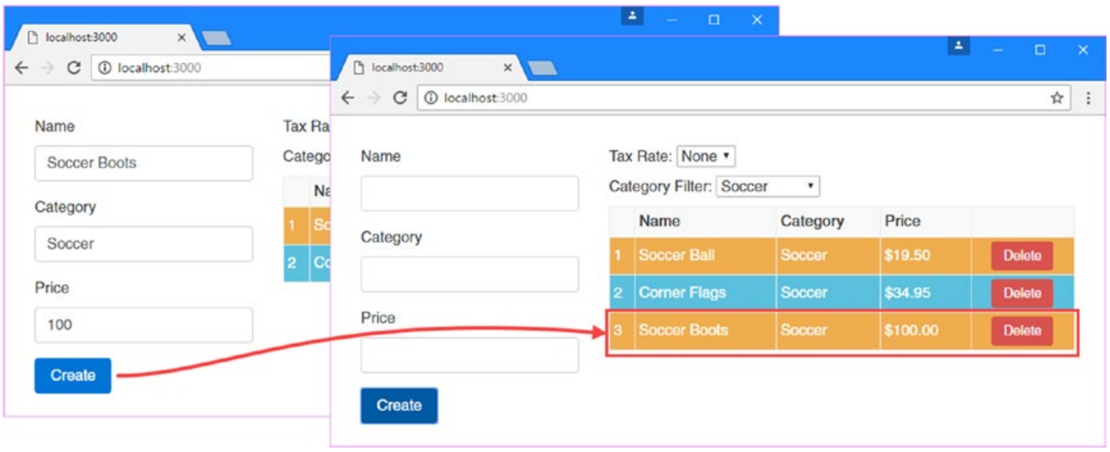
The table isn't updated because, as far as Angular is concerned, none of the inputs to the `filter` pipe has changed. The component's `getProducts` method returns the same array object, and the `categoryFilter` property is still set to `Soccer`. The fact that there is a new object inside the array returned by the `getProducts` method isn't recognized by Angular.

The solution is to set the pipe's `pure` property to `false`, as shown in Listing 18-16.

Listing 18-16. Marking a Pipe as Impure in the categoryFilter.pipe.ts File

```
import { Pipe } from "@angular/core";
import { Product } from "./product.model";

@Pipe({
    name: "filter",
    pure: false
})
export class PaCategoryFilterPipe {

    transform(products: Product[], category: string): Product[] {
        return category == undefined ?
            products : products.filter(p => p.category == category);
    }
}
```

If you repeat the test, you will see that the new product is now correctly displayed in the table, as shown in Figure 18-7.



	Name	Category	Price	
1	Soccer Ball	Soccer	$19.50	Delete
2	Corner Flags	Soccer	$34.95	Delete
3	Soccer Boots	Soccer	$100.00	Delete

Figure 18-7. *Using an impure pipe*

Using the Built-in Pipes

Angular includes a set of built-in pipes that perform commonly required tasks. These pipes are described in Table 18-4 and demonstrated in the sections that follow.

Table 18-4. *The Built-in Pipes*

Name	Description
`number`	This pipe performs location-sensitive formatting of number values. See the “Formatting Numbers” section for details.
`currency`	This pipe performs location-sensitive formatting of currency amounts. See the “Formatting Currency Values” section for details.
`percent`	This pipe performs location-sensitive formatting of percentage values. See the “Formatting Percentages” section for details.
`date`	This pipe performs location-sensitive formatting of dates. See the “Formatting Dates” section for details.
`uppercase`	This pipe transforms all the characters in a string to uppercase. See the “Changing String Case” section for details.
`lowercase`	This pipe transforms all the characters in a string to lowercase. See the “Changing String Case” section for details.
`json`	This pipe transforms an object into a JSON string. See the “Serializing Data as JSON” section for details.
`slice`	This pipe selects items from an array or characters from a string, as described in the “Slicing Data Arrays” section.
`async`	This pipe subscribes to an observable or a promise and displays the most recent value it produces. This pipe is demonstrated in Chapter 23.

■ **Tip** Angular also includes i18nPlural and i18nSelect pipes, which are used to localize content. I don't cover the localization support in Angular in this book because it not ready for production use. See `http://angular.io/docs/ts/latest/cookbook/i18n.html` for details.

Formatting Numbers

The `number` pipe formats `number` values using location-sensitive rules, which requires the Internationalization API for which I added a polyfill at the start of the chapter. Listing 18-17 shows the use of the `number` pipe, along with the argument that specifies the formatting that will be used. I have removed the custom pipes and the associated `select` elements from the template.

Listing 18-17. Using the number Pipe in the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">{{item.price | number:"3.2-2" }}</td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

The `number` pipe accepts a single argument that specifies the number of digits that are included in the formatted result. The argument is in the following format (note the period and hyphen that separate the values and that the entire argument is quoted as a string):

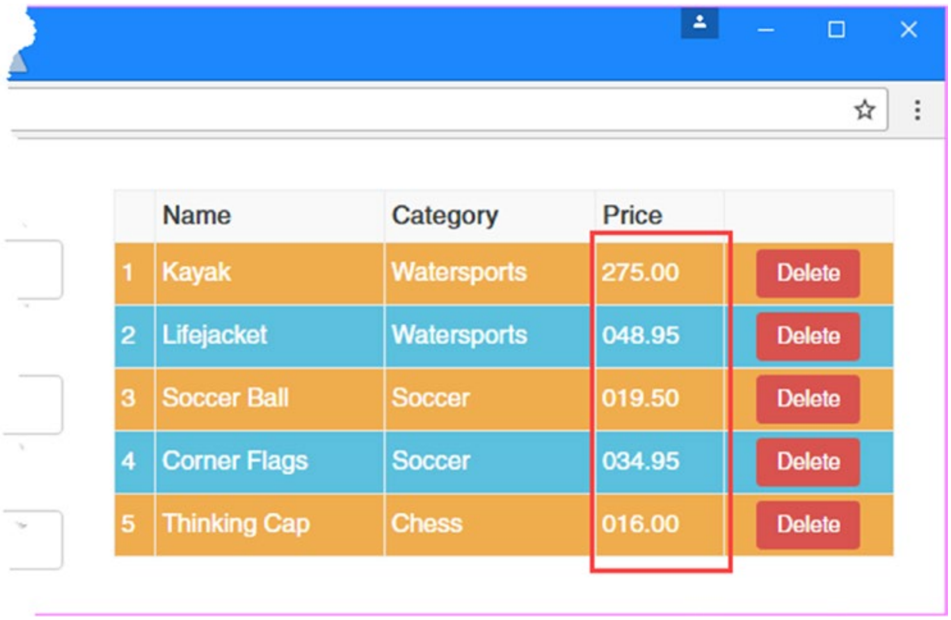
```
"<minIntegerDigits>.<minFactionDigits>-<maxFractionDigits>"
```

Each element of the formatting argument is described in Table 18-5.

Table 18-5. *The Elements of the number Pipe Argument*

Name	Description
`minIntegerDigits`	This value specifies the minimum number of digits. The default value is 1.
`minFractionDigits`	This value specifies the minimum number of factional digits. The default value is 0.
`maxFractionDigits`	This value specifies the maximum number of fractional digits. The default value is 3.

The argument used in the listing is "3.2-2", which specifies that at least three digits should be used to display the integer portion of the number and that two fractional digits should always be used. This produces the result shown in Figure 18-8.



	Name	Category	Price	
1	Kayak	Watersports	275.00	Delete
2	Lifejacket	Watersports	048.95	Delete
3	Soccer Ball	Soccer	019.50	Delete
4	Corner Flags	Soccer	034.95	Delete
5	Thinking Cap	Chess	016.00	Delete

Figure 18-8. *Formatting number values*

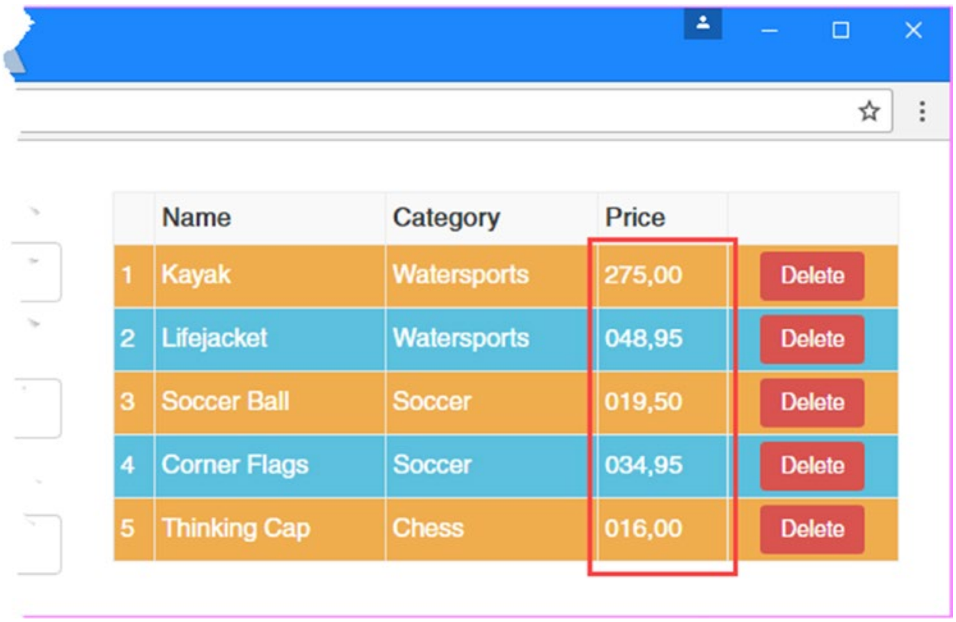
The number pipe is location sensitive, which means that the same format argument will produce differently formatted results based on the user's locale setting. Angular applications default to the en-US locale by default and require it to be changed explicitly with an entry in the root module, as shown in Listing 18-18.

Listing 18-18. Setting the Locale in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaToggleView } from "./toggleView.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { LOCALE_ID } from "@angular/core";
```

```
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaToggleView, PaAddTaxPipe,
        PaCategoryFilterPipe],
    providers: [{ provide: LOCALE_ID, useValue: "fr-FR" }],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

Setting the locale relies on features that I describe in Chapter 20, but the effect is to change to the fr-FR locale, which represents the French language as it is used in France, which changes the format of the number values, as shown in Figure 18-9.



	Name	Category	Price	
1	Kayak	Watersports	275,00	Delete
2	Lifejacket	Watersports	048,95	Delete
3	Soccer Ball	Soccer	019,50	Delete
4	Corner Flags	Soccer	034,95	Delete
5	Thinking Cap	Chess	016,00	Delete

***Figure 18-9.** Locale-sensitive formatting*

Formatting Currency Values

The currency pipe formats number values that represent monetary amounts. Listing 18-8 used this pipe to introduce the topic, and Listing 18-19 shows another application of the same pipe but with the addition of number format specifiers.

Listing 18-19. Using the currency Pipe in the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true:"2.2-2" }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

The currency pipe can be configured using three arguments, which are described in Table 18-6.

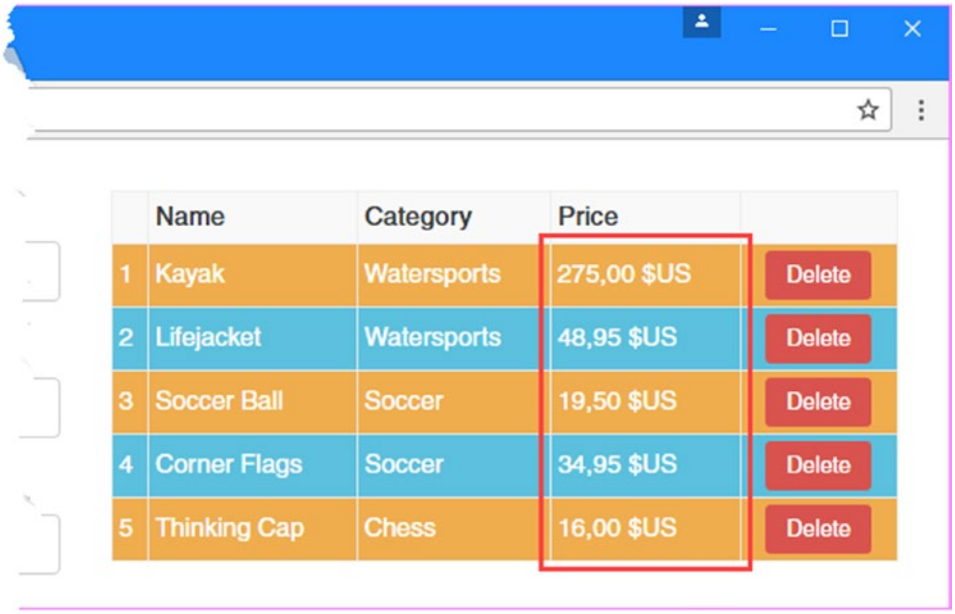
Table 18-6. *The Types of Web Forms Code Nuggets*

Name	Description
currencyCode	This string argument specifies the currency using an ISO 4217 code. The default value is USD if this argument is omitted. You can see a list of currency codes at http://en.wikipedia.org/wiki/ISO_4217.
symbolDisplay	When true, this Boolean argument specifies that the currency symbol should be displayed. When false, the ISO 4217 currency code will be used instead. The default value is false.
digitInfo	This string argument specifies the formatting for the number, using the same formatting instructions supported by the number pipe, as described in the “Formatting Numbers” section.

The arguments specified in Listing 18-19 tell the pipe to use the US dollar as the currency (which has the ISO code USD), to display the symbol rather than the code in the output, and to format the number so that it has at least two integer digits and exactly two fraction digits.

This pipe relies on the Internationalization API to get details of the currency—especially its symbol—but doesn’t select the currency automatically to reflect the user’s locale setting.

This means that the formatting of the number and the position of the currency symbol are affected by the application’s locale setting, regardless of the currency that has been specified by the pipe. The example application is still configured to use the fr-FR locale, which produces the results shown in Figure 18-10.



	Name	Category	Price	
1	Kayak	Watersports	275,00 $US	Delete
2	Lifejacket	Watersports	48,95 $US	Delete
3	Soccer Ball	Soccer	19,50 $US	Delete
4	Corner Flags	Soccer	34,95 $US	Delete
5	Thinking Cap	Chess	16,00 $US	Delete

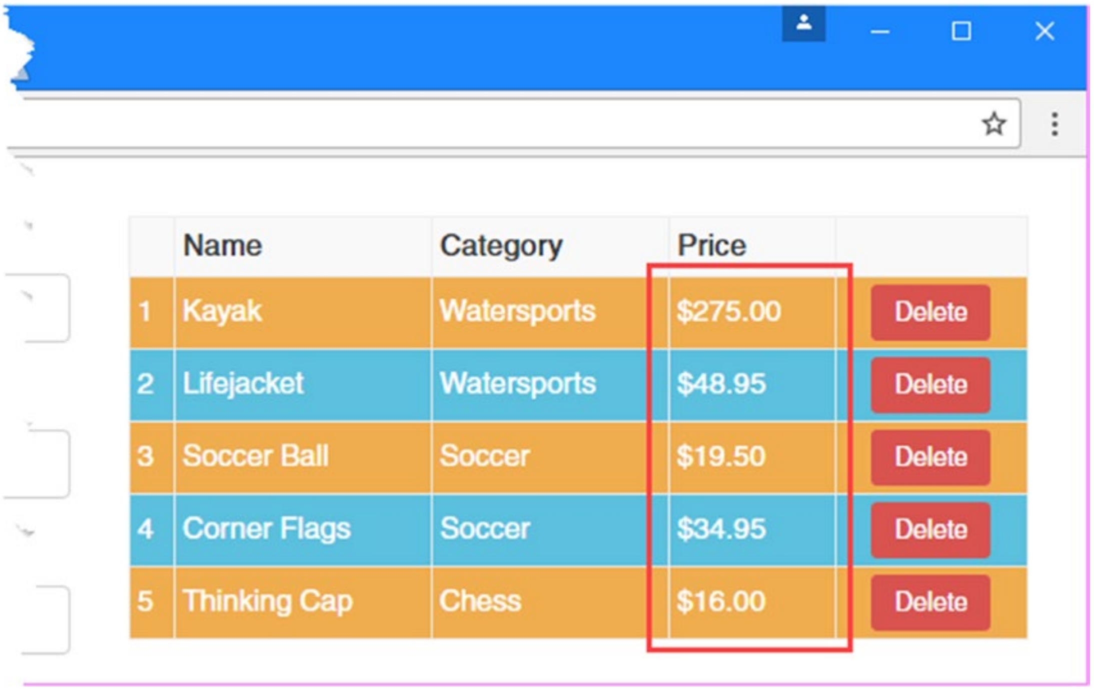
Figure 18-10. *Location-sensitive currency formatting*

To revert to the default locale, Listing 18-20 removes the `fr-FR` setting from the application's root module.

Listing 18-20. Removing the locale setting in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaToggleView } from "./toggleView.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
//import { LOCALE_ID } from "@angular/core";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaToggleView, PaAddTaxPipe,
        PaCategoryFilterPipe],
    //providers: [{ provide: LOCALE_ID, useValue: "fr-FR" }],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

Figure 18-11 shows the result.



	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete
2	Lifejacket	Watersports	$48.95	Delete
3	Soccer Ball	Soccer	$19.50	Delete
4	Corner Flags	Soccer	$34.95	Delete
5	Thinking Cap	Chess	$16.00	Delete

Figure 18-11. *Formatting currency values*

Formatting Percentages

The percent pipe formats number values as percentages, where values between 0 and 1 are formatted to represent 0 to 100 percent. This pipe has an optional argument that is used to specify the number formatting options, using the same format as the number pipe. Listing 18-21 reintroduces the custom sales tax filter and populates the associated select element with option elements whose content is formatted with the percent filter.

Listing 18-21. Formatting Percentage Values in the productTable.component.html File

```
<div>
    <label>Tax Rate:</label>
    <select [value]="taxRate || 0" (change)="taxRate=$event.target.value">
        <option value="0">None</option>
        <option value="10">{{ 0.1 | percent }}</option>
        <option value="20">{{ 0.2 | percent }}</option>
        <option value="50">{{ 0.5 | percent }}</option>
        <option value="150">{{ 1.5 | percent }}</option>
    </select>
</div>

<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | addTax:(taxRate || 0) | currency:"USD":true:"2.2-2" }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

Values that are greater than 1 are formatted into percentages greater than 100 percent. You can see this in the last item shown in Figure 18-12, where the value 1.5 produces a formatted value of 150 percent.

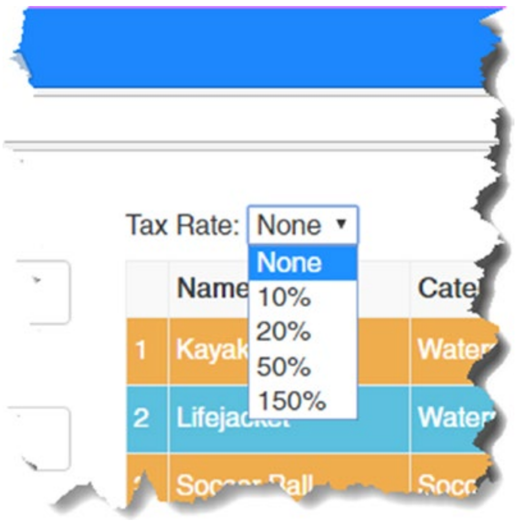


Figure 18-12. Formatting percentage values

The formatting of percentage values is location-sensitive, although the differences between locales can be subtle. As an example, while the en-US locale produces a result such as 10 percent, with the numerals and the percent sign next to one another, many locales, including fr-FR, will produce a result such as 10%, with a space between the numerals and the percent sign.

Formatting Dates

The date pipe performs location-sensitive formatting of dates. Dates can be expressed using JavaScript Date objects, as a number value representing milliseconds since the beginning of 1970 or as a well-formatted string. Listing 18-22 adds three properties to the ProductTableComponent class, each of which encodes a date in one of the formats supported by the date pipe.

Listing 18-22. Defining Dates in the productTable.component.ts File

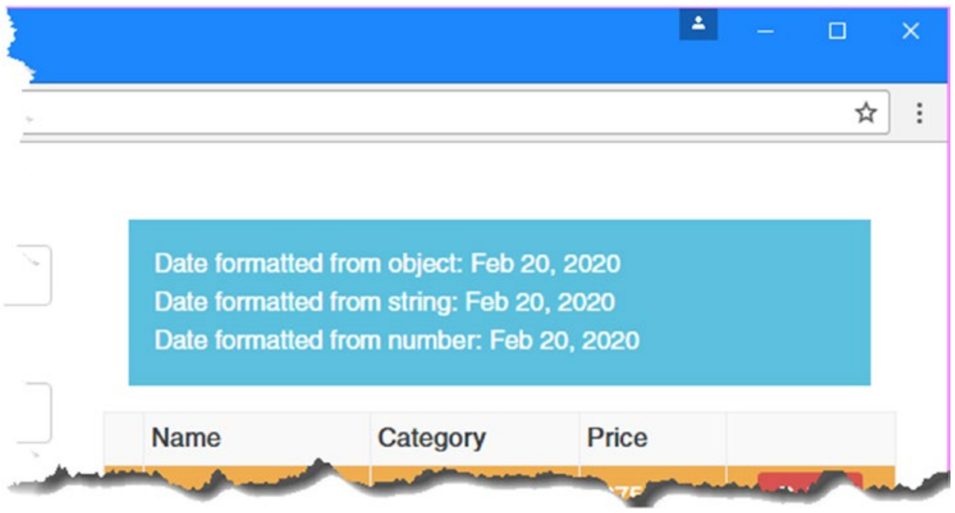
```
import { Component, Input, ViewChildren, QueryList } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";

@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {

    @Input("model")
    dataModel: Model;

    getProduct(key: number): Product {
        return this.dataModel.getProduct(key);
    }

    getProducts(): Product[] {
        return this.dataModel.getProducts();
    }

    deleteProduct(key: number) {
        this.dataModel.deleteProduct(key);
    }

    dateObject: Date = new Date(2020, 1, 20);
    dateString: string = "2020-02-20T00:00:00.000Z";
    dateNumber: number = 1582156800000;
}
```

All three properties describe the same date, which is February 20, 2020, with no time specified. In Listing 18-23, I have used the date pipe to format all three properties.

Listing 18-23. Formatting Dates in the productTable.component.html File

```
<div class="bg-info m-a-1 p-a-1">
    <div>Date formatted from object: {{ dateObject | date }}</div>
    <div>Date formatted from string: {{ dateString | date }}</div>
    <div>Date formatted from number: {{ dateNumber | date }}</div>
</div>

<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | addTax:(taxRate || 0) | currency:"USD":true:"2.2-2" }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

The pipe works out which data type it is working with, parses the value to get a date, and then formats it, as shown in Figure 18-13.



Date formatted from object: Feb 20, 2020
Date formatted from string: Feb 20, 2020
Date formatted from number: Feb 20, 2020

Name	Category	Price

Figure 18-13. *Formatting dates*

The date pipe accepts a single argument, which is used to specify the date format that should be used. Individual date components can be selected for the output using the symbols described in Table 18-7.

Table 18-7. *The Date Pipe Format Symbols*

Name	Description
`y, yy`	These symbols select the year.
`M, MMM, MMMM`	These symbols select the month.
`d, dd`	These symbols select the day (as a number).
`E, EE, EEEE`	These symbols select the day (as a name).
`j, jj`	These symbols select the hour.
`h, hh, H, HH`	These symbols select the hour in 12- and 24-hour forms.
`m, mm`	These symbols select the minutes.
`s, ss`	These symbols select the seconds.
`Z`	This symbol selects the time zone.

The symbols in Table 18-7 provide access to the date components in differing levels of brevity so that M will return 2 if the month is February, MM will return 02, MMM will return Feb, and MMMM will return February, assuming that you are using the en-US locale. The date pipe also supports predefined date formats for commonly used combinations, as described in Table 18-8.

Table 18-8. *The Predefined date Pipe Formats*

Name	Description
`short`	This format is equivalent to the component string yMdjm. It presents the date in a concise format, including the time component.
`medium`	This format is equivalent to the component string yMMMdjms. It presents the date as a more expansive format, including the time component.
`shortDate`	This format is equivalent to the component string yMd. It presents the date in a concise format and excludes the time component.
`mediumDate`	This format is equivalent to the component string yMMMd. It presents the date in a more expansive format and excludes the time component.
`longDate`	This format is equivalent to the component string yMMMMd. It presents the date and excludes the time component.
`fullDate`	This format is equivalent to the component string yMMMMEEEEd. It presents the date fully and excludes the date format.
`shortTime`	This format is equivalent to the component string jm.
`mediumTime`	This format is equivalent to the component string jms.

Listing 18-24 shows the use of the predefined formats as arguments to the date pipe, rendering the same date in different ways.

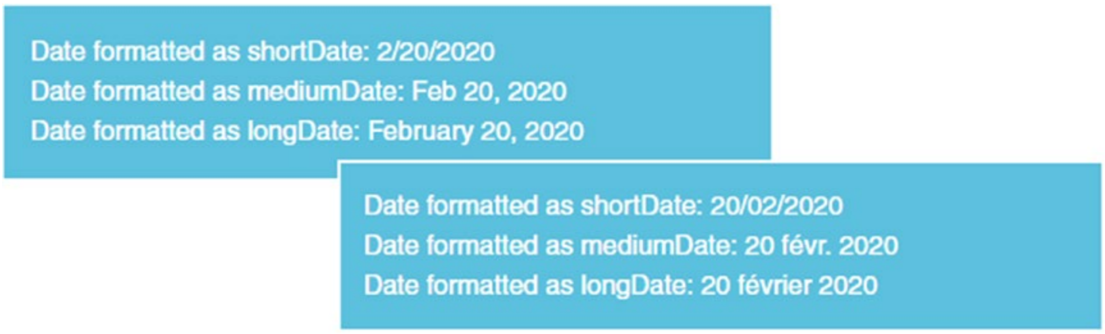
Listing 18-24. Formatting Dates in the productTable.component.html File

```
...
<div class="bg-info m-a-1 p-a-1">
    <div>Date formatted as shortDate: {{ dateObject | date:"shortDate" }}</div>
    <div>Date formatted as mediumDate: {{ dateObject | date:"mediumDate" }}</div>
    <div>Date formatted as longDate: {{ dateObject | date:"longDate" }}</div>
</div>
...
```

Arguments are specified as literal strings. Take care to capitalize the format string correctly because `shortDate` will be interpreted as one of the predefined formats from Table 18-8, but `shortdate` (with a lowercase letter `d`) will be interpreted a series of characters from Table 18-7 and produce nonsensical output.

■ **Caution** Date parsing and formatting is a complex and time-consuming process. As a consequence, the `pure` property for the `date` pipe is `true`; as a result, changes to individual components of a `Date` object won't trigger an update. If you need to reflect changes in the way that a date is displayed, then you must change the reference to the `Date` object that the binding containing the `date` pipe refers to.

Date formatting is location- sensitive, which means that you will receive different components for different locales. Do not assume that a date format that makes sense in one locale will have any meaning in another. Figure 18-14 shows the formatted dates, in the `en-US` and `fr-FR` locales.



```
Date formatted as shortDate: 2/20/2020
Date formatted as mediumDate: Feb 20, 2020
Date formatted as longDate: February 20, 2020
```

```
Date formatted as shortDate: 20/02/2020
Date formatted as mediumDate: 20 févr. 2020
Date formatted as longDate: 20 février 2020
```

Figure 18-14. *Location-sensitive date formatting*

Changing String Case

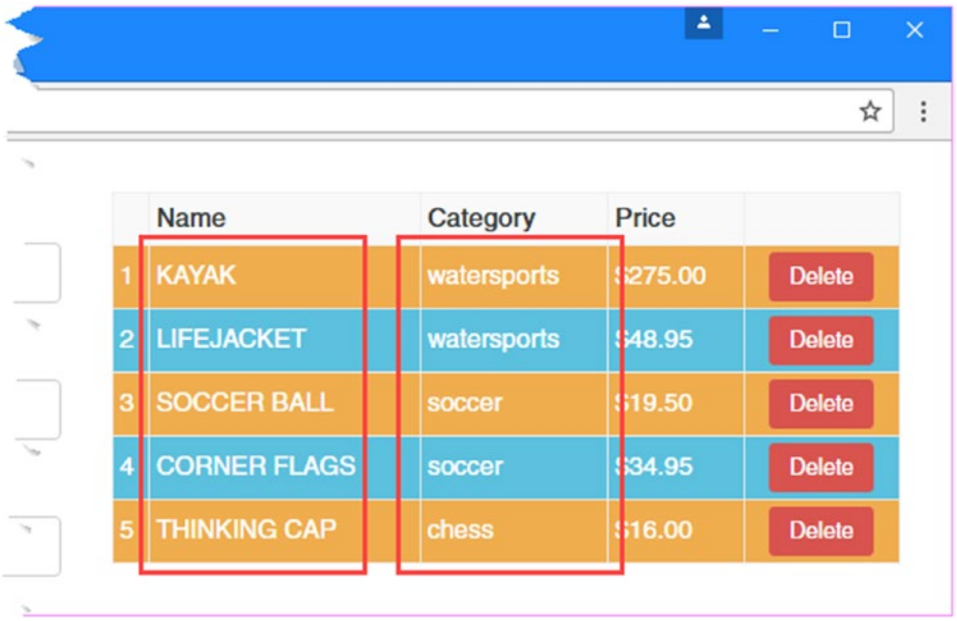
The `uppercase` and `lowercase` pipes convert all the characters in a string to uppercase or lowercase, respectively. Listing 18-25 shows both pipes applied to cells in the product table.

Listing 18-25. Changing Character Case in the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
```

```
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name | uppercase }}</td>
        <td style="vertical-align:middle">{{item.category | lowercase }}</td>
        <td style="vertical-align:middle">
            {{item.price | addTax:(taxRate || 0) | currency:"USD":true:"2.2-2" }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

These pipes use the standard JavaScript string methods `toUpperCase` and `toLowerCase`, which are not sensitive to locale settings, as shown in Figure 18-15.



	Name	Category	Price	
1	KAYAK	watersports	$275.00	Delete
2	LIFEJACKET	watersports	$48.95	Delete
3	SOCCER BALL	soccer	$19.50	Delete
4	CORNER FLAGS	soccer	$34.95	Delete
5	THINKING CAP	chess	$16.00	Delete

Figure 18-15. *Changing character case*

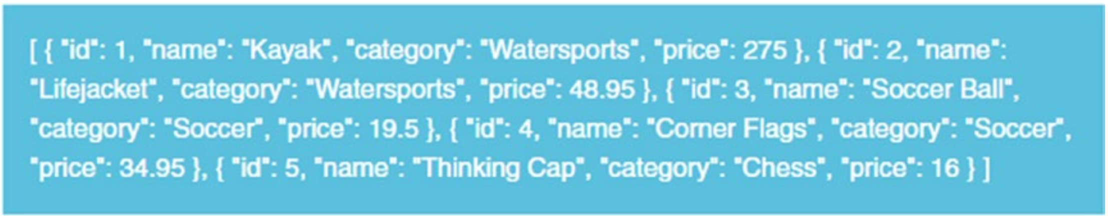
Serializing Data as JSON

The `json` pipe creates a JSON representation of a data value. No arguments are accepted by this pipe, which uses the browser's `JSON.stringify` method to create the JSON string. Listing 18-26 applies this pipe to create a JSON representation of the objects in the data model.

Listing 18-26. Creating a JSON String in the productTable.component.html File

```
<div class="bg-info m-a-1 p-a-1">
    <div>{{ getProducts() | json }}</div>
</div>

<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index; let odd = odd;
            let even = even" [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name | uppercase }}</td>
        <td style="vertical-align:middle">{{item.category | lowercase }}</td>
        <td style="vertical-align:middle">
            {{item.price | addTax:(taxRate || 0) | currency:"USD":true:"2.2-2" }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

This pipe is useful during debugging, and its decorator's `pure` property is `false` so that any change in the application will cause the pipe's `transform` method to be invoked, ensuring that even collection-level changes are shown. Figure 18-16 shows the JSON generated from the objects in the example application's data model.



```
[ { "id": 1, "name": "Kayak", "category": "Watersports", "price": 275 }, { "id": 2, "name": "Lifejacket", "category": "Watersports", "price": 48.95 }, { "id": 3, "name": "Soccer Ball", "category": "Soccer", "price": 19.5 }, { "id": 4, "name": "Corner Flags", "category": "Soccer", "price": 34.95 }, { "id": 5, "name": "Thinking Cap", "category": "Chess", "price": 16 } ]
```

Figure 18-16. *Generating JSON strings for debugging*

Slicing Data Arrays

The `slice` pipe operates on an array or string and returns a subset of the elements or characters it contains. This is an impure pipe, which means that it will reflect any changes that occur within the data object it is operating on but also means that the slice operation will be performed after any change in the application, even if that change was not related to the source data.

The objects or characters selected by the `slice` pipe are specified using two arguments, which are described in Table 18-9.

Table 18-9. *The Slice Pipe Arguments*

Name	Description
`start`	This argument must be specified. If the value is positive, the start index for items to be included in the result counts from the first position in the array. If the value is negative, then pipe counts back from the end of the array.
`end`	This optional argument is used to specify how many items from the `start` index should be included in the result. If this value is omitted, all of the items after the `start` index (or before in the case of negative values) will be included.

Listing 18-27 demonstrates the use of the `slice` pipe in combination with a `select` element that specifies how many items should be displayed in the product table.

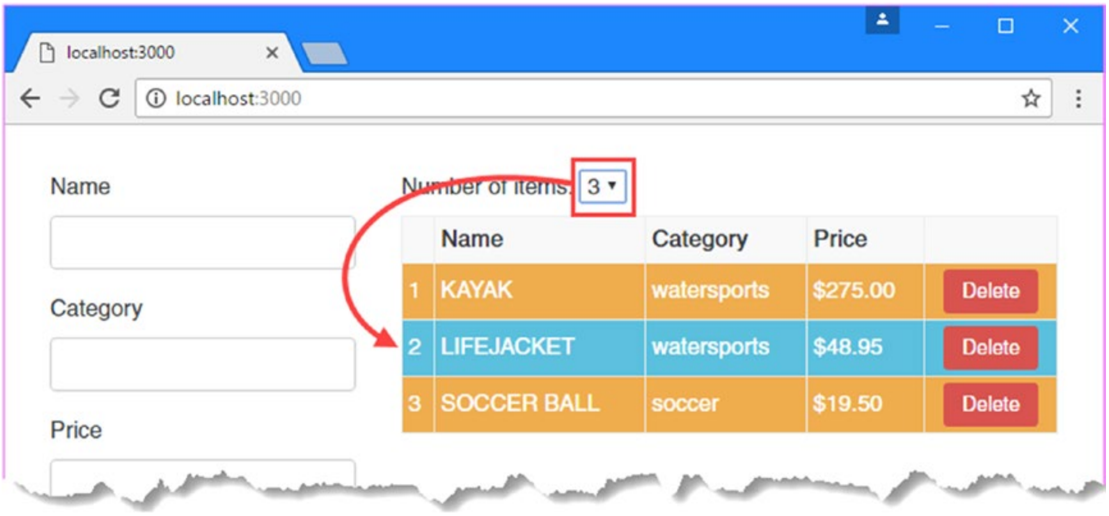
Listing 18-27. Using the slice Pipe in the productTable.component.html File

```
<div>
    <label>Number of items:</label>
    <select [value]="itemCount || 1" (change)="itemCount=$event.target.value">
        <option *ngFor="let item of getProducts(); let i = index" [value]="i + 1">
            {{i + 1}}
        </option>
    </select>
</div>

<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts() | slice:0:(itemCount || 1);
            let i = index; let odd = odd; let even = even"
            [class.bg-info]="odd" [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name | uppercase }}</td>
        <td style="vertical-align:middle">{{item.category | lowercase }}</td>
        <td style="vertical-align:middle">
            {{item.price | addTax:(taxRate || 0) | currency:"USD":true:"2.2-2" }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

The `select` element is populated with `option` elements created with the `ngFor` directive. This directive doesn't directly support iterating a specific number of times, so I have used the `index` variable to generate the values that are required. The `select` element sets a variable called `itemCount`, which is used as the second argument of the `slice` pipe, like this:

```
...
<tr *paFor="let item of getProducts() | slice:0:(itemCount || 1);
    let i = index; let odd = odd; let even = even"
    [class.bg-info]="odd" [class.bg-warning]="even">
...
```

The effect is that changing the value displayed by the `select` element changes the number of items displayed in the product table, as shown in Figure 18-17.



	Name	Category	Price	
1	KAYAK	watersports	$275.00	Delete
2	LIFEJACKET	watersports	$48.95	Delete
3	SOCCER BALL	soccer	$19.50	Delete

***Figure 18-17.** Using the slice pipe*

Summary

In this chapter, I introduced pipes and explained how they are used to transform data values so they can be presented to the user in the template. I demonstrated the process for creating custom pipes, explained how some pipes are pure and others are not, and demonstrated the built-in pipes that Angular provides for handling common tasks. In the next chapter, I introduce services, which can be used to simplify the design of Angular applications and allow building blocks to easily collaborate.

CHAPTER 19

Using Services

Services are objects that provide common functionality to support other building blocks in an application, such as directives, components, and pipes. What's important about services is the way that they are used, which is through a process called *dependency injection*. Using services can increase the flexibility and scalability of an Angular application, but dependency injection can be a difficult topic to understand, both in terms of how it works and why it can be useful. To that end, I start this chapter slowly and explain the problems that services and dependency injection can be used to solve, how dependency injection works, and why you should consider using services in your own projects. In Chapter 20, I introduce some more advanced features that Angular provides for service. Table 19-1 puts services in context.

Table 19-1. *Putting Services in Context*

Question	Answer
What are they?	Services are objects that define functionality required by other building blocks such as components or directives. What separates services from regular objects is that they are provided to building blocks by an external provider, rather than being created directly using the `new` keyword or received by an input property.
Why are they useful?	Services simplify the structure of applications, make it easier to move or reuse functionality, and make it easier to isolate building blocks for effective unit testing.
How are they used?	Classes declare dependencies on services using constructor parameters, which are then resolved using the set of services for which the application has been configured. Services are classes to which the `@Injectable` decorator has been applied.
Are there any pitfalls or limitations?	Dependency injection is a contentious topic, and not all developers like using it. If you don't perform unit tests or if your applications are relatively simple, the extra work required to implement dependency injection is unlikely to pay any long-term dividends.
Are there any alternatives?	Services and dependency injection are hard to avoid because Angular uses them to provide access to built-in functionality. But you are not required to define services for your own custom functionality, if that is your preference.

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Table 19-2 summarizes the chapter.

Table 19-2. *Chapter Summary*

Problem	Solution	Listing
Avoid the need to distribute shared objects manually	Use services	1–14, 21–28
Declare a dependency on a service	Add a constructor argument with the type of the service you require	15–20

Preparing the Example Project

I continue using the example project in this chapter that I have been working with since Chapter 11. To prepare for this chapter, I have removed most of the pipes from the data binding expressions in the table of products and also removed the `select` element that was used to choose how many products were displayed, as shown in Listing 19-1.

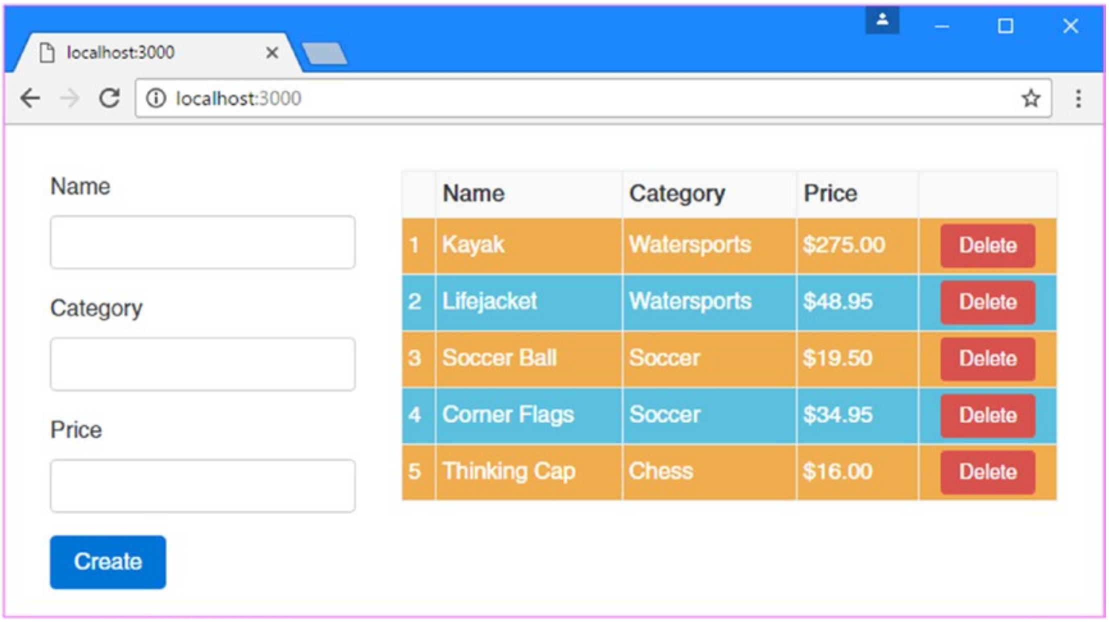
Listing 19-1. Removing the Pipe from the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index;
            let odd = odd; let even = even" [class.bg-info]="odd"
            [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
```

Run the following command in the `example` folder to start the TypeScript compiler and the development HTTP server:

```
npm start
```

A new browser tab will open and display the content shown in Figure 19-1.



	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete
2	Lifejacket	Watersports	$48.95	Delete
3	Soccer Ball	Soccer	$19.50	Delete
4	Corner Flags	Soccer	$34.95	Delete
5	Thinking Cap	Chess	$16.00	Delete

Figure 19-1. *Running the example application*

Understanding the Object Distribution Problem

In Chapter 17, I added components to the project to help break up the monolithic structure of the application. In doing this, I used input and output properties to connect components together, using host elements to bridge the isolation that Angular enforces between a parent component and its children. I also showed you how to query the contents of the template for view children, which complements the content children feature described in Chapter 16.

These techniques for coordinating between directives and components can be powerful and useful if applied carefully. But they can also end up as a general tool for distributing shared objects throughout an application, where the result is to increase the complexity of the application and to tightly bind components together.

Demonstrating the Problem

To help demonstrate the problem, I need to add a shared object to the project and two components that rely on it. To get started, I created a file called `discount.service.ts` to the app folder and defined the class shown in Listing 19-2. I'll explain the significance of the `service` part the file name later in the chapter.

Listing 19-2. The Contents of the discount.service.ts File in the app Folder

```
export class DiscountService {
    private discountValue: number = 10;

    public get discount(): number {
        return this.discountValue;
    }

    public set discount(newValue: number) {
        this.discountValue = newValue || 0;
    }

    public applyDiscount(price: number) {
        return Math.max(price - this.discountValue, 5);
    }
}
```

The `DiscountService` class defines a private property called `discountValue` that is used to store a number that will be used to reduce the product prices in the data model. This value is exposed through getters and setters called `discount`, and there is a convenience method called `applyDiscount` that reduces a price while applying a minimum value of 5.

For the first of the components that make use of the `DiscountService` class, I added a file called `discountDisplay.component.ts` to the app folder and added the code shown in Listing 19-3.

Listing 19-3. The Contents of the discountDisplay.component.ts in the app Folder

```
import { Component, Input } from "@angular/core";
import { DiscountService } from "./discount.service";

@Component({
    selector: "paDiscountDisplay",
    template: `<div class="bg-info p-a-1">
                The discount is {{discounter.discount}}
               </div>`
})
export class PaDiscountDisplayComponent {

    @Input("discounter")
    discounter: DiscountService;
}
```

The `DiscountDisplayComponent` uses an inline template to display the discount amount, which is obtained from a `DiscountService` object received through an `input` property.

For the second of the components that make use of the `DiscountService` class, I added a file called `discountEditor.component.ts` to the app folder and added the code shown in Listing 19-4.

Listing 19-4. The Contents of the discountEditor.component.ts File in the app Folder

```
import { Component, Input } from "@angular/core";
import { DiscountService } from "./discount.service";

@Component({
    selector: "paDiscountEditor",
    template: `<div class="form-group">
                   <label>Discount</label>
                   <input [(ngModel)]="discounter.discount"
                        class="form-control" type="number" />
               </div>`
})
export class PaDiscountEditorComponent {

    @Input("discounter")
    discounter: DiscountService;
}
```

The `DiscountEditorComponent` uses an inline template with an `input` element that allows the discount amount to be edited. The `input` element has a two-way binding on the `DiscountService.discount` property that targets the `ngModel` directive. Listing 19-5 shows the new components being enabled in the Angular module.

Listing 19-5. Enabling the Components in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

To get the new components working, I need to add them to parent component's template. I want to position the new content underneath the table that lists the products, which means that I need to edit the productTable.component.html file, as shown in Listing 19-6.

Listing 19-6. Adding Component Elements in the productTable.component.html File

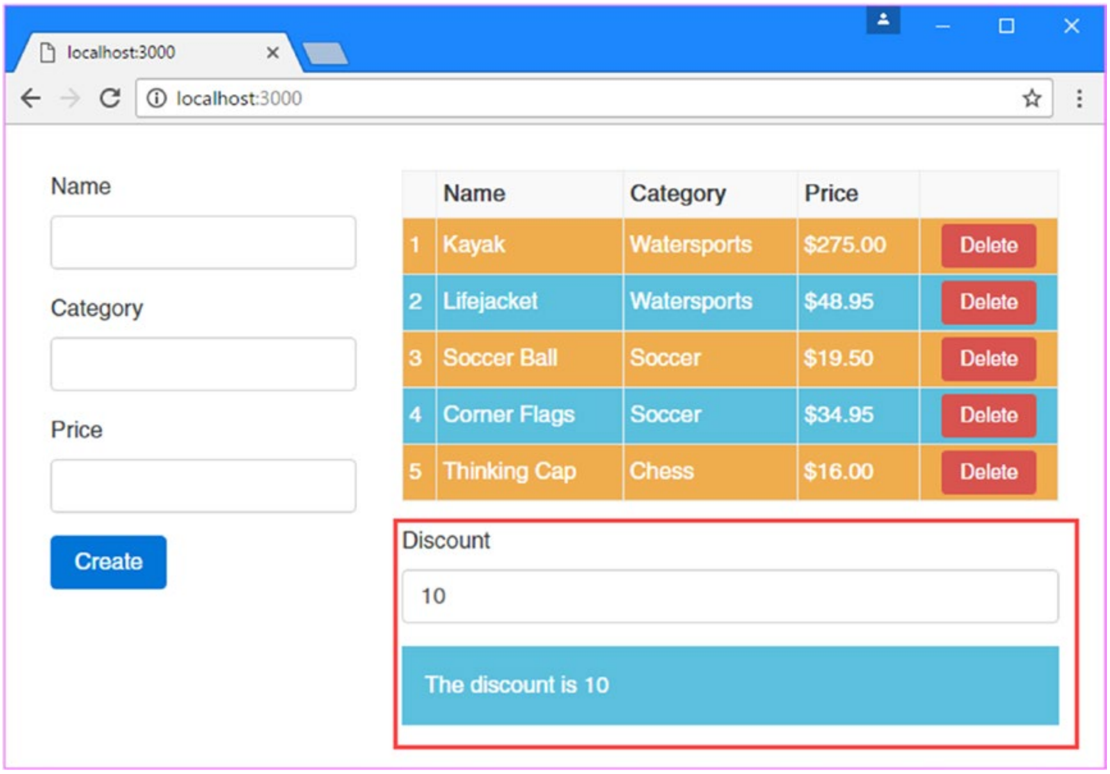
```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index;
            let odd = odd; let even = even" [class.bg-info]="odd"
            [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>

<paDiscountEditor [discounter]="discounter"></paDiscountEditor>
<paDiscountDisplay [discounter]="discounter"></paDiscountDisplay>
```

These elements correspond to the components' selector properties in Listing 19-3 and Listing 19-4 and use data bindings to set the value of the input properties. The final step is to create an object in the parent component that will provide the value for the data binding expressions, as shown in Listing 19-7.

Listing 19-7. Creating the Shared Object in the productTable.component.ts File

```
import { Component, Input, ViewChildren, QueryList } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { DiscountService } from "./discount.service";

@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {
    discounter: DiscountService = new DiscountService();

    @Input("model")
    dataModel: Model;

    getProduct(key: number): Product {
        return this.dataModel.getProduct(key);
    }
    getProducts(): Product[] {
        return this.dataModel.getProducts();
    }

    deleteProduct(key: number) {
        this.dataModel.deleteProduct(key);
    }

    dateObject: Date = new Date(2020, 1, 20);
    dateString: string = "2020-02-20T00:00:00.000Z";
    dateNumber: number = 1582156800000;
}
```

Figure 19-2 shows the content from the new components. Changes to the value in the `input` element provided by one of the components will be reflected in the string interpolation binding provided by the other component, reflecting the use of the shared `DiscountService` object and its discount property.



	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete
2	Lifejacket	Watersports	$48.95	Delete
3	Soccer Ball	Soccer	$19.50	Delete
4	Corner Flags	Soccer	$34.95	Delete
5	Thinking Cap	Chess	$16.00	Delete

The discount is 10

Figure 19-2. *Adding components to the example application*

The process for adding the new components and the shared object was straightforward and logical, until the final stage. The problem arises in the way that I had to create and distribute the shared object: the instance of the `DiscountService` class.

Because Angular isolates components from one another, I had no way to share the `DiscountService` object directly between the `DiscountEditorComponent` and `DiscountDisplayComponent`. Each component could have created its own `DiscountService` object, but that means that changes from the editor component wouldn't be shown in the display component.

That is what led me to create the `DiscountService` object in the product table component, which is the first shared ancestor of the discount editor and display components. This allowed me to distribute the `DiscountService` object through the product table component's template, ensuring that a single object was shared with both of the components that need it.

But there are a couple of problems. The first is that the `ProductTableComponent` class doesn't actually need or use a `DiscountService` object to deliver its own functionality. It just happens to be the first common ancestor of the components that do need the object. And creating the shared object in the `ProductTableComponent` class makes that class slightly more complex and slightly more difficult to test effectively. This is a modest increment of complexity, but it will occur for every shared object that the application requires—and a complex application can depend on a lot of shared objects, each of which ends up being created by components that just happen to be the first common ancestor of the classes that depend on them.

The second problem is hinted at by the term *first common ancestor*. The `ProductTableComponent` class happens to be the parent of both of the classes that depend on the `DiscountService` object, but think about what would happen if I wanted to move the `DiscountEditorComponent` so that it was displayed under the form rather than the table. In this situation, I have to work my way up the tree of components until I find a common ancestor, which would end up being the root component. And then I would have to work my way down the component tree adding input properties and modifying templates so that each intermediate component could receive the `DiscountService` object from its parent and pass it on to any children who have descendants that need it. And the same applies to any directives that depend on receiving a `DiscountService` object, where any component whose template contains data bindings that target that directive must make sure they are part of the distribution chain, too.

The result is that the components and directives in the application become tightly bound together. A major refactoring is required if you need to move or reuse a component in a different part of the application and the management of the input properties and data bindings becomes unmanageable.

Distributing Objects as Services Using Dependency Injection

There is a better way to distribute objects to the classes that depend on them, which is to use *dependency injection*, where objects are provided to classes from an external source. Angular includes a built-in dependency injection system and supplies the external source of objects, known as *providers*. In the sections that follow, I rework the example application to provide the `DiscountService` object without needing to use the component hierarchy as a distribution mechanism.

Preparing the Service

Any object that is managed and distributed through dependency injection is called a *service*, which is why I selected the name `DiscountService` for the class that defines the shared object and why that class is defined in a file called `discount.service.ts`. Angular denotes service classes using the `@Injectable` decorator, as shown in Listing 19-8. The `@Injectable` decorator doesn't define any configuration properties.

Listing 19-8. Preparing a Class as a Service in the discount.service.ts File

```
import { Injectable } from "@angular/core";

@Injectable()
export class DiscountService {
    private discountValue: number = 10;

    public get discount(): number {
        return this.discountValue;
    }

    public set discount(newValue: number) {
        this.discountValue = newValue || 0;
    }

    public applyDiscount(price: number) {
        return Math.max(price - this.discountValue, 5);
    }
}
```

Preparing the Dependent Components

A class declares dependencies using its constructor. When Angular needs to create an instance of the class—such as when it finds an element that matches the `selector` property defined by a component—its constructor is inspected, and the type of each argument is examined. Angular then uses the services that have been defined to try to satisfy the dependencies. The term *dependency injection* arises because each dependency is *injected* into the constructor to create the new instance.

For the example application, it means that the components that depend on a `DiscountService` object no longer require input properties and can declare a constructor dependency instead. Listing 19-9 shows the changes to the `DiscountDisplayComponent` class.

Listing 19-9. Declaring a Dependency in the discountDisplay.component.ts File

```
import { Component, Input } from "@angular/core";
import { DiscountService } from "./discount.service";

@Component({
    selector: "paDiscountDisplay",
    template: `<div class="bg-info p-a-1">
                The discount is {{discounter.discount}}
               </div>`
})
export class PaDiscountDisplayComponent {

    constructor(private discounter: DiscountService) { }
}
```

The same change can be applied to the `DiscountEditorComponent` class, replacing the input property with a dependency declared through the constructor, as shown in Listing 19-10.

Listing 19-10. Declaring a Dependency in the discountEditor.component.ts File

```
import { Component, Input } from "@angular/core";
import { DiscountService } from "./discount.service";

@Component({
    selector: "paDiscountEditor",
    template: `<div class="form-group">
                   <label>Discount</label>
                   <input [(ngModel)]="discounter.discount"
                        class="form-control" type="number" />
               </div>`
})
export class PaDiscountEditorComponent {

    constructor(private discounter: DiscountService) { }
}
```

These are small changes, but they avoid the need to distribute objects using templates and input properties and produce a more flexible application. I can now remove the `DiscountService` object from the product table component, as shown in Listing 19-11.

Listing 19-11. Removing the Shared Object in the productTable.component.ts File

```
import { Component, Input } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { DiscountService } from "./discount.service";

@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {
    //discounter: DiscountService = new DiscountService();

    // ...other methods and properties omitted for brevity...
}
```

And since the parent component is no longer providing the shared object through data bindings, I can remove them from the template, as shown in Listing 19-12.

Listing 19-12. Removing the Data Bindings in the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index;
            let odd = odd; let even = even" [class.bg-info]="odd"
            [class.bg-warning]="even">
```

```
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>

<paDiscountEditor></paDiscountEditor>
<paDiscountDisplay></paDiscountDisplay>
```

Registering the Service

The final change is to configure the dependency injection feature so that it can provide `DiscountService` objects to the components that require them. To make the service available throughout the application, it is registered in the Angular module, as shown in Listing 19-13.

Listing 19-13. Registering a Service in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent],
    providers: [DiscountService],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

The NgModule decorator's providers property is set to an array of the classes that will be used as services. There is only one service at the moment, which is provided by the DiscountService class.

When you save the changes to the application, there won't be any visual changes, but the dependency injection feature will be used to provide the components with the DiscountService object they require.

Reviewing the Dependency Injection Changes

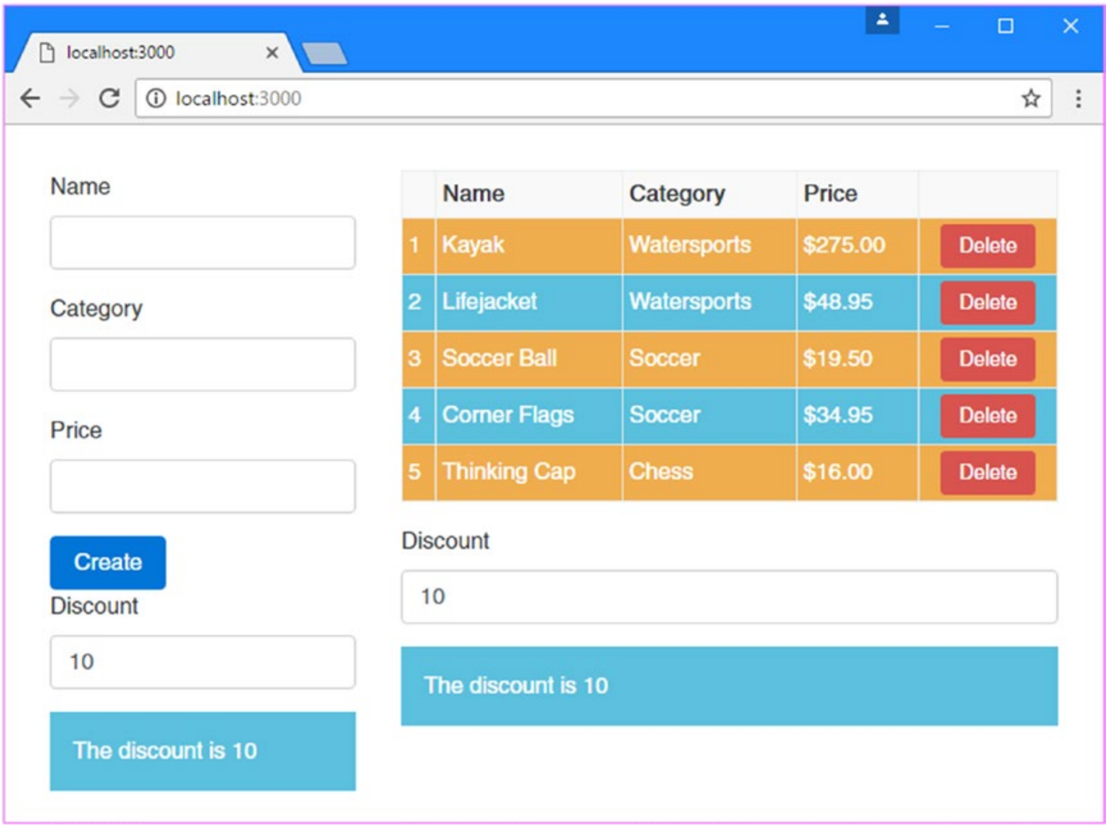
Angular seamlessly integrates dependency injection into its feature set. Each time that Angular encounters an element that requires a new building block, such as a component or a pipe, to be instantiated, it examines the class constructor to check what dependencies have been declared and uses its services to try to resolve them. The set of services used to resolve dependencies includes the custom services defined by the application, such as the DiscountService service that has been registered in Listing 19-13, and a set of built-in services provided by Angular and that are described in later chapters.

The changes to introduce dependency injection in the previous section didn't result in a big bang change in the way that the application works—or any visible change at all. But there is a profound difference in the way that the application is put together that makes it more flexible and fluid. The best demonstration of this is to add the components that require the DiscountService to a different part of the application, as shown in Listing 19-14.

Listing 19-14. Adding Components in the productForm.component.html File

```
<form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">
    <div class="form-group" *ngFor="let control of form.productControls">
        <label>{{control.label}}</label>
        <input class="form-control"
            [(ngModel)]="newProduct[control.modelProperty]"
            name="{{control.modelProperty}}"
            formControlName="{{control.modelProperty}}" />
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || control.dirty) && !control.valid">
            <li *ngFor="let error of control.getValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>
    <button class="btn btn-primary" type="submit"
        [disabled]="formSubmitted && !form.valid"
        [class.btn-secondary]="formSubmitted && !form.valid">
            Create
    </button>
</form>
<paDiscountEditor></paDiscountEditor>
<paDiscountDisplay></paDiscountDisplay>
```

These new elements duplicate the discount display and editor components so they appear below the form used to create new products, as shown in Figure 19-3.



	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete
2	Lifejacket	Watersports	$48.95	Delete
3	Soccer Ball	Soccer	$19.50	Delete
4	Corner Flags	Soccer	$34.95	Delete
5	Thinking Cap	Chess	$16.00	Delete

Figure 19-3. *Duplicating components with dependencies*

There are two points of note. First, using dependency injection made this a simple process of adding elements to a template, without needing to modify the ancestor components to provide a `DiscountService` object using input properties.

The second point of note is that all the components in the application that have declared a dependency on `DiscountService` have received the same object. If you edit the value in either of the `input` elements, the changes will be reflected in the other `input` element and in the string interpolation bindings, as shown in Figure 19-4.

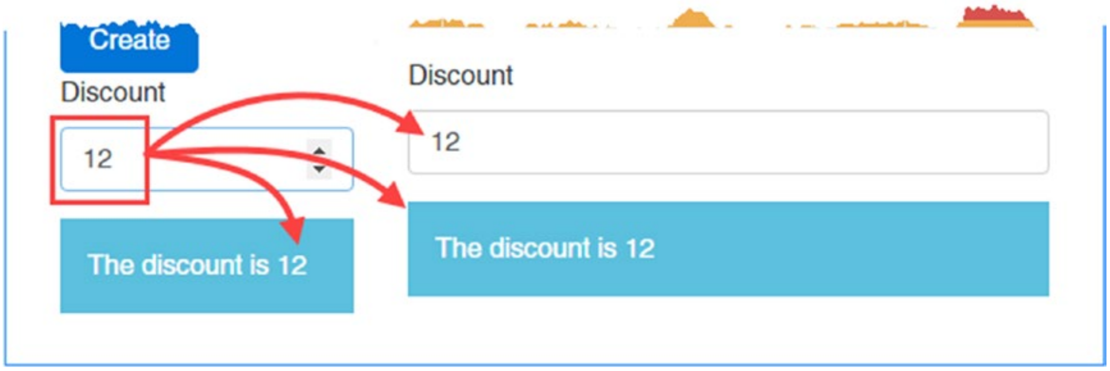


Figure 19-4. *Checking that the dependency is resolved using a shared object*

Declaring Dependencies in Other Building Blocks

It isn't just components that can declare constructor dependencies, and once you have defined a service, you can use it more widely, including in other building blocks in the application, such as pipes and directives, as demonstrated in the sections that follow.

Declaring a Dependency in a Pipe

Pipes can declare dependencies on services by defining a constructor with arguments for each required service. To demonstrate, I added a file called `discount.pipe.ts` to the app folder and used it to define the pipe shown in Listing 19-15.

Listing 19-15. The Contents of the discount.pipe.ts File in the app Folder

```
import { Pipe, Injectable } from "@angular/core";
import { DiscountService } from "./discount.service";

@Pipe({
    name: "discount",
    pure: false
})
export class PaDiscountPipe {

    constructor(private discount: DiscountService) { }

    transform(price: number): number {
        return this.discount.applyDiscount(price);
    }
}
```

The `PaDiscountPipe` class is a pipe that receives a `price` and generates a result by calling the `DiscountService.applyDiscount` method, where the service is received through the constructor. The `pure` property in the `@Pipe` decorator is `false`, which means that the pipe will be asked to update its result when the value stored by the `DiscountService` changes, which won't be recognized by the Angular change-detection process.

■ **Tip** As explained in Chapter 18, this feature should be used with caution because it means that the `transform` method will be called after every change in the application, not just when the service is changed.

Listing 19-16 shows the new pipe being registered in the application's Angular module.

Listing 19-16. Registering a Pipe in the app.module.ts File

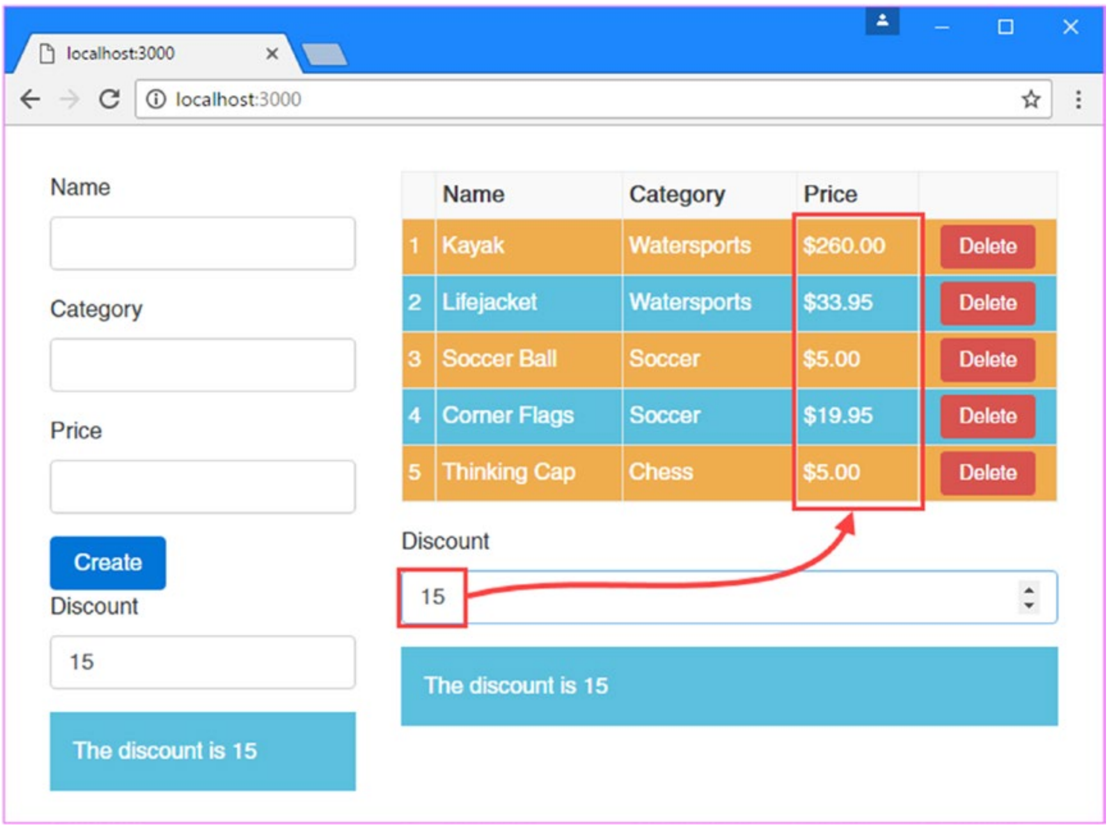
```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe],
    providers: [DiscountService],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

Listing 19-17 shows the new pipe applied to the price column in the product table.

Listing 19-17. Applying a Pipe in the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr><th></th><th>Name</th><th>Category</th><th>Price</th><th></th></tr>
    <tr *paFor="let item of getProducts(); let i = index;
            let odd = odd; let even = even" [class.bg-info]="odd"
            [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | discount | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>

<paDiscountEditor></paDiscountEditor>
<paDiscountDisplay></paDiscountDisplay>
```

The `discount` pipe processes the price to apply the discount and then passes on the value to the `currency` pipe for formatting. You can see the effect of using the service in the pipe by changing the value in one of the discount `input` elements, as shown in Figure 19-5.



	Name	Category	Price	
1	Kayak	Watersports	$260.00	Delete
2	Lifejacket	Watersports	$33.95	Delete
3	Soccer Ball	Soccer	$5.00	Delete
4	Corner Flags	Soccer	$19.95	Delete
5	Thinking Cap	Chess	$5.00	Delete

The discount is 15

The discount is 15

Figure 19-5. *Using a service in a pipe*

Declaring Dependencies in Directives

Directives can also use services. As I explained in Chapter 17, components are just directives with templates, so anything that works in a component will also work in a directive.

To demonstrate using a service in a directive, I added a file called `discountAmount.directive.ts` to the app folder and used it to define the directive shown in Listing 19-18.

Listing 19-18. The Contents of the discountAmount.directive.ts File in the app Folder

```
import { Directive, HostBinding, Input,
    SimpleChange, KeyValueDiffer, KeyValueDiffers,
    ChangeDetectorRef } from "@angular/core";
import { DiscountService } from "./discount.service";

@Directive({
    selector: "td[pa-price]",
    exportAs: "discount"
})
export class PaDiscountAmountDirective {
    private differ: KeyValueDiffer;

    constructor(private keyValueDiffers: KeyValueDiffers,
        private changeDetector: ChangeDetectorRef,
        private discount: DiscountService) { }

    @Input("pa-price")
    originalPrice: number;

    discountAmount: number;

    ngOnInit() {
        this.differ =
            this.keyValueDiffers.find(this.discount).create(this.changeDetector);
    }

    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        if (changes["originalPrice"] != null) {
            this.updateValue();
        }
    }

    ngDoCheck() {
        if (this.differ.diff(this.discount) != null) {
            this.updateValue();
        }
    }

    private updateValue() {
        this.discountAmount = this.originalPrice
            - this.discount.applyDiscount(this.originalPrice);
    }
}
```

Directives don't have an equivalent to the pure property used by pipes and must take direct responsibility for responding to changes propagated through services. Some services, such as the built-in Http service described in Chapter 24, provide support for receiving notifications when a change occurs. Others, such as the DiscountService used in this example, leave it to the directive to do the work.

This directive displays the discounted amount for a product. The selector property matches td elements that have a pa-price attribute, which is also used as an input property to receive the price that will be discounted. The directive exports its functionality using the exportAs property and provides a property called discountAmount whose value is set to the discount that has been applied to the product.

There are two other points to note about this directive. The first is that the DiscountService object isn't the only constructor parameters in the directive's class.

```
...
constructor(private keyValueDiffers: KeyValueDiffers,
            private changeDetector: ChangeDetectorRef,
            private discount: DiscountService) { }
...
```

The KeyValueDiffers and ChangeDetectorRef parameters are also dependencies that Angular will have to resolve when it creates a new instance of the directive class. These are examples of the built-in services that Angular provides that deliver commonly required function functionality.

The second point of note is what the directive does with the services it receives. The components and the pipe that use the DiscountService service don't have to worry about tracking updates, either because Angular automatically evaluates the expressions of the data bindings and updates them when the discount rate changed (for the components) or because any change in the application triggers an update (for the impure pipe).

The data binding for this directive is on the price property, which will trigger a change if is altered. But there is also a dependency on the discount property defined by the DsscountService class. Changes in the discount property are detected using the services received through the constructor, which are similar to the ones used to track changes in iterable sequences described in Chapter 16 but which operate on key/value pair objects, such as Map objects or regular objects that define properties, such as DiscountService. When Angular invokes the ngDoCheck method, the directive uses the key/value pair differ to see whether there has been a change. (This change direction could also have been handled by keeping track of the previous update in the directive class, but I wanted to provide an example of using the key/value differ feature.)The directive also implements the ngOnChanges method so that it can respond to changes in the value of the input property. For both types of update, the updateValue method is called, which calculates the discounted price and assigns it to the discountAmount property. Listing 19-19 registers the new directive in the application's Angular module.

Listing 19-19. Registering a Directive in the app.module.ts File

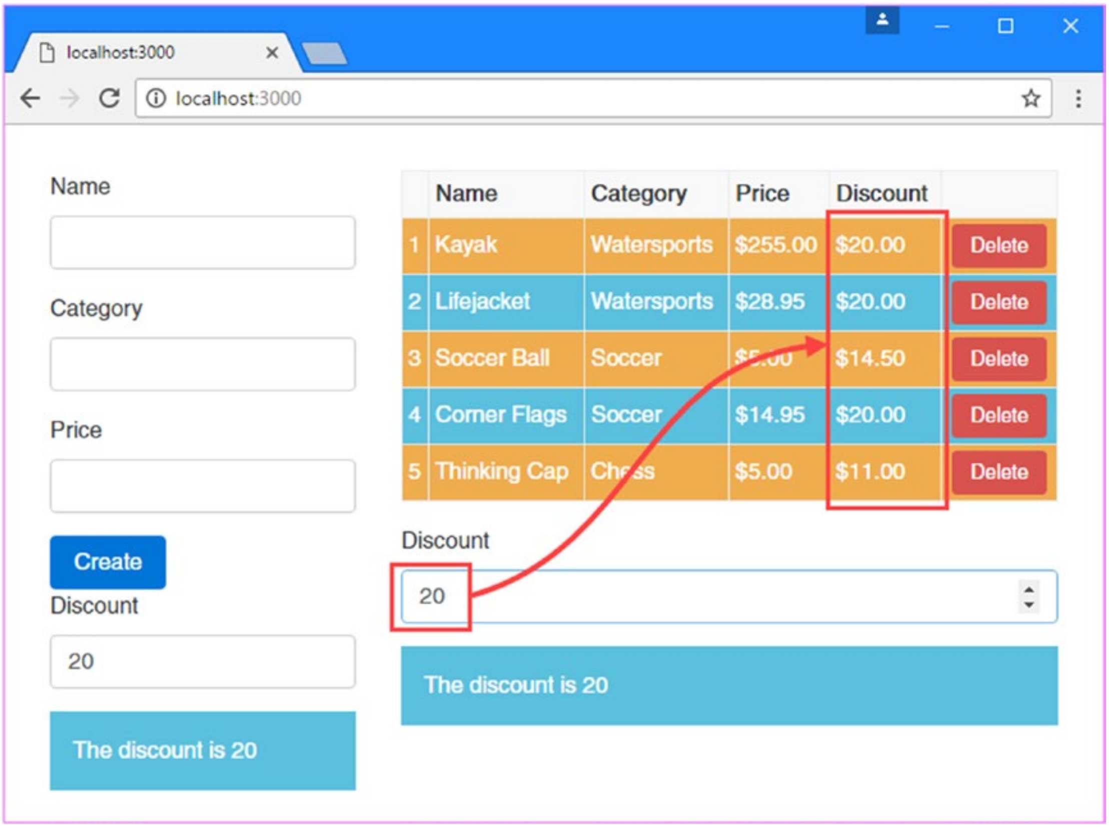
```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

To apply the new directive, Listing 19-20 adds a new column to the table, using a string interpolation binding to access the property provided by the directive and pass it to the currency pipe.

Listing 19-20. Creating a New Column in the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th></th><th>Name</th><th>Category</th><th>Price</th>
        <th>Discount</th><th></th>
    </tr>
    <tr *paFor="let item of getProducts(); let i = index;
            let odd = odd; let even = even" [class.bg-info]="odd"
            [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | discount | currency:"USD":true }}
        </td>
        <td style="vertical-align:middle" [pa-price]="item.price"
                #discount="discount">
            {{ discount.discountAmount | currency:"USD": true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>

<paDiscountEditor></paDiscountEditor>
<paDiscountDisplay></paDiscountDisplay>
```

The directive could have created a host binding on the `textContent` property to set the contents of its host element, but that would have prevented the `currency` pipe being used. Instead, the directive is assigned to the `discount` template variable, which is then used in the string interpolation binding to access and then format the `discountAmount` value. Figure 19-6 shows the results. Changes to the discount amount in either of the discount editor `input` elements will be reflected in the new table column.



Name

Category

Price

Create

Discount

20

The discount is 20

	Name	Category	Price	Discount	
1	Kayak	Watersports	$255.00	$20.00	Delete
2	Lifejacket	Watersports	$28.95	$20.00	Delete
3	Soccer Ball	Soccer	[illegible]	$14.50	Delete
4	Corner Flags	Soccer	$14.95	$20.00	Delete
5	Thinking Cap	Chess	$5.00	$11.00	Delete

Discount

20

The discount is 20

Figure 19-6. *Using a service in a directive*

Understanding the Test Isolation Problem

The example application contains a related problem that services and dependency injection can be used to solve. Consider how the `Model` class is created in the root component:

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
```

```
export class ProductComponent {
    model: Model = new Model();

    addProduct(p: Product) {
        this.model.saveProduct(p);
    }
}
```

The root component is defined as the ProductComponent class, and it sets up a value for its model property by creating a new instance of the Model class. This works—and is a perfectly legitimate way to create an object—but it makes it harder to perform unit testing effectively.

Unit testing works best when you can isolate one small part of the application and focus on it to perform tests. But when you create an instance of the ProductComponent class, you are implicitly creating an instance of the Model class as well. If you were to run tests on the root component's addProduct method and you found a problem, you would have no indication of whether the problem was in the ProductComponent or Model classes.

Isolating Components Using Services and Dependency Injection

The underlying problem is that the ProductComponent class is tightly bound to the Model class, which is, in turn, tightly bound to the SimpleDataSource class. Dependency injection can be used to tease apart the building blocks in an application so that each class can be isolated and tested on its own. In the sections that follow, I walk through the process of breaking up these tightly coupled classes, following essentially the same process as in the previous section but delving deeper into the example application.

Preparing the Services

The @Injectable decorator is used to denote services, just as in the previous example. Listing 19-21 shows the decorator applied to the SimpleDataSource class.

Listing 19-21. Denoting a Service in the datasource.model.ts File

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";

@Injectable()
export class SimpleDataSource {
    private data:Product[];

    constructor() {
        this.data = new Array<Product>(
        new Product(1, "Kayak", "Watersports", 275),
        new Product(2, "Lifejacket", "Watersports", 48.95),
        new Product(3, "Soccer Ball", "Soccer", 19.50),
        new Product(4, "Corner Flags", "Soccer", 34.95),
        new Product(5, "Thinking Cap", "Chess", 16));
    }

    getData(): Product[] {
        return this.data;
    }
}
```

No other changes are required. Listing 19-22 shows the same decorator being applied to the data repository, and since this class has a dependency on the `SimpleDataSource` class, it declares it as a constructor dependency rather than creating an instance directly.

Listing 19-22. Denoting a Service and Declaring a Dependency in the repository.model.ts File

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";
import { SimpleDataSource } from "./datasource.model";

@Injectable()
export class Model {
    //private dataSource: SimpleDataSource;
    private products: Product[];
    private locator = (p:Product, id:number) => p.id == id;

    constructor(private dataSource: SimpleDataSource) {
        //this.dataSource = new SimpleDataSource();
        this.products = new Array<Product>();
        this.dataSource.getData().forEach(p => this.products.push(p));
    }

    // ...other members omitted for brevity...
}
```

The important point to note in this listing is that services can declare dependencies on other services. When Angular comes to create a new instance of a service class, it inspects the constructor and tries to resolve the services in the same way as when dealing with a component or directive.

Registering the Services

These services must be registered so that Angular knows how to resolve dependencies on them, as shown in Listing 19-23.

Listing 19-23. Registering the Services in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

Preparing the Dependent Component

Rather than create a `Model` object directly, the root component can declare a constructor dependency that Angular will resolve using dependency injection when the application starts, as shown in Listing 19-24.

Listing 19-24. Declaring a Service Dependency in the component.ts File

```
import { ApplicationRef, Component } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    //model: Model = new Model();

    constructor(private model: Model) { }

    addProduct(p: Product) {
        this.model.saveProduct(p);
    }
}
```

There is now a chain of dependencies that Angular has to resolve. When the application starts, the Angular module specifies that the `ProductComponent` class needs a `Model` object. Angular inspects the `Model` class and finds that it needs a `SimpleDataSource` object. Angular inspects the `SimpleDataSource` object and finds that there are no declared dependencies and therefore knows that this is the end of the chain. It creates a `SimpleDataSource` object and passes it as an argument to the `Model` constructor in order to create a `Model` object, which can then be passed to the `ProductComponent` class constructor to create the object that will be used as the root component. All of this happens automatically, based on the constructors defined by each class and the use of the `@Injectable` decorator.

These changes don't create any visible changes in the way that the application works, but they do allow a completely different way of performing unit tests. The `ProductComponent` class requires that a `Model` object is provided as a constructor argument, which allows for a mock object to be used.

Breaking up the direct dependencies between the classes in the application means that each of them can be isolated for the purposes of unit testing and provided with mock objects through their constructor, allowing the effect of a method or some other feature to be consistently and independently assessed.

Completing the Adoption of Services

Once you start using services in an application, the process generally takes on a life of its own, and you start to examine the relationships between the building blocks you have created. The extent to which you introduce services is—at least in part—a matter of personal preference.

A good example is the use of the `Model` class in the root component. Although the component does implement a method that uses the `Model` object, it does so because it needs to handle a custom event from one of its child components. The only other reason that the root component has for needing a `Model` object is to pass it on via its template to the other child component, via an input property.

This situation isn't an enormous problem, and your preference may be to have these kinds of relationships in a project. After all, each of the components can be isolated for unit testing, and there is some purpose, however limited, to the relationships between them. This kind of relationship between components can help make sense of the functionality that an application provides.

On the other hand, the more you use services, the more the building blocks in your project become self-contained and reusable blocks of functionality, which can ease the process of adding or changing functionality as the project matures.

There is no absolute right or wrong, and you must find the balance that suits you, your team, and, ultimately, your users and customers. Not everyone likes using dependency injection, and not everyone performs unit testing.

My preference is to use dependency injection as widely as possible. I find that the final structure of my applications can differ significantly from what I expect when I start a new project and that the flexibility offered by dependency injection helps me avoid repeated periods of refactoring. And so, to complete this chapter, I am going to push the use of the `Model` service into the rest of the application, breaking the coupling between the root component and its immediate children.

Updating the Root Component and Template

The first changes I will make are to remove the `Model` object from the root component, along with the method that uses it and the input property in the template that distributes the model to one of the child components. Listing 19-25 shows the changes to the component class.

Listing 19-25. Removing the Model Object from the component.ts File

```
import { Component } from "@angular/core";
//import { Model } from "./repository.model";
//import { Product } from "./product.model";
//import { ProductFormGroup } from "./form.model";
```

```
@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {
    //model: Model = new Model();

    //constructor(private model: Model) { }

    //addProduct(p: Product) {
    //    this.model.saveProduct(p);
    //}
}
```

The revised root component class doesn't define any functionality and now exists only to provide the top-level application content in its template. Listing 19-26 shows the corresponding changes in the root template to remove the custom event binding and the input property.

Listing 19-26. Removing the Data Bindings in the template.html File

```
<div class="col-xs-4 p-a-1">
    <paProductForm></paProductForm>
</div>
<div class="col-xs-8 p-a-1">
    <paProductTable></paProductTable>
</div>
```

Updating the Child Components

The component that provides the form for creating new `Product` objects relied on the root component to handle its custom event and update the model. Without this support, the component must now declare a `Model` dependency and perform the update itself, as shown in Listing 19-27.

Listing 19-27. Working Directly with the Model in the productForm.component.ts File

```
import { Component, Output, EventEmitter, ViewEncapsulation } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";
import { Model } from "./repository.model";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    //styleUrls: ["app/productForm.component.css"],
    //encapsulation: ViewEncapsulation.Emulated
})
export class ProductFormComponent {
    form: ProductFormGroup = new ProductFormGroup();
    newProduct: Product = new Product();
    formSubmitted: boolean = false;
    constructor(private model: Model) { }

    //@Output("paNewProduct")
    //newProductEvent = new EventEmitter<Product>();

    submitForm(form: any) {
        this.formSubmitted = true;
        if (form.valid) {
            //this.newProductEvent.emit(this.newProduct);
            this.model.saveProduct(this.newProduct);
            this.newProduct = new Product();
            this.form.reset();
            this.formSubmitted = false;
        }
    }
}
```

The component that manages the table of product objects used an input property to receive a `Model` object from its parent but must now obtain it directly by declaring a constructor dependency, as shown in Listing 19-28.

Listing 19-28. Declaring a Model Dependency in the productTable.component.ts File

```
import { Component, Input } from "@angular/core";
import { Model } from "./repository.model";
import { Product } from "./product.model";
import { DiscountService } from "./discount.service";

@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {
    //discounter: DiscountService = new DiscountService();

    constructor(private dataModel: Model) { }

    //@Input("model")
    //dataModel: Model;

    getProduct(key: number): Product {
        return this.dataModel.getProduct(key);
    }

    getProducts(): Product[] {
        return this.dataModel.getProducts();
    }

    deleteProduct(key: number) {
        this.dataModel.deleteProduct(key);
    }
    dateObject: Date = new Date(2020, 1, 20);
    dateString: string = "2020-02-20T00:00:00.000Z";
    dateNumber: number = 1582156800000;
}
```

You will see the same functionality displayed in the browser window when all of the changes have been saved and the browser reloads the Angular application—but the way that the functionality is wired up has changed substantially, with each component obtaining the share objects it needs through the dependency injection feature, rather than relying on its parent component to provide it.

Summary

In this chapter, I explained the problems that dependency injection can be used to address and demonstrated the process for defining and consuming services. I described how services can be used to increase the flexibility in the structure of an application and how dependency injection makes it possible to isolate building blocks so they can be unit tested effectively. In the next chapter, I describe the advanced features that Angular provides for working with services.

CHAPTER 20

Using Service Providers

In the previous chapter, I introduced services and explained how they are distributed using dependency injection. When using dependency injection, the objects that are used to resolve dependencies are created by *service providers*, known more commonly as *providers*. In this chapter, I explain how providers work, describe the different types of provider that are available, and demonstrate how providers can be created in different parts of the application to change the way that services behave. Table 20-1 puts providers in context.

Table 20-1. *Putting Service Providers in Context*

Question	Answer
What are they?	Providers are classes that create service objects the first time that Angular needs to resolve a dependency.
Why are they useful?	Providers allow the creation of service objects to be tailored to the needs of the application. The simplest provider just creates an instance of a specified class, but there are other providers that can be used to tailor the way that service objects are created and configured.
How are they used?	Providers are defined in the `providers` property of the Angular module's decorator. They can also be defined by components and directives to provide services to their children, as described in the "Using Local Providers" section.
Are there any pitfalls or limitations?	It is easy to create unexpected behavior, especially when working with local providers. If you encounter problems, check the scope of the local providers you have created and make sure that your dependencies and providers are using the same tokens.
Are there any alternatives?	Many applications will require only the basic dependency injection features described in Chapter 19. You should use the features in this chapter only if you cannot build your application using the basic features and only if you have a solid understanding of dependency injection.

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WHY YOU SHOULD CONSIDER SKIPPING THIS CHAPTER

Dependency injection provokes strong reactions in developers and polarizes opinion. If you are new to dependency injection and have yet to form your own opinion, then you might want to skip this chapter and just use the features that I described in Chapter 19. That's because features like the ones I describe in this chapter are exactly why many developers dread using dependency injection and form a strong preference against its use.

The basic Angular dependency injection features are easy to understand and have an immediate and obvious benefit in making applications easier to write and maintain. The features described in this chapter provide fine-grained control over how dependency injection works, but they also make it possible to sharply increase the complexity of an Angular application and, ultimately, undermine many of the benefits that the basic features offer.

If you decide that you want all of the gritty detail, then read on. But if you are new to the world of dependency injection, you may prefer to skip this chapter until you find that the basic features from Chapter 19 don't deliver the functionality you require.

Table 20-2 summarizes the chapter.

Table 20-2. *Chapter Summary*

Problem	Solution	Listing
Change the way that services are created	Use a service provider	1–3
Specify a service using a class	Use the class provider	4–6, 10–13
Define arbitrary tokens for services	Use the `OpaqueToken` class	7–9
Specify a service using an object	Use the value provider	14–15
Specify a service using a function	Use the factory provider	16–18
Specify one service using another	Use the existing service provider	19
Change the scope of a service	Use a local service provider	20–28
Control the resolution of dependencies	Use the `@Host`, `@Optional`, or `@SkipSelf` decorator	29–30

Preparing the Example Project

As with the other chapters in this part of the book, I am going to continue working with the project created in Chapter 11 and most recently modified in Chapter 19. To prepare for this chapter, I added a file called `log.service.ts` to the app folder and used it to define the service shown in Listing 20-1.

Listing 20-1. The Contents of the log.service.ts File in the app Folder

```
import { Injectable } from "@angular/core";

export enum LogLevel {
    DEBUG, INFO, ERROR
}
```

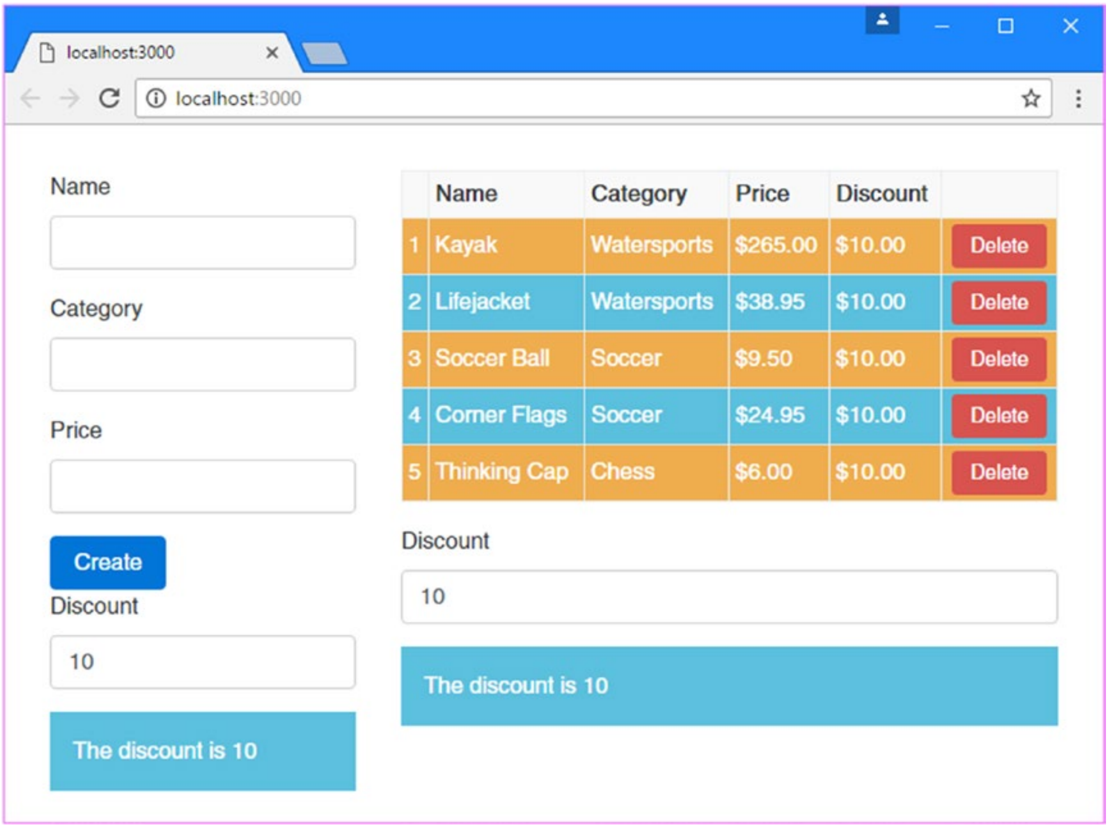
```
@Injectable()
export class LogService {
    minimumLevel: LogLevel = LogLevel.INFO;

    logInfoMessage(message: string) {
        this.logMessage(LogLevel.INFO, message);
    }

    logDebugMessage(message: string) {
        this.logMessage(LogLevel.DEBUG, message);
    }

    logErrorMessage(message: string) {
        this.logMessage(LogLevel.ERROR, message);
    }

    logMessage(level: LogLevel, message: string) {
        if (level >= this.minimumLevel) {
            console.log(`Message (${LogLevel[level]}): ${message}`);
        }
    }
}
```

This service writes out log messages, with differing levels of severity, to the browser's JavaScript console. I will register and use this service later in the chapter.

When you have created the service and saved the changes, run the following command in the `example` folder to start the TypeScript compiler and the development HTTP server:

```
npm start
```

A new browser window will open and display the application shown in Figure 20-1.



	Name	Category	Price	Discount	
1	Kayak	Watersports	$265.00	$10.00	Delete
2	Lifejacket	Watersports	$38.95	$10.00	Delete
3	Soccer Ball	Soccer	$9.50	$10.00	Delete
4	Corner Flags	Soccer	$24.95	$10.00	Delete
5	Thinking Cap	Chess	$6.00	$10.00	Delete

Figure 20-1. *Running the example application*

Using Service Providers

As I explained in the previous chapters, classes declare dependencies on services using their constructor arguments. When Angular needs to create a new instance of the class, it inspects the constructor and uses a combination of built-in and custom services to resolve each argument. In Listing 20-2 shows the `DiscountService` class updated so that it depends on the `LogService` class created in the previous section.

Listing 20-2. Creating a Dependency in the discount.service.ts File

```
import { Injectable } from "@angular/core";
import { LogService } from "./log.service";

@Injectable()
export class DiscountService {
    private discountValue: number = 10;

    constructor(private logger: LogService) { }

    public get discount(): number {
        return this.discountValue;
    }
    public set discount(newValue: number) {
        this.discountValue = newValue || 0;
    }

    public applyDiscount(price: number) {
        this.logger.logInfoMessage(`Discount ${this.discount}`
            + ` applied to price: ${price}`);
        return Math.max(price - this.discountValue, 5);
    }
}
```

The changes in Listing 20-2 prevent the application from running. Angular processes the HTML document and starts creating the hierarchy of components, each with their templates that require directives and data bindings, and it encounters the classes that depend on the `DiscountService` class. But it can't create an instance of `DiscountService` because its constructor requires a `LogService` object and it doesn't know how to handle this class.

When you save the changes in Listing 20-2, you will see an error like this one in the browser's JavaScript console:

```
Error in app/productForm.component.html:20:0 caused by: No provider for LogService!
```

Angular delegates responsibility for creating the objects needed for dependency injection to providers, each of which managed a single type of dependency. When it needs to create an instance of the `DiscountService` class, it looks for a suitable provider to resolve the `LogService` dependency. Since there is no such provider, Angular can't create the objects it needs to start the application and reports the error.

The simplest way to create a provider is to add the service class to the array assigned to the Angular module's `providers` property, as shown in Listing 20-3.

Listing 20-3. Creating a Provider in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";
import { LogService } from "./log.service";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model, LogService],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

When you save the changes, you will have defined the provider that Angular requires to handle the `LogService` dependency, and you will see messages like this one shown in the browser's JavaScript console:

```
Message (INFO): Discount 10 applied to price: 16
```

You might wonder why the configuration step in Listing 20-3 is required. After all, Angular could just assume that it should create a new `LogService` object the first time it needs one.

In fact, Angular provides a range of different providers, each of which creates objects in a different way to let you take control of the service creation process. Table 20-3 describes the set of providers that are available, which are described in the sections that follow.

Table 20-3. *The Angular Providers*

Name	Description
Class provider	This provider is configured using a class. Dependencies on the service are resolved by an instance of the class, which Angular creates.
Value provider	This provider is configured using an object, which is used to resolve dependencies on the service.
Factory provider	This provider is configured using a function. Dependencies on the service are resolved using an object that is created by invoking the function.
Existing service provider	This provider is configured using the name of another service and allows aliases for services to be created.

Using the Class Provider

This provider is the most commonly used. This is the provider that is targeted by adding the class names to the module's `providers` property in Listing 20-3, but this is a shorthand syntax. There is also a literal syntax that achieves the same result, as shown in Listing 20-4.

Listing 20-4. Using the Class Provider Literal Syntax in the app.module.ts File

```
...
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
               { provide: LogService, useClass: LogService }],
    bootstrap: [ProductComponent]
})
...
```

Providers are defined as classes, but they can be specified and configured using the JavaScript object literal format, like this:

```
...
{
    provide: LogService,
    useClass: LogService
}
...
```

The class provider supports three properties, which are described in Table 20-4 and explained in the sections that follow.

Table 20-4. *The Class Provider's Properties*

Name	Description
provide	This property is used to specify the token, which is used to identify the provider and the dependency that will be resolved. See the "Understanding the Token" section.
useClass	This property is used to specify the class that will be instantiated to resolve the dependency by the provider. See the "Understanding the useClass Property" section.
multi	This property can be used to deliver an array of service objects to resolve dependencies. See the "Resolving a Dependency with Multiple Objects" section.

Understanding the Token

All providers rely on a token, which the dependency injection system uses to identity the dependency that the provider can resolve. The simplest approach is to use a class as the token, which is the approach taken in Listing 20-4.

However, you can use any object as the token, which allows the dependency and the type of the object to be separated. This increases the flexibility of the dependency injection configuration because it allows a provider to supply objects of different types, which can be useful with some of the more advanced providers described later in the chapter.

Listing 20-5 uses the class provider to register the log service created at the start of the chapter using a string.

Listing 20-5. Registering a Service with a Token in the app.module.ts File

```
...
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
                { provide: "logger", useClass: LogService }],
    bootstrap: [ProductComponent]
})
...
```

In the listing the `provide` property of the new provider is set to `logger`. Angular will automatically match providers whose token is a class but needs some additional help for other token types. Listing 20-6 shows the `DiscountService` class updated with a dependency on the logging service, accessed using the `logger` token.

Listing 20-6. Using a String Provider Token in the discount.service.ts File

```
import { Injectable, Inject } from "@angular/core";
import { LogService } from "./log.service";

@Injectable()
export class DiscountService {
    private discountValue: number = 10;

    constructor(@Inject("logger") private logger: LogService) { }

    public get discount(): number {
        return this.discountValue;
    }

    public set discount(newValue: number) {
        this.discountValue = newValue || 0;
    }

    public applyDiscount(price: number) {
        this.logger.logInfoMessage(`Discount ${this.discount}`
            + ` applied to price: ${price}`);
        return Math.max(price - this.discountValue, 5);
    }
}
```

The `@Inject` decorator is applied to the constructor argument and is used to specify the provider token that should be used to resolve the dependency. When Angular needs to create an instance of the `DiscountService` class, it will inspect the constructor and use the `@Inject` decorator argument to select the provider that will be used to resolve the dependency.

Using Opaque Tokens

When using simple types as provider tokens, there is a chance that two different parts of the application will try to use the same token to identify different services, which means that the wrong type of object may be used to resolve dependencies and cause errors.

To help work around this, Angular provides the `OpaqueToken` class, which provides an object wrapper around a `string` value and which can be used to create unique token values. In Listing 20-7, I have used the `OpaqueToken` class to create a token that will be used to identify dependencies on the `LogService` class.

Listing 20-7. Creating a Token Using the OpaqueToken Class in the log.service.ts File

```
import { Injectable, OpaqueToken } from "@angular/core";
export const LOG_SERVICE = new OpaqueToken("logger");

export enum LogLevel {
    DEBUG, INFO, ERROR
}

@Injectable()
export class LogService {
    minimumLevel: LogLevel = LogLevel.INFO;

    // ...methods omitted for brevity...
}
```

The constructor for the `OpaqueToken` class accepts a `string` value that describes the service, but it is the `OpaqueToken` object itself that will be the token. Dependencies must be declared on the same `OpaqueToken` that is used to create the provider in the module, which is why the token has been created using the `const` keyword, which presents the object from being modified. Listing 20-8 shows the provider configuration using the new token.

Listing 20-8. Creating a Provider Using an OpaqueToken in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";
import { LogService, LOG_SERVICE } from "./log.service";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
        { provide: LOG_SERVICE, useClass: LogService }],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

And finally, Listing 20-9 shows the DiscountService class updated to declare a dependency using the OpaqueToken instead of a string.

Listing 20-9. Declaring a Dependency Using an OpaqueToken in the discount.service.ts File

```
import { Injectable, Inject } from "@angular/core";
import { LogService, LOG_SERVICE } from "./log.service";

@Injectable()
export class DiscountService {
    private discountValue: number = 10;

    constructor( @Inject(LOG_SERVICE) private logger: LogService) { }

    public get discount(): number {
        return this.discountValue;
    }

    public set discount(newValue: number) {
        this.discountValue = newValue || 0;
    }

    public applyDiscount(price: number) {
        this.logger.logInfoMessage(`Discount ${this.discount}`
            + ` applied to price: ${price}`);
        return Math.max(price - this.discountValue, 5);
    }
}
```

There is no difference in the functionality offered by the application, but using the OpaqueToken means that there will be no confusion between services.

Understanding the useClass Property

The class provider's useClass property specifies the class that will be instantiated to resolve dependencies. The provider can be configured with any class, which means that you can change the implementation of a service by changing the provider configuration. However, this should be used with caution, because the recipients of the service object will be expecting a specific type, and any mismatches won't result in problems until the application is running in the browser. (TypeScript type enforcement has no effect on dependency injection because it occurs at runtime, long after the type annotations have been processed by the TypeScript compiler.)

The most common way to change classes is to use different subclasses. In Listing 20-10, I extended the LogService class to create a service that writes a different format of message in the browser's JavaScript console.

Listing 20-10. Creating a Subclassed Service in the log.service.ts File

```
import { Injectable, OpaqueToken } from "@angular/core";
export const LOG_SERVICE = new OpaqueToken("logger");

export enum LogLevel {
    DEBUG, INFO, ERROR
}

@Injectable()
export class LogService {
    minimumLevel: LogLevel = LogLevel.INFO;

    logInfoMessage(message: string) {
        this.logMessage(LogLevel.INFO, message);
    }

    logDebugMessage(message: string) {
        this.logMessage(LogLevel.DEBUG, message);
    }

    logErrorMessage(message: string) {
        this.logMessage(LogLevel.ERROR, message);
    }

    logMessage(level: LogLevel, message: string) {
        if (level >= this.minimumLevel) {
            console.log(`Message (${LogLevel[level]}): ${message}`);
        }
    }
}
```

```
@Injectable()
export class SpecialLogService extends LogService {

    constructor() {
        super()
        this.minimumLevel = LogLevel.DEBUG;
    }

    logMessage(level: LogLevel, message: string) {
        if (level >= this.minimumLevel) {
            console.log(`Special Message (${LogLevel[level]}): ${message}`);
        }
    }
}
```

The SpecialLogService class extends LogService and provides its own implementation of the logMessage method. Listing 20-11 updates the provider configuration so that the useClass property specifies the new service.

Listing 20-11. Configuring the Provider in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";
import { LogService, LOG_SERVICE, SpecialLogService } from "./log.service";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
        { provide: LOG_SERVICE, useClass: SpecialLogService }],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

The combination of token and class means that dependencies on the `LOG_SERVICE` opaque token will be resolved using a `SpecialLogService` object. When you save the changes, you will see messages like this one displayed in the browser's JavaScript console, indicating that the derived service has been used:

```
Special Message (INFO): Discount 10 applied to price: 275
```

Care must be taken when setting the `useClass` property to specify a type that the dependent classes are expecting. Specifying a subclass is the safe option because the functionality of the base class is guaranteed to be available.

Resolving a Dependency with Multiple Objects

The class provider can be configured to deliver an array of objects to resolve a dependency, which can be useful if you want to provide a set of related services that differ in how they are configured. To provide an array, multiple class providers are configured using the same token and with the `multi` property set as `true`, as shown in Listing 20-12.

Listing 20-12. Configuring Multiple Service Objects in the app.module.ts File

```
...
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
        { provide: LOG_SERVICE, useClass: LogService, multi: true },
        { provide: LOG_SERVICE, useClass: SpecialLogService, multi: true }],
    bootstrap: [ProductComponent]
})
...
```

The Angular dependency injection system will resolve dependencies on the `LOG_SERVICE` token by creating `LogService` and `SpecialLogService` objects, placing them in an array, and passing them to the dependent class's constructor. The class that receives the services must be expecting an array, as shown in Listing 20-13.

Listing 20-13. Receiving Multiple Services in the discount.service.ts File

```
import { Injectable, Inject } from "@angular/core";
import { LogService, LOG_SERVICE, LogLevel } from "./log.service";

@Injectable()
export class DiscountService {
    private discountValue: number = 10;
    private logger: LogService;

    constructor( @Inject(LOG_SERVICE) loggers: LogService[]) {
        this.logger = loggers.find(l => l.minimumLevel == LogLevel.DEBUG);
    }

    public get discount(): number {
        return this.discountValue;
    }

    public set discount(newValue: number) {
        this.discountValue = newValue || 0;
    }

    public applyDiscount(price: number) {
        this.logger.logInfoMessage(`Discount ${this.discount}`
            + ` applied to price: ${price}`);
        return Math.max(price - this.discountValue, 5);
    }
}
```

The services are received as an array by the constructor, which uses the array `find` method to locate the first logger whose `minimumLevel` property is `LogLevel.Debug` and assign it to the `logger` property. The `applyDiscount` method calls the service's `logDebugMessage` method, which results in messages like this one displayed in the browser's JavaScript console:

```
Special Message (INFO): Discount 10 applied to price: 275
```

Using the Value Provider

The value provider is used when you need to take responsibility for creating the service objects yourself, rather than leaving it to the class provider. This can also be useful when services are simple types, such as `string` or `number` values, which can be a useful way of providing access to common configuration settings. The value provider can be applied using a literal object and supports the properties described in Table 20-5.

Table 20-5. *The Value Provider Properties*

Name	Description
`provide`	This property defines the service token, as described in the "Understanding the Token" section earlier in the chapter.
`useValue`	This property specifies the object that will be used to resolve the dependency.
`multi`	This property is used to allow multiple providers to be combined to provide an array of objects that will be used to resolve a dependency on the token. See the "Resolving a Dependency with Multiple Objects" section earlier in the chapter for an example.

The value provider works in the same way as the class provider except that it is configured with an object rather than a type. Listing 20-14 shows the use of the value provider to create an instance of the `LogService` class that is configured with a specific property value.

Listing 20-14. Using the Value Provider in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";
import { LogService, LOG_SERVICE, SpecialLogService, LogLevel } from "./log.service";

let logger = new LogService();
logger.minimumLevel = LogLevel.DEBUG;

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
        { provide: LogService, useValue: logger }],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

This value provider is configured to resolve dependencies on the `LogService` token with a specific object that has been created and configured outside of the module class.

The value provider—and, in fact, all of the providers—can use any object as the token, as described in the previous section, but I have returned to using types as tokens because it is the most commonly used technique and because it works so nicely with TypeScript constructor parameter typing. Listing 20-15 shows the corresponding change to the `DiscountService`, which declares a dependency using a typed constructor argument.

Listing 20-15. Declaring a Dependency Using a Type in the discount.service.ts File

```
import { Injectable, Inject } from "@angular/core";
import { LogService, LOG_SERVICE, LogLevel } from "./log.service";

@Injectable()
export class DiscountService {
    private discountValue: number = 10;

    constructor(private logger: LogService) { }

    public get discount(): number {
        return this.discountValue;
    }

    public set discount(newValue: number) {
        this.discountValue = newValue || 0;
    }

    public applyDiscount(price: number) {
        this.logger.logInfoMessage(`Discount ${this.discount}`
            + ` applied to price: ${price}`);
        return Math.max(price - this.discountValue, 5);
    }
}
```

Using the Factory Provider

The factory provider uses a function to create the object required to resolve a dependency. This provider supports the properties described in Table 20-6.

Table 20-6. *The Factory Provider Properties*

Name	Description
`provide`	This property defines the service token, as described in the "Understanding the Token" section earlier in the chapter.
`deps`	This property specifies an array of provider tokens that will be resolved and passed to the function specified by the `useFactory` property.
`useFactory`	This property specifies the function that will create the service object. The objects produced by resolving the tokens specified by the `deps` property will be passed to the function as arguments. The result returned by the function will be used as the service object.
`multi`	This property is used to allow multiple providers to be combined to provide an array of objects that will be used to resolve a dependency on the token. See the "Resolving a Dependency with Multiple Objects" section earlier in the chapter for an example.

This is the provider that gives the most flexibility in how service objects are created because you can define functions that are tailored to your application's requirements. Listing 20-16 shows a factory function that creates `LogService` objects.

Listing 20-16. Using the Factory Provider in the app.module.ts File

```
...
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
        {
            provide: LogService, useFactory: () => {
                let logger = new LogService();
                logger.minimumLevel = LogLevel.DEBUG;
                return logger;
            }
        }],

    bootstrap: [ProductComponent]
})
...
```

The function in this example is simple: it receives no arguments and just creates a new `LogService` object. The real flexibility of this provider comes when the `deps` property is used, which allows for dependencies to be created on other services. In Listing 20-17, I have defined a token that specifies a debugging level.

Listing 20-17. Defining a Logging Level Service in the log.service.ts File

```
import { Injectable, OpaqueToken } from "@angular/core";

export const LOG_SERVICE = new OpaqueToken("logger");
export const LOG_LEVEL = new OpaqueToken("log_level");

export enum LogLevel {
    DEBUG, INFO, ERROR
}

@Injectable()
export class LogService {
    minimumLevel: LogLevel = LogLevel.INFO;

    // ...methods omitted for brevity...
}

@Injectable()
export class SpecialLogService extends LogService {

    // ...methods omitted for brevity...
}
```

In Listing 20-18, I have defined a value provider that creates a service using the LOG_LEVEL token and used that service in the factory function that creates the LogService object.

Listing 20-18. Using Factory Dependencies in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";
import { LogService, LOG_SERVICE, SpecialLogService,
         LogLevel, LOG_LEVEL} from "./log.service";
```

```
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
        { provide: LOG_LEVEL, useValue: LogLevel.DEBUG },
        { provide: LogService,
          deps: [LOG_LEVEL],
          useFactory: (level) => {
            let logger = new LogService();
            logger.minimumLevel = level;
            return logger;
         }
        }],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

The `LOG_LEVEL` token is used by a value provider to define a simple value as a service. The factory provider specifies this token in its `deps` array, which the dependency injection system resolves and provides as an argument to the factory function, which uses it to set the `minimumLevel` property of a new `LogService` object.

Using the Existing Service Provider

This provider is used to create aliases for services so they can be targeted using more than one token, using the properties described in Table 20-7.

Table 20-7. *The Existing Provider Properties*

Name	Description
`provide`	This property defines the service token, as described in the “Understanding the Token” section earlier in the chapter.
`useExisting`	This property is used to specify the token of another provider, whose service object will be used to resolve dependencies on this service.
`multi`	This property is used to allow multiple providers to be combined to provide an array of objects that will be used to resolve a dependency on the token. See the “Resolving a Dependency with Multiple Objects” section earlier in the chapter for an example.

This provider can be useful when you want to refactor the set of providers but don’t want to eliminate all the obsolete tokens in order to avoid refactoring the rest of the application. Listing 20-19 shows the use of this provider.

Listing 20-19. Creating a Service Alias in the app.module.ts File

```
...
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
        { provide: LOG_LEVEL, useValue: LogLevel.DEBUG },
        { provide: "debugLevel", useExisting: LOG_LEVEL },
        { provide: LogService,
          deps: ["debugLevel"],
          useFactory: (level) => {
            let logger = new LogService();
            logger.minimumLevel = level;
            return logger;
         }
        }],
    bootstrap: [ProductComponent]
})
...
```

The token for the new service is the string `debugLevel`, and it is aliased to the provider with the `LOG_LEVEL` token. Using either token will result in the dependency being resolved with the same value.

Using Local Providers

When Angular creates a new instance of a class, it resolves any dependencies using an *injector*. It is an injector that is responsible for inspecting the constructors of classes to determine what dependencies have been declared and resolving them using the available providers.

So far, all of the dependency injection examples have relied on providers configured in the application's Angular module. But the Angular dependency injection system is more complex: there is a hierarchy of injectors that corresponds to the application's tree of components and directives. Each component and directive can have its own injector, and each injector can be configured with its own set of providers, known as *local providers*.

When there is a dependency to resolve, Angular uses the injector for the nearest component or directive. The injector first tries to resolve the dependency using its own set of local providers. If no local providers have been set up or there are no providers that can be used to resolve this specific dependency, then the injector consults the parent component's injector. The process is repeated—the parent component's injector tries to resolve the dependency using its own set of local providers. If a suitable provider is available, then it is used to provide the service object required to resolve the dependency. If there is no suitable provider, then the request is passed up to the next level in the hierarchy, to the grandparent of the original injector. At the top of the hierarchy is the root Angular module, whose providers are the last resort before reporting an error.

Defining providers in the Angular module means that all dependencies for a token within the application will be resolved using the same object. As I explain in the following sections, registering providers further down the injector hierarchy can change this behavior and alter the way that services are created and used.

Understanding the Limitations of Single Service Objects

Using a single service object can be a powerful tool, allowing building blocks in different parts of the application to share data and respond to user interactions. But some services don't lend themselves to being shared so widely. As a simple example, Listing 20-20 adds a dependency on LogService to one of the pipes created in Chapter 18.

Listing 20-20. Adding a Service Dependency in the discount.pipe.ts File

```
import { Pipe, Injectable } from "@angular/core";
import { DiscountService } from "./discount.service";
import { LogService } from "./log.service";

@Pipe({
    name: "discount",
    pure: false
})
export class PaDiscountPipe {

    constructor(private discount: DiscountService,
                private logger: LogService) { }

    transform(price: number): number {
        if (price > 100) {
            this.logger.logInfoMessage(`Large price discounted: ${price}`);
        }
        return this.discount.applyDiscount(price);
    }
}
```

The pipe's transform method uses the LogService object, which is received as a constructor argument, to generate logging messages when the price it transforms is greater than 100.

The problem is that these log messages are drowned out by the messages generated by the DiscountService object, which creates a message every time a discount is applied. The obvious thing to do is to change the minimum level in the LogService object when it is created by the module provider's factory function, as shown in Listing 20-21.

Listing 20-21. Changing the Logging Level in the app.module.ts File

```
...
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective],
    providers: [DiscountService, SimpleDataSource, Model,
        { provide: LOG_LEVEL, useValue: LogLevel.ERROR },
        { provide: "debugLevel", useExisting: LOG_LEVEL },
        {
            provide: LogService,
            deps: ["debugLevel"],
            useFactory: (level) => {
                let logger = new LogService();
                logger.minimumLevel = level;
                return logger;
            }
        }],
    bootstrap: [ProductComponent]
})
...
```

Of course, this doesn't have the desired effect because the same `LogService` object is used throughout the application and filtering the `DiscountService` messages means that the pipe messages are filtered too.

I could enhance the `LogService` class so there are different filters for each source of logging messages, but that gets complicated pretty quickly. Instead, I am going to solve the problem by creating a local provider so that there are multiple `LogService` objects in the application, each of which can then be configured separately.

Creating Local Providers in a Directive

Directives define local providers using the `providers` property, using the same providers and syntax described at the start of the chapter. When Angular needs to resolve a dependency for the directive or one of its content children—meaning the directives or pipes contained within its host element—then the local provider will be used. Listing 20-22 shows a local provider created by a directive.

Listing 20-22. Creating a Local Provider in the cellColorSwitches.directive.ts File

```
import {
    Directive, Input, Output, EventEmitter,
    SimpleChange, ContentChildren, QueryList
} from "@angular/core";
import { PaCellColor } from "./cellColor.directive";
import { LogService } from "./log.service";

@Directive({
    selector: "table",
    providers: [LogService]
})
export class PaCellColorSwitcher {

    @Input("paCellDarkColor")
    modelProperty: Boolean;

    @ContentChildren(PaCellColor)
    contentChildren: QueryList<PaCellColor>;

    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        this.updateContentChildren(changes["modelProperty"].currentValue);
    }
    ngAfterContentInit() {
        this.contentChildren.changes.subscribe(() => {
            setTimeout(() => this.updateContentChildren(this.modelProperty), 0);
        });
    }

    private updateContentChildren(dark: Boolean) {
        if (this.contentChildren != null && dark != undefined) {
            this.contentChildren.forEach((child, index) => {
                child.setColor(index % 2 ? dark : !dark);
            });
        }
    }
}
```

This directive was responsible for changing the color of table cells in an earlier chapter by coordinating with another directive. It may seem like an odd place to create a local provider, but the hierarchy of injectors follows the structure of the application, and this directive operates on the `table` element, which means that the pipe objects that have the `LogService` dependency are children of the directive's host element.

When Angular needs to create a new pipe object, it detects the dependency on `LogService` and starts working its way up the application hierarchy, examining each component and directive that it finds to determine whether they have a provider that can be used to resolve the dependency. The `PaCellColorSwitcher` directive does have a `LogService` provider, which is used to create the service used to resolve the pipe's dependency. This means there are now two `LogService` objects in the application, each of which can be configured separately, as shown in Figure 20-2.

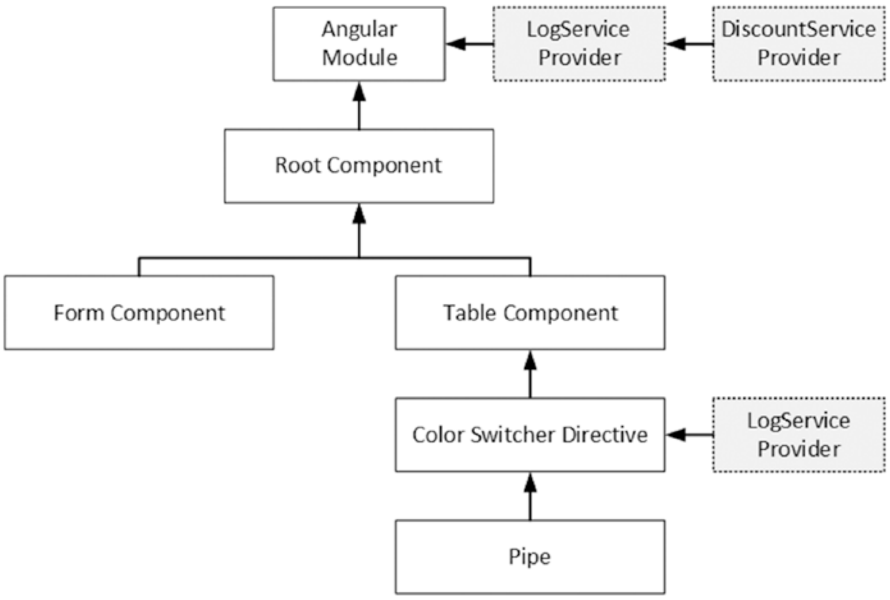


Figure 20-2. *Creating a local provider*

The LogService object created by the color switcher directive's provider uses the default value for its minimumLevel property and will display LogLevel.INFO messages. The LogService object created by the module, which will be used to resolve all other dependencies in the application, including the one declared by the DiscountService class, is configured so that it will display only LogLevel.ERROR messages. When you save the changes, you will see the logging messages from the pipe (which receives the service from the directive) but not from DiscountService (which receives the service from the module).

Creating Local Providers in a Component

Creating local providers is slightly more complex in a component because there is a decision to be made about the visibility of the services that are created. Components support two decorator properties for creating local providers, as described in Table 20-8.

Table 20-8. *The Component Decorator Properties for Local Providers*

Name	Description
providers	This property is used to create a provider used to resolve dependencies of view and content children.
viewProviders	This property is used to create a provider used to resolve dependencies of view children.

To demonstrate the use of these properties, I added a file called valueDisplay.directive.ts to the app folder and used it to define the directive shown in Listing 20-23.

Listing 20-23. The Contents of the valueDisplay.directive.ts File in the app Folder

```
import { Directive, OpaqueToken, Inject, HostBinding} from "@angular/core";
export const VALUE_SERVICE = new OpaqueToken("value_service");

@Directive({
    selector: "[paDisplayValue]"
})
export class PaDisplayValueDirective {

    constructor( @Inject(VALUE_SERVICE) serviceValue: string) {
        this.elementContent = serviceValue;
    }

    @HostBinding("textContent")
    elementContent: string;
}
```

The VALUE_SERVICE opaque token will be used to define a value-based service, on which the directive in this listing declares a dependency so that it can be displayed in the host element's content. Listing 20-24 shows the service being defined and the directive being registered in the Angular module. I have also simplified the LogService provider in the module for brevity.

Listing 20-24. Registering the Directive and Service in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";
import { LogService, LOG_SERVICE, SpecialLogService,
    LogLevel, LOG_LEVEL} from "./log.service";
import { VALUE_SERVICE, PaDisplayValueDirective} from "./valueDisplay.directive";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective, PaDisplayValueDirective],
    providers: [DiscountService, SimpleDataSource, Model, LogService,
                { provide: VALUE_SERVICE, useValue: "Apples" }],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

The provider sets up a value of `Apples` for the `VALUE_SERVICE` service. The next step is to apply the new directive so there is an instance that is a view child of a component and another that is a content child. Listing 20-25 sets up the content child instance.

Listing 20-25. Applying a Content Child Directive in the template.html File

```
<div class="col-xs-4 p-a-1">
    <paProductForm>
        <span paDisplayValue></span>
    </paProductForm>
</div>
```

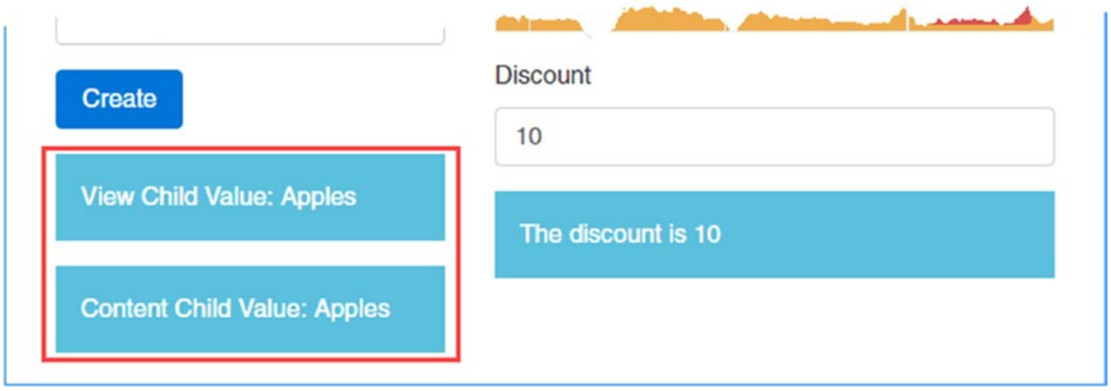
```
<div class="col-xs-8 p-a-1">
    <paProductTable></paProductTable>
</div>
```

Listing 20-26 projects the host element's content and adds a view child instance of the new directive.

Listing 20-26. Adding Directives in the productForm.component.html File

```
<form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">
    <div class="form-group" *ngFor="let control of form.productControls">
        <label>{{control.label}}</label>
        <input class="form-control"
            [(ngModel)]="newProduct[control.modelProperty]"
            name="{{control.modelProperty}}"
            formControlName="{{control.modelProperty}}" />
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || control.dirty) && !control.valid">
            <li *ngFor="let error of control.getValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>
    <button class="btn btn-primary" type="submit"
        [disabled]="formSubmitted && !form.valid"
        [class.btn-secondary]="formSubmitted && !form.valid">
            Create
    </button>
</form>
<div class="bg-info m-t-1 p-a-1">
    View Child Value: <span paDisplayValue></span>
</div>
<div class="bg-info m-t-1 p-a-1">
    Content Child Value: <ng-content></ng-content>
</div>
```

When you save the changes, you will see the new elements, as shown in Figure 20-3, both of which show the same value because the only provider for VALUE_SERVICE is defined in the module.



View Child Value: Apples

Content Child Value: Apples

The discount is 10

Figure 20-3. *View and content child directives*

Creating a Local Provider for All Children

The `@Component` decorator's `providers` property is used to define providers that will be used to resolve service dependencies for all children, regardless of whether they are defined in the template (view children) or projected from the host element (content children). Listing 20-27 defines a `VALUE_SERVICE` provider in the parent component for two new directive instances.

Listing 20-27. Defining a Provider in the productForm.component.ts File

```
import { Component, Output, EventEmitter, ViewEncapsulation } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";
import { Model } from "./repository.model";
import { VALUE_SERVICE } from "./valueDisplay.directive";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    providers: [{ provide: VALUE_SERVICE, useValue: "Oranges" }]
})
export class ProductFormComponent {
    form: ProductFormGroup = new ProductFormGroup();
    newProduct: Product = new Product();
    formSubmitted: boolean = false;

    constructor(private model: Model) { }

    submitForm(form: any) {
        this.formSubmitted = true;
        if (form.valid) {
            this.model.saveProduct(this.newProduct);
            this.newProduct = new Product();
            this.form.reset();
            this.formSubmitted = false;
        }
    }
}
```

The new provider changes the service value. When Angular comes to create the instances of the new directive, it begins its search for providers by working its way up the application hierarchy and finds the VALUE_SERVICE provider defined in Listing 20-27. The service value is used by both instances of the directive, as shown in Figure 20-4.

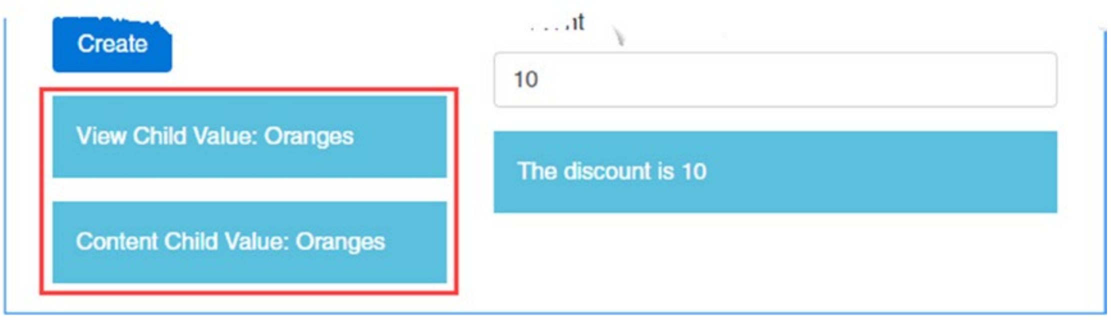


Figure 20-4. *Defining a provider for all children in a component*

Creating a Provider for View Children

The viewProviders property defines providers that are used to resolve dependencies for view children but not content children. Listing 20-28 uses the viewProviders property to define a provider for VALUE_SERVICE.

Listing 20-28. Defining a View Child Provider in the productForm.component.ts File

```
import { Component, Output, EventEmitter, ViewEncapsulation } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";
import { Model } from "./repository.model";
import { VALUE_SERVICE } from "./valueDisplay.directive";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    viewProviders: [{ provide: VALUE_SERVICE, useValue: "Oranges" }]
})
export class ProductFormComponent {

    // ...methods and properties omitted for brevity...
}
```

Angular uses the provider when resolving dependencies for view children but not for content children. This means dependencies for content children are referred up the application's hierarchy as though the component had not defined a provider. In the example, this means that the view child will receive the service created by the component's provider, and the content child will receive the service created by the module's provider, as shown in Figure 20-5.

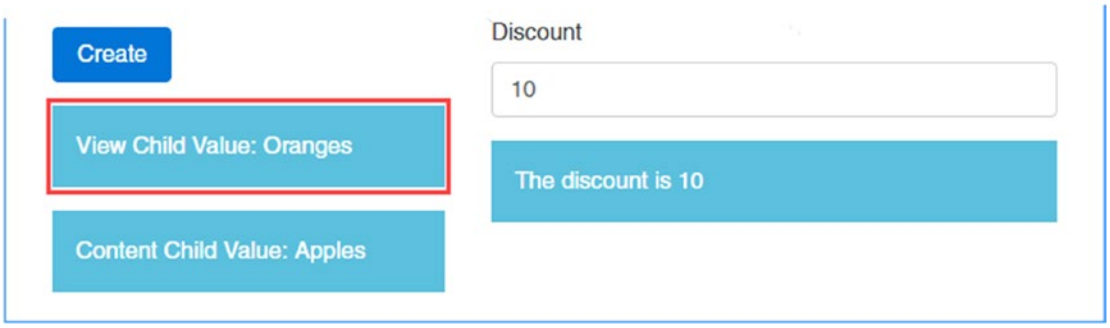


Figure 20-5. *Defining a provider for view children*

■ **Caution** Defining providers for the same service using both the `providers` and `viewProviders` properties is not supported. If you do this, the view and content children will both receive the service created by the `viewProviders` provider.

Controlling Dependency Resolution

Angular provides three decorators that can be used to provide instructions about how a dependency is resolved. These decorators are described in Table 20-9 and demonstrated in the following sections.

Table 20-9. *The Dependency Resolution Decorators*

Name	Description
`@Host`	This decorator restricts the search for a provider to the nearest component.
`@Optional`	This decorator stops Angular from reporting an error if the dependency cannot be resolved.
`@SkipSelf`	This decorator excludes the providers defined by the component/directive whose dependency is being resolved.

Restricting the Provider Search

The `@Host` decorator restricts the search for a suitable provider so that it stops once the closest component has been reached. The decorator is typically combined with `@Optional`, which prevents Angular from throwing an exception if a service dependency cannot be resolved. Listing 20-29 shows the addition of both decorators to the directive in the example.

Listing 20-29. Adding Dependency Decorators in the valueDisplay.directive.ts File

```
import { Directive, OpaqueToken, Inject,
         HostBinding, Host, Optional} from "@angular/core";

export const VALUE_SERVICE = new OpaqueToken("value_service");

@Directive({
    selector: "[paDisplayValue]"
})
export class PaDisplayValueDirective {

    constructor( @Inject(VALUE_SERVICE) @Host() @Optional() serviceValue: string) {
        this.elementContent = serviceValue || "No Value";
    }

    @HostBinding("textContent")
    elementContent: string;
}
```

When using the `@Optional` decorator, you must ensure that the class is able to function if the service cannot be resolved, in which case the constructor argument for the service is `undefined`. The nearest component defines a service for its view children but not content children, which means that one instance of the directive will receive a service object and the other will not, as illustrated in Figure 20-6.

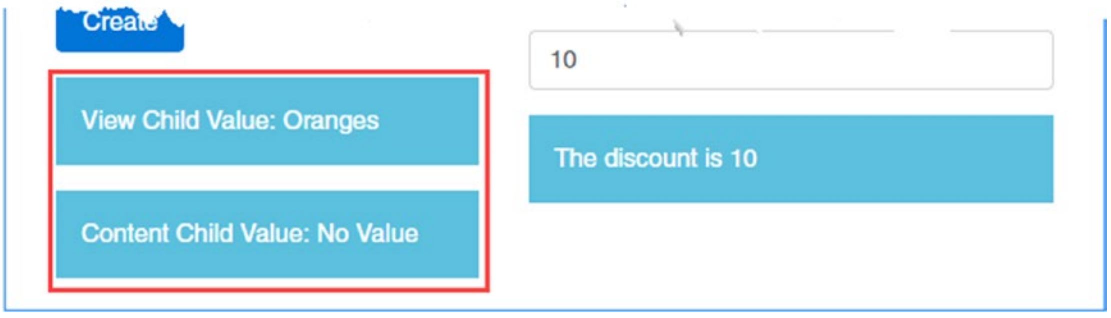


Figure 20-6. *Controlling how a dependency is resolved*

Skipping Self-Defined Providers

By default, the providers defined by a component or directive are used to resolve its dependencies. The `@SkipSelf` decorator can be applied to constructor arguments to tell Angular to ignore the local providers and start the search at the next level in the application hierarchy, which means that the local providers will be used only to resolve dependencies for children. In Listing 20-30, I have added a dependency on the `VALUE_SERVICE` provider that is decorated with `@SkipSelf`.

Listing 20-30. Skipping Local Providers in the productForm.component.ts File

```
import { Component, Output, EventEmitter, ViewEncapsulation,
         Inject, SkipSelf } from "@angular/core";
import { Product } from "./product.model";
import { ProductFormGroup } from "./form.model";
import { Model } from "./repository.model";
import { VALUE_SERVICE } from "./valueDisplay.directive";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    viewProviders: [{ provide: VALUE_SERVICE, useValue: "Oranges" }]
})
export class ProductFormComponent {
    form: ProductFormGroup = new ProductFormGroup();
    newProduct: Product = new Product();
    formSubmitted: boolean = false;

    constructor(private model: Model,
            @Inject(VALUE_SERVICE) @SkipSelf() private serviceValue: string) {
        console.log("Service Value: " + serviceValue);
    }

    submitForm(form: any) {
        this.formSubmitted = true;
        if (form.valid) {
            this.model.saveProduct(this.newProduct);
            this.newProduct = new Product();
            this.form.reset();
            this.formSubmitted = false;
        }
    }
}
```

When you save the changes and the browser reloads the page, you will see the following message in the browser's JavaScript console, showing that the service value defined locally (`Oranges`) has been skipped and allowing the dependency to be resolved by the Angular module:

```
Service Value: Apples
```

Summary

In this chapter, I explained the role that providers play in dependency injection and explained how they can be used to change how services are used to resolve dependencies. I described the different types of provider that can be used to create service objects and demonstrated how directives and components can define their own providers to resolve their own dependencies and those of their children. In the next chapter, I describe modules, which are the final building block for Angular applications.

CHAPTER 21

Using and Creating Modules

In this chapter, I describe the last of the Angular building blocks: modules. In the first part of the chapter, I describe the root module, which every Angular application uses to describe the configuration of the application to Angular. In the second part of the chapter, I describe feature modules, which are used to add structure to an application so that related features can be grouped as a single unit. Table 21-1 puts modules in context.

Table 21-1. *Putting Modules in Context*

Question	Answer
What are they?	Modules provide configuration information to Angular.
Why are they useful?	The root module describes the application to Angular, setting up essential features such as components and services. Feature modules are useful for adding structure to complex projects, making them easier to manage and maintain.
How are they used?	Modules are classes to which the `@NgModule` decorator has been applied. The properties used by the decorator have different meanings for root and feature modules.
Are there any pitfalls or limitations?	There is no module-wide scope for providers, which means that the providers defined by a feature module will be available as though they had been defined by the root module.
Are there any alternatives?	Every application must have a rot module, but the use of feature modules is entirely optional. However, if you don't use feature modules, then the files in an application can become difficult to manage.

Table 21-2 summarizes the chapter.

Table 21-2. *Chapter Summary*

Problem	Solution	Listing
Describe an application and the building blocks it contains	Use the root module	1–7
Group related features together	Create a feature module	8–28

Preparing the Example Project

As with the other chapters in this part of the book, I am going to use the example project that was created in Chapter 11 and has been expanded and extended in each chapter since.

■ **Tip** You can download the same code for all the chapters in this book from apress.com if you don't want to have to create the project yourself.

To prepare for this chapter, I have removed some functionality from the component templates. Listing 21-1 shows the template for the product table, in which I have commented out the elements for the discount editor and display components.

Listing 21-1. The Contents of the productTable.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th></th><th>Name</th><th>Category</th><th>Price</th>
        <th>Discount</th><th></th>
    </tr>
    <tr *paFor="let item of getProducts(); let i = index;
            let odd = odd; let even = even" [class.bg-info]="odd"
            [class.bg-warning]="even">
        <td style="vertical-align:middle">{{i + 1}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | discount | currency:"USD":true }}
        </td>
        <td style="vertical-align:middle" [pa-price]="item.price"
            #discount="discount">
            {{ discount.discountAmount | currency:"USD": true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
        </td>
    </tr>
</table>
<!--<paDiscountEditor></paDiscountEditor>-->
<!--<paDiscountDisplay></paDiscountDisplay>-->
```

Listing 21-2 shows the template from the product form component, in which I have commented out the elements that I used to demonstrate the difference between providers for view children and content children in Chapter 20.

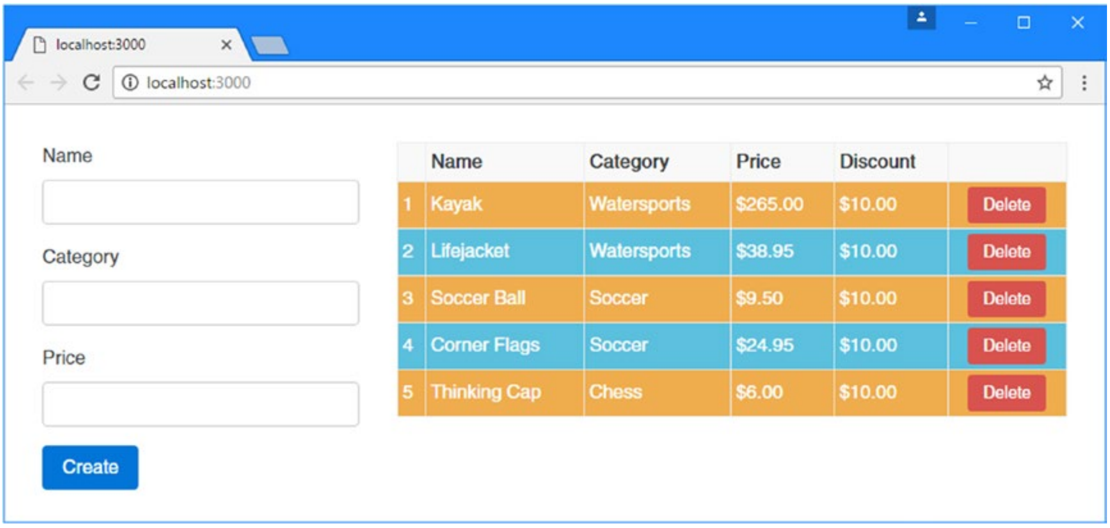
Listing 21-2. The Contents of the productForm.component.html File

```
<form novalidate [formGroup]="form" (ngSubmit)="submitForm(form)">
    <div class="form-group" *ngFor="let control of form.productControls">
        <label>{{control.label}}</label>
        <input class="form-control"
            [(ngModel)]="newProduct[control.modelProperty]"
            name="{{control.modelProperty}}"
            formControlName="{{control.modelProperty}}" />
        <ul class="text-danger list-unstyled"
                *ngIf="(formSubmitted || control.dirty) && !control.valid">
            <li *ngFor="let error of control.getValidationMessages()">
                {{error}}
            </li>
        </ul>
    </div>
    <button class="btn btn-primary" type="submit"
        [disabled]="formSubmitted && !form.valid"
        [class.btn-secondary]="formSubmitted && !form.valid">
            Create
    </button>
</form>
<!--<div class="bg-info m-t-1 p-a-1">
    View Child Value: <span paDisplayValue></span>
</div>
<div class="bg-info m-t-1 p-a-1">
    Content Child Value: <ng-content></ng-content>
</div>-->
```

Start the TypeScript compiler and development HTTP server by running the following command in the example folder:

```
npm start
```

A new browser window or tab will open and you will see the content shown in Figure 21-1.



	Name	Category	Price	Discount	
1	Kayak	Watersports	$265.00	$10.00	Delete
2	Lifejacket	Watersports	$38.95	$10.00	Delete
3	Soccer Ball	Soccer	$9.50	$10.00	Delete
4	Corner Flags	Soccer	$24.95	$10.00	Delete
5	Thinking Cap	Chess	$6.00	$10.00	Delete

Figure 21-1. *Running the example application*

Understanding the Root Module

Every Angular has at least one module, known as the root module. The root module is conventionally defined in a file called `app.module.ts` in the app folder, and it contains a class to which the `@NgModule` decorator has been applied. Listing 21-3 shows the root module from the example application.

Listing 21-3. The Root Module in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";
import { LogService, LOG_SERVICE, SpecialLogService,
    LogLevel, LOG_LEVEL} from "./log.service";
import { VALUE_SERVICE, PaDisplayValueDirective} from "./valueDisplay.directive";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective, PaDisplayValueDirective],
    providers: [DiscountService, SimpleDataSource, Model, LogService,
        { provide: VALUE_SERVICE, useValue: "Apples" }],
    bootstrap: [ProductComponent]
})
export class AppModule { }
```

There can be multiple modules in a project but the root module is the one used in the bootstrap file, which is conventionally called `main.ts` and is defined in the app folder. Listing 21-4 shows the `main.ts` file for the example project.

ANGULAR MODULES VERSUS JAVASCRIPT MODULES

There are two kinds of module in an Angular application: Angular modules and JavaScript modules. The Angular module is a class to which the `@NgModule` decorator has been applied. Every application has a root Angular module, and Angular modules are added to the application using the root component's `imports` property. In Listing 21-3, the `FormsModule` is included in the root module's `imports` property, enabling the functionality that it contains.

```
...
imports: [BrowserModule, FormsModule, ReactiveFormsModule],
...
```

The browser needs to load the code in the Angular module, which is where the JavaScript package comes in. To bring the `FormsModule` type into scope, the `app.module.ts` file contains an `import` statement like this:

```
...
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
...
```

The `@angular/forms` reference is for a JavaScript module. The JavaScript module loader, the SystemJS package in the case of the example application, maps the `@angular/forms` reference to the file `node_modules/@angular/forms/bundles/forms.umd.min.js`, which is a minified JavaScript code file that contains multiple Angular modules.

So, even though the term *module* has two different meanings in an Angular application, those meaning are related. Angular modules are classes that provide access to Angular functionality and that are packaged for delivery to the browser in JavaScript modules.

Listing 21-4. The Angular Bootstrap in the main.ts File

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { AppModule } from './app.module';

platformBrowserDynamic().bootstrapModule(AppModule);
```

Angular applications can be run in different environments, such as web browsers and native application containers. The job of the bootstrap file is to select the platform and identify the root module. The `platformBrowserDynamic` method creates the browser runtime, and the `bootstrapModule` method is used to specify the module, which is the `AppModule` class from Listing 21-3.

When defining the root module, the `@NgModule` decorator properties described in Table 21-3 are used. (There are additional decorator properties, which are described later in the chapter.)

Table 21-3. *The @NgModule Decorator Root Module Properties*

Name	Description
`imports`	This property specifies the Angular modules that are required to support the directives, components, and pipes in the application.
`declarations`	This property is used to specify the directives, components, and pipes that are used in the application.
`providers`	This property defines the service providers that will be used by the module's injector. These are the providers that will be available throughout the application and used when no local provider for a service is available, as described in Chapter 20.
`bootstrap`	This property specifies the root components for the application.

Understanding the Imports Property

The `imports` property is used to list the other modules that the application requires. In the example application, these are all modules provided by the Angular framework.

```
...
imports: [BrowserModule, FormsModule, ReactiveFormsModule],
...
```

The `BrowserModule` provides the functionality required to run Angular applications in web browsers. The other two modules provide support for working with HTML forms and model-based forms, as described in Chapter 14. There are other Angular modules, which are introduced in later chapters.

The `imports` property is also used to declare dependency on custom modules, which are used to manage complex Angular applications and to create units of reusable functionality. I explain how custom modules are defined in the "Creating Feature Modules" section.

Understanding the Declarations Property

The `declarations` property is used to provide Angular with a list of the directives, components, and pipes that the application requires, known collectively as the *declarable classes*. The `declarations` property in the example project root module contains a long list of classes, each of which is available only for use elsewhere in the application because it is listed here.

```
...
declarations: [ProductComponent, PaAttrDirective, PaModel,
    PaStructureDirective, PaIteratorDirective,
    PaCellColor, PaCellColorSwitcher, ProductTableComponent,
    ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
    PaDiscountDisplayComponent, PaDiscountEditorComponent,
    PaDiscountPipe, PaDiscountAmountDirective, PaDisplayValueDirective],
...
```

Notice that the built-in declarable classes, such as the directives described in Chapter 13 and the pipes described in Chapter 18, are not included in the `declarations` property for the root module. This is because they are managed by the `BrowserModule`, and when you add a module to the `imports` property, its declarable classes are automatically available for use in the application.

Understanding the Providers Property

The `providers` property is used to define the service providers that will be used to resolve dependencies when there are no suitable local providers available. The use of providers for services is described in detail in Chapters 19 and 20.

Understanding the Bootstrap Property

The `bootstrap` property specifies the root component or components for the application. When Angular process the main HTML document, which is conventionally called `index.html`, it inspects the root components and applies them using the value of the `selector` property in the `@Component` decorators.

■ **Tip** The components listed in the bootstrap property must also be included in the `declarations` list.

Here is the `bootstrap` property from the example project's root module:

```
...
bootstrap: [ProductComponent]
...
```

The `ProductComponent` class provides the root component, and its `selector` property specifies the app element, as shown in Listing 21-5.

Listing 21-5. The Root Component in the component.ts File

```
import { Component } from "@angular/core";

@Component({
    selector: "app",
    templateUrl: "app/template.html"
})
export class ProductComponent {

}
```

When I started the example project in Chapter 11, the root component had a lot of functionality. But since the introduction of additional components, the role of this component has been reduced, and it is now essentially a placeholder that tells Angular to project the contents of the `app/template.html` file into the `app` element in the HTML document, which allows the components that do the real work in the application to be loaded.

There is nothing wrong with this approach, but it does mean that the root component in the application doesn't have a great deal to do. If this kind of redundancy feels untidy, then you can specify multiple root components in the root module, and all of them will be used to target elements in the HTML document. To demonstrate, I have removed the existing root component from the root module's `bootstrap` property and replaced it with the component classes that are responsible for the product form and the product table, as shown in Listing 21-6.

Listing 21-6. Specifying Multiple Root Components in the app.module.ts File

```
...
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective, PaDisplayValueDirective],
    providers: [DiscountService, SimpleDataSource, Model, LogService,
        { provide: VALUE_SERVICE, useValue: "Apples" }],
    bootstrap: [ProductFormComponent, ProductTableComponent]
})
export class AppModule { }
...
```

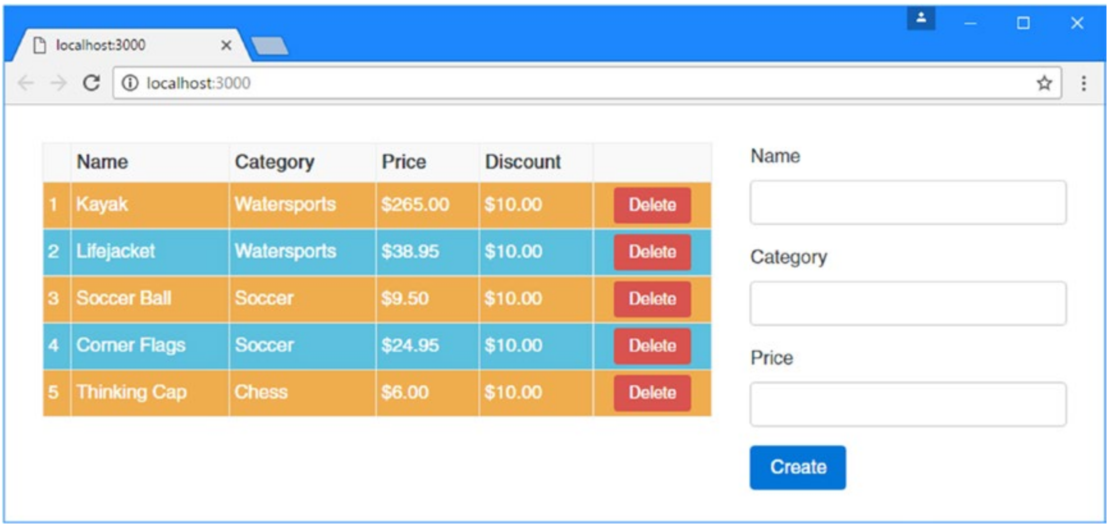
Listing 21-7 reflects the change in the root components in the main HTML document.

Listing 21-7. Changing the Root Component Elements in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <title></title>
    <meta charset="utf-8" />
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/intl/dist/Intl.complete.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
</head>
```

```
<body class="m-a-1">
    <div class="col-xs-8 p-a-1">
        <paProductTable></paProductTable>
    </div>
    <div class="col-xs-4 p-a-1">
        <paProductForm></paProductForm>
    </div>
</body>
</html>
```

I have reversed the order in which these components appear compared to previous examples, just to create a detectable change in the application's layout. When all the changes are saved and the browser has reloaded the page, you will see the new root components displayed, as illustrated by Figure 21-2.



	Name	Category	Price	Discount	
1	Kayak	Watersports	$265.00	$10.00	Delete
2	Lifejacket	Watersports	$38.95	$10.00	Delete
3	Soccer Ball	Soccer	$9.50	$10.00	Delete
4	Corner Flags	Soccer	$24.95	$10.00	Delete
5	Thinking Cap	Chess	$6.00	$10.00	Delete

***Figure 21-2.** Using multiple root components*

The module's service providers are used to resolve dependencies for all root components. In the case of the example application, this means that there is a single `Model` service object that is shared throughout the application and that allows products created with the HTML form to be displayed automatically in the table, even though these components have been promoted to be root components.

Creating Feature Modules

As I have described different features to the example application, the root module has become increasingly complex, with a long list of `import` statements to load JavaScript modules and a set of classes in the `declararations` property of the `@NgModule` decorator that spans several lines, as shown in Listing 21-8.

Listing 21-8. The Contents of the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule  } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";
import { LogService, LOG_SERVICE, SpecialLogService,
    LogLevel, LOG_LEVEL} from "./log.service";
import { VALUE_SERVICE, PaDisplayValueDirective} from "./valueDisplay.directive";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective, PaDisplayValueDirective],
    providers: [DiscountService, SimpleDataSource, Model, LogService,
        { provide: VALUE_SERVICE, useValue: "Apples" }],
    bootstrap: [ProductFormComponent, ProductTableComponent]
})
export class AppModule { }
```

Feature modules are used to group related functionality together so that it can be used as a single entity, just like the Angular modules. When I need to use the features for working with forms, for example, I don't have to add `import` statements and `declarations` entries for each individual directive, component, or pipe. Instead, I just add `BrowserModule` to the decorator's `import` property, and all of the functionality it contains is available throughout the application.

When you create a feature module, you can choose to focus on an application function or elect to group together a set of related building blocks that provide your application's infrastructure. I'll do both in the sections that follow because they work in slightly different ways and have different considerations. Feature modules use the same `@NgModule` decorator but with an overlapping set of configuration properties, some of which are new and some of which are used in common with the root module but have a different effect. I explain how these properties are used in the following sections, but Table 21-4 provides a summary for future quick reference.

Table 21-4. *The @NgModule Decorator Properties for Feature Modules*

Name	Description
`imports`	This property is used to import the modules that are required by the classes in the modules.
`providers`	This property is used to define the module's providers. When the feature module is loaded, the set of providers are combined with those in the root module, which means that the feature module's services are available throughout the application (and not just within the module).
`declarations`	This property is used to specify the directives, components, and pipes in the module. This property must contain the classes that are used within the module and those that are exposed by the module to the rest of the application.
`exports`	This property is used to define the public exports from the module. It contains some or all of the directives, components, and pipes from the `declarations` property and some or all of the modules from the `imports` property.

Creating a Model Module

The term *model module* might be a tongue twister, but it is generally a good place to start when refactoring an application using feature modules because just about every other building block in the application depends on the model.

The first step is to create the folder that will contain the module. Module folders are defined within the `app` folder and are given a meaningful name. For this module, I created an `app/model` folder.

The naming conventions used for Angular files makes it easy to move and delete multiple files. Run the following commands in the `example` folder to move the files (they will work in Windows PowerShell, Linux, and macOS):

```
mv app/*.model.ts app/model/
mv app/limit.formvalidator.ts app/model/
```

Once you have moved all the files, you should delete the corresponding JavaScript files by running the following commands in the example folder:

```
rm app/*.model.js
rm app/limit.formvalidator.js
```

The result is that the files listed in Table 21-5 are moved to the `model` folder.

Table 21-5. *The File Moves Required for the Module*

File	New Location
`app/datasource.model.ts`	`app/model/datasource.model.ts`
`app/form.model.ts`	`app/model/form.model.ts`
`app/limit.formvalidator.ts`	`app/model/limit.formvalidator.ts`
`app/product.model.ts`	`app/model/product.model.ts`
`app/repository.model.ts`	`app/model/repository.model.ts`

When you have finished moving and deleting file, the TypeScript compiler will list a series of compiler errors because some of the key declarable classes are unavailable and the browser will report errors because it can't find the JavaScript files that were removed. I'll work through dealing with these problems in the sections that follow.

Creating the Module Definition

The next step is to define a module that brings together the functionality in the files that have been moved to the new folder. I added a file called `model.module.ts` in the `app/model` folder and defined the module shown in Listing 21-9.

Listing 21-9. The Contents of the model.module.ts File in the app/model Folder

```
import { NgModule } from "@angular/core";
import { SimpleDataSource } from "./datasource.model";
import { Model } from "./repository.model";

@NgModule({
    providers: [Model, SimpleDataSource]
})
export class ModelModule { }
```

This is a simple module, but there are some important characteristics to understand because the purpose of a feature module is to selectively expose the contents of the module folder to the rest of the application.

The `@NgModule` decorator for this module uses only the `providers` property to define class providers for the `Model` and `SimpleDataSource` services. When you use providers in a feature module, they are registered with the root module's injector, which means they are available throughout the application, which is exactly what is required for the data model in the example application.

■ **Tip** A common mistake is to assume that services defined in a module are accessible only to the classes within that module. There is no module scope in Angular. Providers defined by a feature module are used as though they were defined by the root module. Local providers defined by directives and components in the feature module are available to their view and content children even if they are defined in other modules.

Updating the Other Classes in the Application

Moving classes into the `model` folder has broken `import` statements in other parts of the application, which depend on either the `Product` or `ProductFormGroup` class. The next step is to update those `import` statements to point to the new module. There are four affected files: `attr.directive.ts`, `categoryFilter.pipe.ts`, `productForm.component.ts`, and `productTable.component.ts`. Listing 21-10 shows the changes required to the `attr.directive.ts` file.

Listing 21-10. Updating the Import Reference in the attr.directive.ts File

```
import { Directive, ElementRef, Attribute, Input,
    SimpleChange, Output, EventEmitter, HostListener, HostBinding }
from "@angular/core";
import { Product } from "./model/product.model";
```

```
@Directive({
    selector: "[pa-attr]"
})
export class PaAttrDirective {

    // ...statements omitted for brevity...
}
```

The only change that is required is to update the path used in the `import` statement to reflect the new location of the code file. Listing 21-11 shows the same change applied to the `categoryFilter.pipe.ts` file.

Listing 21-11. Updating the Import Reference in the categoryFilter.pipe.ts File

```
import { Pipe } from "@angular/core";
import { Product } from "./model/product.model";

@Pipe({
    name: "filter",
    pure: false
})
export class PaCategoryFilterPipe {

    transform(products: Product[], category: string): Product[] {
        return category == undefined ?
            products : products.filter(p => p.category == category);
    }
}
```

Listing 21-12 updates the `import` statements in the `productForm.component.ts` file.

Listing 21-12. Updating Import Paths in the productForm.component.ts File

```
import { Component, Output, EventEmitter, ViewEncapsulation,
    Inject, SkipSelf } from "@angular/core";
import { Product } from "./model/product.model";
import { ProductFormGroup } from "./model/form.model";
import { Model } from "./model/repository.model";
import { VALUE_SERVICE } from "./valueDisplay.directive";

@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    viewProviders: [{ provide: VALUE_SERVICE, useValue: "Oranges" }]
})
export class ProductFormComponent {

    // ...statements omitted for brevity...
}
```

Listing 21-13 updates the paths in the final file, `productTable.component.ts`.

Listing 21-13. Updating Import Paths in the productTable.component.ts File

```
import { Component, Input, ViewChildren, QueryList } from "@angular/core";
import { Model } from "./model/repository.model";
import { Product } from "./model/product.model";
import { DiscountService } from "./discount.service";

@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {

    // ...statements omitted for brevity...
}
```

Updating the Root Module

The final step is to update the root module so that the services defined in the feature module are made available throughout the application. Listing 21-14 shows the required changes.

Listing 21-14. Updating the Root Module in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule } from "@angular/forms";
import { PaAttrDirective } from "./attr.directive";
import { PaModel } from "./twoway.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { DiscountService } from "./discount.service";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { ModelModule } from "./model/model.module";
import {
    LogService, LOG_SERVICE, SpecialLogService,
    LogLevel, LOG_LEVEL
} from "./log.service";
import { VALUE_SERVICE, PaDisplayValueDirective } from "./valueDisplay.directive";
```

```
@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule, ModelModule],
    declarations: [ProductComponent, PaAttrDirective, PaModel,
        PaStructureDirective, PaIteratorDirective,
        PaCellColor, PaCellColorSwitcher, ProductTableComponent,
        ProductFormComponent, PaAddTaxPipe, PaCategoryFilterPipe,
        PaDiscountDisplayComponent, PaDiscountEditorComponent,
        PaDiscountPipe, PaDiscountAmountDirective, PaDisplayValueDirective],
    providers: [DiscountService, LogService,
        { provide: VALUE_SERVICE, useValue: "Apples" }],
    bootstrap: [ProductFormComponent, ProductTableComponent]
})
export class AppModule { }
```

I imported the feature module and added it to the root module's imports list. Since the feature module defines providers for `Model` and `SimpleDataSource`, I removed the entries from the root module's providers list and removed the associated import statements.

When you save the changes to the root module, the browser will reload the application. The root module will load the model feature module, which will provide access to the model services, and the application will start correctly.

Creating a Utility Feature Module

A model module is good place to start because it demonstrates the basic structure of a feature module and how it relates to the root module. The impact on the application was slight, however, and not a great deal of simplification was achieved.

The next step up in complexity is a utility feature module, which groups together all of the common functionality in the application, such as pipes and directives. In a real project, you might be more selective about how you group these types of building block together so that there are several modules, each containing similar functionality. For the example application, I am going to move all of the pipes, directives, and services into a single module.

Creating the Module Folder and Moving the Files

As with the previous module, the first step is to create the folder. For this module, I created a folder called `app/common`. Run the following commands in the `example` folder to move the TypeScript files for the pipes and directives:

```
mv app/*.pipe.ts app/common/
mv app/*.directive.ts app/common/
```

These commands should work in Windows PowerShell, Linux, and macOS. Some of the directives and pipes in the application rely on the `DiscountService` and `LogServices` classes, which is provided to them through dependency injection. Run the following command in the `app` folder to move the TypeScript file for the service into the module folder:

```
mv app/*.service.ts app/common/
```

Once you have moved the TypeScript files, you should delete the corresponding JavaScript files by running the following commands in the example folder:

```
rm app/*.pipe.js
rm app/*.directive.js
rm app/*.service.js
```

The result is that the files listed in Table 21-6 are moved to the module folder.

Table 21-6. *The File Moves Required for the Module*

File	New Location
`app/addTax.pipe.ts`	`app/common/addTax.pipe.ts`
`app/attr.directive.ts`	`app/common/attr.directive.ts`
`app/categoryFilter.pipe.ts`	`app/common/categoryFilter.pipe.ts`
`app/cellColor.directive.ts`	`app/common/cellColor.directive.ts`
`app/cellColorSwitcher.directive.ts`	`app/common/cellColorSwitcher.directive.ts`
`app/discount.pipe.ts`	`app/common/discount.pipe.ts`
`app/discountAmount.directive.ts`	`app/common/discountAmount.directive.ts`
`app/iterator.directive.ts`	`app/common/iterator.directive.ts`
`app/structure.directive.ts`	`app/common/structure.directive.ts`
`app/twoway.directive.ts`	`app/common/twoway.directive.ts`
`app/valueDisplay.directive.ts`	`app/common/valueDisplay.directive.ts`
`app/discount.service.ts`	`app/common/discount.service.ts`
`app/log.service.ts`	`app/common/log.service.ts`

Updating the Classes in the New Module

Some of the classes that have been moved into the new folder have `import` statements that have to be updated to reflect the new path to the model module. Listing 21-15 shows the change required to the `attr.directive.ts` file.

Listing 21-15. Updating the Imports in the attr.directive.ts File

```
import {
    Directive, ElementRef, Attribute, Input,
    SimpleChange, Output, EventEmitter, HostListener, HostBinding
}
    from "@angular/core";
import { Product } from "../model/product.model";

@Directive({
    selector: "[pa-attr]"
})
```

```
export class PaAttrDirective {

    // ...statements omitted for brevity...
}
```

Listing 21-16 shows the corresponding change to the categoryFilter.pipe.ts file.

Listing 21-16. Updating the Imports in the categoryFilfer.pipe.ts File

```
import { Pipe } from "@angular/core";
import { Product } from "../model/product.model";

@Pipe({
    name: "filter",
    pure: false
})
export class PaCategoryFilterPipe {

    transform(products: Product[], category: string): Product[] {
        return category == undefined ?
            products : products.filter(p => p.category == category);
    }
}
```

Creating the Module Definition

The next step is to define a module that brings together the functionality in the files that have been moved to the new folder. I added a file called `common.module.ts` in the `app/common` folder and defined the module shown in Listing 21-17.

Listing 21-17. The Contents of the common.module.ts File in the app/common Folder

```
import { NgModule } from "@angular/core";
import { PaAddTaxPipe } from "./addTax.pipe";
import { PaAttrDirective } from "./attr.directive";
import { PaCategoryFilterPipe } from "./categoryFilter.pipe";
import { PaCellColor } from "./cellColor.directive";
import { PaCellColorSwitcher } from "./cellColorSwitcher.directive";
import { PaDiscountPipe } from "./discount.pipe";
import { PaDiscountAmountDirective } from "./discountAmount.directive";
import { PaIteratorDirective } from "./iterator.directive";
import { PaStructureDirective } from "./structure.directive";
import { PaModel } from "./twoway.directive";
import { VALUE_SERVICE, PaDisplayValueDirective} from "./valueDisplay.directive";
import { DiscountService } from "./discount.service";
import { LogService } from "./log.service";
import { ModelModule } from "../model/model.module";

@NgModule({
    imports: [ModelModule],
    providers: [LogService, DiscountService,
        { provide: VALUE_SERVICE, useValue: "Apples" }],
    declarations: [PaAddTaxPipe, PaAttrDirective, PaCategoryFilterPipe,
        PaCellColor, PaCellColorSwitcher, PaDiscountPipe,
        PaDiscountAmountDirective, PaIteratorDirective, PaStructureDirective,
        PaModel, PaDisplayValueDirective],
    exports: [PaAddTaxPipe, PaAttrDirective, PaCategoryFilterPipe,
        PaCellColor, PaCellColorSwitcher, PaDiscountPipe,
        PaDiscountAmountDirective, PaIteratorDirective, PaStructureDirective,
        PaModel, PaDisplayValueDirective]
})
export class CommonModule { }
```

This is a more complex module than the one required for the data model. In the sections that follow, I describe the values that are used for each of the decorator's properties.

Understanding the Imports

Some of the directives and pipes in the module depend on the services defined in the model module, created earlier in this chapter. To ensure that the features in that module are available, I have added to the common module's imports property.

Understanding the Providers

The providers property ensures that the services that the directives and pipes in the feature module have access to the services they require. This means adding class providers to create LogService and DiscountService services, which will be added to the root module's providers when the module is loaded. Not only will the services be available to the directives and pipes in the common module; they will also be available throughout the application.

Understanding the Declarations

The declarations property is used to provide Angular with a list of the directives and pipes (and components, if there are any) in the module. In a feature module, this property has two purposes: it enables the declarable classes for use in any templates contained within the module, and it allows a module to make those declarable classes available outside of the module. I create a module that contains template content later in this chapter, but for this module, the value of the declarations property is that it must be used in order to prepare for the exports property, described in the next section.

Understanding the Exports

For a module that contains directives and pipes intended for use elsewhere in the application, the exports property is the most important in the @NgModule decorator because it defines the set of directives, components, and pipes that the module provides for use when it is imported elsewhere in the application. The exports property can contain individual classes and module types, although both must already be listed in the declarations or imports property. When the module is imported, the types listed behave as though they had been added to the importing module's declarations property.

Updating the Other Classes in the Application

Now that the module has been defined, I can update the other files in the application that contain `import` statements for the types that are now part of the `common` module. Listing 21-18 shows the changes required to the `discountDisplay.component.ts` file.

Listing 21-18. Updating the Import Reference in the discountDisplay.component.ts File

```
import { Component, Input } from "@angular/core";
import { DiscountService } from "./common/discount.service";

@Component({
    selector: "paDiscountDisplay",
    template: `<div class="bg-info p-a-1">
                The discount is {{discounter.discount}}
               </div>`
})
export class PaDiscountDisplayComponent {

    constructor(private discounter: DiscountService) { }
}
```

Listing 21-19 shows the changes to the `discountEditor.component.ts` file.

Listing 21-19. Updating the Import Reference in the discountEditor.component.ts File

```
import { Component, Input } from "@angular/core";
import { DiscountService } from "./common/discount.service";

@Component({
    selector: "paDiscountEditor",
    template: `<div class="form-group">
                   <label>Discount</label>
                   <input [(ngModel)]="discounter.discount"
                        class="form-control" type="number" />
               </div>`
})
export class PaDiscountEditorComponent {

    constructor(private discounter: DiscountService) { }
}
```

Listing 21-20 shows the changes to the `productForm.component.ts` file.

Listing 21-20. Updating the Import Reference in the productForm.component.ts File

```
import { Component, Output, EventEmitter, ViewEncapsulation,
    Inject, SkipSelf } from "@angular/core";
import { Product } from "./model/product.model";
import { ProductFormGroup } from "./model/form.model";
import { Model } from "./model/repository.model";
import { VALUE_SERVICE } from "./common/valueDisplay.directive";
```

```
@Component({
    selector: "paProductForm",
    templateUrl: "app/productForm.component.html",
    viewProviders: [{ provide: VALUE_SERVICE, useValue: "Oranges" }]
})
export class ProductFormComponent {

    // ...statements omitted for brevity...
}
```

The final change is to the `productTable.component.ts` File, as shown in Listing 21-21.

Listing 21-21. Updating the Import Reference in the productTable.component.ts File

```
import { Component, Input, ViewChildren, QueryList } from "@angular/core";
import { Model } from "./model/repository.model";
import { Product } from "./model/product.model";
import { DiscountService } from "./common/discount.service";

@Component({
    selector: "paProductTable",
    templateUrl: "app/productTable.component.html"
})
export class ProductTableComponent {

    // ...statements omitted for brevity...
}
```

Updating the Root Module

The final step is to update the root module so that it loads the `common` module in order to provide access to the directives and pipes it contains, as shown in Listing 21-22.

Listing 21-22. Importing a Feature Module in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule } from "@angular/forms";
import { ProductTableComponent } from "./productTable.component";
import { ProductFormComponent } from "./productForm.component";
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { ModelModule } from "./model/model.module";
import { CommonModule } from "./common/common.module";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule,
        ModelModule, CommonModule],
    declarations: [ProductComponent, ProductTableComponent,
        ProductFormComponent, PaDiscountDisplayComponent, PaDiscountEditorComponent],
    bootstrap: [ProductFormComponent, ProductTableComponent]
})
export class AppModule { }
```

The root module has been substantially simplified with the creation of the common module, which has been added to the imports list. All of the individual classes for directives and pipes have been removed from the declarations list, and their associated import statements have been removed from the file. When common module is imported, all of the types listed in its exports property will be added to the root module's declarations property.

Creating a Feature Module with Components

The final module that I am going to create will contain the application's components so that I can demonstrate how to deal with external templates. The basic process for creating the module is the same as in the previous examples, as described in the sections that follow.

Creating the Module Folder and Moving the Files

The module will be called components, and I created an app/components to contain the files. Run the following commands in the example folder to move the directive TypeScript, HTML, and CSS files into the new folder and to delete the corresponding JavaScript files:

```
mv app/*.component.ts app/components/
mv app/*.component.html app/components/
mv app/*.component.css app/components/
rm app/*.component.js
```

The result of these commands is that the directive code files are moved into the new folder, as listed in Table 21-7.

Table 21-7. *The File Moves Required for the Component Module*

File	New Location
app/discountDisplay.component.ts	app/component/discountDisplay.component.ts
app/discountEditor.component.ts	app/component/discountEditor.component.ts
app/productForm.component.ts	app/component/productForm.component.ts
app/productTable.component.ts	app/component/productTable.component.ts

Updating the Template URLs

Two of the components in the new module use external templates, the locations of which are specified using the @Component decorators templateUrl property. Now that the files have been moved, these URLs are no longer accurate because they refer to the old locations of the HTML files. There are two ways to solve this problem. The simplest is just to update the value of the templateUrl property so that it reflects the new location of the HTML file, as shown in Listing 21-23, which also updates the paths to the other modules in the import statements.

Listing 21-23. Updating the Template Location in the productTable.component.ts File

```
import { Component, Input } from "@angular/core";
import { Model } from "../model/repository.model";
import { Product } from "../model/product.model";
import { DiscountService } from "../common/discount.service";

@Component({
    selector: "paProductTable",
    templateUrl: "app/components/productTable.component.html"
})
export class ProductTableComponent {

    // ...statements omitted for brevity...
}
```

This is easy to do, but it does mean you have to revise the template URL if you refactor the application into different modules. A more flexible approach is to use the `moduleId` property and take advantage of a feature provided by the JavaScript module loader to configure the URL automatically, as shown in Listing 21-24.

Listing 21-24. Configuring the Module ID in the productForm.component.ts File

```
import {
    Component, Output, EventEmitter, ViewEncapsulation,
    Inject, SkipSelf
} from "@angular/core";
import { Product } from "../model/product.model";
import { ProductFormGroup } from "../model/form.model";
import { Model } from "../model/repository.model";
import { VALUE_SERVICE } from "../common/valueDisplay.directive";

@Component({
    selector: "paProductForm",
    moduleId: module.id,
    templateUrl: "productForm.component.html",
    viewProviders: [{ provide: VALUE_SERVICE, useValue: "Oranges" }]
})
export class ProductFormComponent {

    // ...statements omitted for brevity...
}
```

The `module.id` property is provided at runtime and will be set to the module that contains the component class. Assigning this value to the `moduleId` property tells Angular to request the value of the `templateUrl` relative to the module location, which no longer needs to be hard-coded into the URL. In fact, the `templateUrl` value should contain only the file name without any path segments, as shown in the listing.

Updating the Module References

There are two classes that have been moved into the new module whose import statements must be updated to reflect the path to other modules in the application. Listing 21-25 shows the change required for the `discountDisplay.component.ts` file.

Listing 21-25. Updating Paths in the discountDisplay.component.ts File

```
import { Component, Input } from "@angular/core";
import { DiscountService } from "../common/discount.service";

@Component({
    selector: "paDiscountDisplay",
    template: `<div class="bg-info p-a-1">
                The discount is {{discounter.discount}}
               </div>`
})
export class PaDiscountDisplayComponent {

    constructor(private discounter: DiscountService) { }
}
```

Listing 21-26 shows the same change applied to the `discountEditor.component.ts` file.

Listing 21-26. Updating Paths in the discountEditor.component.ts File

```
import { Component, Input } from "@angular/core";
import { DiscountService } from "../common/discount.service";

@Component({
    selector: "paDiscountEditor",
    template: `<div class="form-group">
                   <label>Discount</label>
                   <input [(ngModel)]="discounter.discount"
                        class="form-control" type="number" />
               </div>`
})
export class PaDiscountEditorComponent {

    constructor(private discounter: DiscountService) { }
}
```

Creating the Module Definition

To create the module, I added a file called `components.module.ts` to the `app/components` folder and added the statements shown in Listing 21-27.

Listing 21-27. The Contents of the components.module.ts File in the app/components Folder

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { CommonModule } from "../common/common.module";
import { FormsModule, ReactiveFormsModule } from "@angular/forms"
import { PaDiscountDisplayComponent } from "./discountDisplay.component";
import { PaDiscountEditorComponent } from "./discountEditor.component";
import { ProductFormComponent } from "./productForm.component";
import { ProductTableComponent } from "./productTable.component";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule, CommonModule],
    declarations: [PaDiscountDisplayComponent, PaDiscountEditorComponent,
        ProductFormComponent, ProductTableComponent],
    exports: [ProductFormComponent, ProductTableComponent]
})
export class ComponentsModule { }
```

This module imports BrowserModule and CommonModule to ensure that the directives have access to the services and the declarable classes they require. It exports the ProductFormComponent and ProductTableComponent, which are the two components used in the root component's bootstrap property. The other components are private to the module.

Updating the Root Module

The final step is to update the root module to remove the outdated references to the individual files and to import the new module, as shown in Listing 21-28.

Listing 21-28. Importing a Feature Module in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ProductComponent } from "./component";
import { FormsModule, ReactiveFormsModule } from "@angular/forms";
import { ProductTableComponent } from "./components/productTable.component";
import { ProductFormComponent } from "./components/productForm.component";
import { ModelModule } from "./model/model.module";
import { CommonModule } from "./common/common.module";
import { ComponentsModule } from "./components/components.module";

@NgModule({
    imports: [BrowserModule, FormsModule, ReactiveFormsModule,
        ModelModule, CommonModule, ComponentsModule],
    bootstrap: [ProductFormComponent, ProductTableComponent]
})
export class AppModule { }
```

Adding modules to the application has radically simplified the root module and allows related features to be defined in self-contained blocks, which can be extended or modified in relative isolation from the rest of the application.

Summary

In this chapter, I described in the last of the Angular building blocks: modules. I explained the role of the root module and demonstrated how to create feature modules in order to add structure to an application. In the next part of the book, I describe the features that Angular provides to shape the building blocks into complex and responsive applications.

CHAPTER 22

Creating the Example Project

Throughout the chapters in the previous part of the book, I added classes and content to the example project to demonstrate different Angular features and then, in Chapter 21 introduced feature modules to add some structure to the project. The result is a project with a lot of redundant and unused functionality, and for this part of the book, I am going to start a new project that takes some of the core features from earlier chapters and provides a clean foundation on which to build in the chapters that follow.

Tip You can download the complete project as part of the free source code download that accompanies this book, which is available from `apress.com`.

Starting the Example Project

To distinguish the project used in this part of the book from earlier examples, I created a folder called `exampleApp`, which will be the root folder for the project. I added a series of subfolders that will be used to contain the application code and some features modules, as listed in Table 22-1.

Note I don't describe the structure or purpose of the files I add to the project in this chapter. See Chapter 11 for a detailed explanation of how an Angular project is created.

Table 22-1. *The Folders Created for the Example Application*

Name	Description
`exampleApp`	This is the root folder, which will contain all the files in the project.
`exampleApp/app`	This is the folder that will contain all the Angular code files, modules, components, and templates.
`exampleApp/app/model`	This folder will contain a feature module containing the data model.
`exampleApp/app/core`	This folder will contain a feature module containing components that provide the core features of the application.
`exampleApp/app/messages`	This folder will contain a feature module that is used to display messages and errors to the user.

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Adding and Configuring the Packages

I added a file called `package.json` to the `exampleApp` folder and used it to define the list of packages that the project requires and the NPM scripts that will be to start the development tools, as shown in Listing 22-1.

Listing 22-1. The Contents of the package.json File in the exampleApp Folder

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/forms": "2.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4",
    "intl": "1.2.4"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.2",
    "typings": "1.3.2",
    "concurrently": "2.2.0",
    "systemjs-builder": "0.15.32"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

This is the same set of packages that I used in Part 2, including the polyfill for the Internationalization API that I added in Chapter 18. There is one new addition in the `devDependencies` section, which is used in the “Creating the Reactive Extensions Module” section.

To download and install the packages, run the following command from the `exampleApp` folder:

```
npm install
```

Configuring TypeScript

Once NPM has downloaded and installed the packages, run the following commands in the exampleApp folder to add the type information that will be used by the TypeScript compiler:

```
npm run typings -- install dt~core-js --save --global
npm run typings -- install dt~node --save --global
```

The typings package will get the latest type information for the Core-JS and Node packages and save them in a folder called typings. It will also generate a file called typings.json, which will contain references to the packages, as shown in Listing 22-2.

Listing 22-2. The Contents of the typings.json File in the exampleApp Folder

```
{
  "globalDependencies": {
    "core-js": "registry:dt/core-js#0.0.0+20160914114559",
    "node": "registry:dt/node#6.0.0+20161110151007"
  }
}
```

TypeScript also requires a configuration for its compiler so that it will generate JavaScript code that works in Angular application. I created a file called tsconfig.json and added the configuration properties shown in Listing 22-3. These are the same properties used in Part 2 of the book.

Listing 22-3. The Contents of the tsconfig.json File in the exampleApp Folder

```
{
  "compilerOptions": {
    "target": "es5",
    "module": "commonjs",
    "moduleResolution": "node",
    "emitDecoratorMetadata": true,
    "experimentalDecorators": true
  },
  "exclude": [ "node_modules" ]
}
```

Configuring the Development HTTP Server

To prepare the BrowserSync package that is used by the lite-server HTTP server, I created a file called bs-config.js in the exampleApp folder and used it to define the configuration shown in Listing 22-4.

Listing 22-4. The Contents of the bs-config.js File in the exampleApp Folder

```
module.exports = {
    ghostMode: false,
    reloadDelay: 1000,
    reloadDebounce: 1000,
    injectChanges: false,
    minify: false
}
```

Configuring the JavaScript Module Loader

To prepare the SystemJS module loader, I added a file called `systemjs.config.js` in the `exampleApp` folder and used it to define the configuration shown in Listing 22-5. This is the same configuration used in Part 2.

Listing 22-5. The Contents of the systemjs.config.js File in the exampleApp Folder

```
(function (global) {

    var paths = {
        "@angular/*": "node_modules/@angular/*"
    }

    var packages = { "app": {} };

    var angularModules = ["common", "compiler",
     "core", "platform-browser", "platform-browser-dynamic", "forms"];

    angularModules.forEach(function (pkg) {
        packages["@angular/" + pkg] = {
            main: "/bundles/" + pkg + ".umd.min.js"
        };
    });

    System.config({ paths: paths, packages: packages });

})(this);
```

Creating the Model Module

The first feature module will contain the project's data model, which is similar to the one used in Part 2, although it won't contain the form validation logic, which will be handled elsewhere.

Creating the Product Data Type

To define the basic data type around which the application is based, I added a file called `product.model.ts` to the `exampleApp/app/model` folder and defined the class shown in Listing 22-6.

Listing 22-6. The product.model.ts File in the exampleApp/app/model Folder

```
export class Product {

    constructor(public id?: number,
                public name?: string,
                public category?: string,
                public price?: number) {}
}
```

Creating the Data Source and Repository

To provide the application with some initial data, I created a file called `static.datasource.ts` in the `exampleApp/app/model` folder and defined the service shown in Listing 22-7. This class will be used as the data source until Chapter 24, where I explain how to use asynchronous HTTP requests to request data from web services.

■ **Tip** I am more relaxed about following the name conventions for Angular files when creating files within a feature module, especially if the purpose of the module is obvious from its name.

Listing 22-7. The static.datasource.ts File in the exampleApp/app/model Folder

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";

@Injectable()
export class StaticDataSource {
    private data: Product[];

    constructor() {
        this.data = new Array<Product>(
            new Product(1, "Kayak", "Watersports", 275),
            new Product(2, "Lifejacket", "Watersports", 48.95),
            new Product(3, "Soccer Ball", "Soccer", 19.50),
            new Product(4, "Corner Flags", "Soccer", 34.95),
            new Product(5, "Thinking Cap", "Chess", 16));
    }

    getData(): Product[] {
        return this.data;
    }
}
```

The next step is to define the repository, through which the rest of the application will access the model data. I created a file called `repository.model.ts` in the `exampleApp/app/model` folder and used it to define the class shown in Listing 22-8.

Listing 22-8. The repository.model.ts File in the exampleApp/app/model Folder

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";
import { StaticDataSource } from "./static.datasource";

@Injectable()
export class Model {
    private products: Product[];
    private locator = (p: Product, id: number) => p.id == id;
    constructor(private dataSource: StaticDataSource) {
        this.products = new Array<Product>();
        this.dataSource.getData().forEach(p => this.products.push(p));
    }

    getProducts(): Product[] {
        return this.products;
    }

    getProduct(id: number): Product {
        return this.products.find(p => this.locator(p, id));
    }

    saveProduct(product: Product) {
        if (product.id == 0 || product.id == null) {
            product.id = this.generateID();
            this.products.push(product);
        } else {
            let index = this.products
                .findIndex(p => this.locator(p, product.id));
            this.products.splice(index, 1, product);
        }
    }

    deleteProduct(id: number) {
        let index = this.products.findIndex(p => this.locator(p, id));
        if (index > -1) {
            this.products.splice(index, 1);
        }
    }

    private generateID(): number {
        let candidate = 100;
        while (this.getProduct(candidate) != null) {
            candidate++;
        }
        return candidate;
    }
}
```

Completing the Model Module

To complete the data model, I need to define the module. I created a file called `model.module.ts` in the `exampleApp/app/model` folder and used it to define the Angular module shown in Listing 22-9.

Listing 22-9. The Contents of the model.module.ts File in the exampleApp/app/model Folder

```
import { NgModule } from "@angular/core";
import { StaticDataSource } from "./static.datasource";
import { Model } from "./repository.model";
```

```
@NgModule({
    providers: [Model, StaticDataSource]
})
export class ModelModule { }
```

Creating the Core Module

The core module will contain the central functionality of the application, built on features that were described in Part 2, presenting the user with a list of the products in the model and the ability to create and edit them.

Creating the Shared State Service

To help the components in this module to collaborate, I am going to add a service that records the current mode, noting whether the user is editing or creating a product. I added a file called `sharedState.model.ts` to the `exampleApp/app/core` folder and defined the enum and class shown in Listing 22-10.

■ **Tip** I have used the `model.ts` file name, rather than `service.ts`, because the role of this class will change in a later chapter. Bear with me for the moment, even though I am breaking the naming convention.

Listing 22-10. The Contents of the sharedState.model.ts File in the exampleApp/app/core Folder

```
export enum MODES {
    CREATE, EDIT
}

export class SharedState {
    mode: MODES = MODES.EDIT;
    id: number;
}
```

The `SharedState` class contains two properties that reflect the current mode and the ID of the data model object that is being operated on.

Creating the Table Component

This component will present the user with the table that lists all the products in the application and that will be the main focal point in the application, providing access to other areas of functionality through buttons that allow objects to be created, edited, or deleted. Listing 22-11 shows the contents of the `table.component.ts` file, which I created in the `exampleApp/app/core` folder.

Listing 22-11. The Contents of the table.component.ts File in the exampleApp/app/core Folder

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { MODES, SharedState } from "./sharedState.model";
```

```
@Component({
    selector: "paTable",
    moduleId: module.id,
    templateUrl: "table.component.html"
})
export class TableComponent {

    constructor(private model: Model, private state: SharedState) { }

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }

    deleteProduct(key: number) {
        this.model.deleteProduct(key);
    }

    editProduct(key: number) {
        this.state.id = key;
        this.state.mode = MODES.EDIT;
    }

    createProduct() {
        this.state.id = undefined;
        this.state.mode = MODES.CREATE;
    }
}
```

This component provides the same basic functionality used in Part 2, with the addition of `editProduct` and `createProduct` methods. These methods update the shared state service when the user wants to edit or create a product.

Creating the Table Component Template

To provide the table component with a template, I added an HTML file called `table.component.html` to the `exampleApp/app/core` folder and added the markup shown in Listing 22-12.

Listing 22-12. The table.component.html File in the exampleApp/app/core Folder

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm" (click)="editProduct(item.id)">
                Edit
            </button>
        </td>
    </tr>
</table>
<button class="btn btn-primary" (click)="createProduct()">
    Create New Product
</button>
```

This template uses the `ngFor` directive to create rows in a table for each product in the data model, including buttons that call the `deleteProduct` and `editProduct` methods. There is also a `button` element outside of the table that calls the component's `createProduct` method when it is clicked.

Creating the Form Component

For this project, I am going to create a form component that will manage an HTML form that will allow new products to be created and allow existing products to be modified. To define the component, I added a file called `form.component.ts` to the exampleApp/app/core folder and added the code shown in Listing 22-13.

Listing 22-13. The Contents of the form.component.ts File in the exampleApp/app/core Folder

```
import { Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model"
import { MODES, SharedState } from "./sharedState.model";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model,
            private state: SharedState) { }

    get editing(): boolean {
        return this.state.mode == MODES.EDIT;
    }
    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.product = new Product();
            form.reset();
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

The same component and form will be used create new products and edit existing ones, so there is some additional functionality compared with the equivalent component from Part 2. The `editing` property will be used in the view to signal the current setting of the shared state service. The `resetForm` method is the other new addition and resets the object used to provide data values to the form. The `submitForm` method hasn't changed and relies on the data model to determine whether the object passed to the `saveProduct` method is a new addition to the model or a replacement for an existing object.

Creating the Form Component Template

To provide the component with a template, I added an HTML file called `form.component.html` to the `exampleApp/app/core` folder and added the markup shown in Listing 22-14.

Listing 22-14. The form.component.html File in the exampleApp/app/core Folder

```
<div class="bg-primary p-a-1" [class.bg-warning]="editing">
    <h5>{{editing  ? "Edit" : "Create"}} Product</h5>
</div>

<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)" (reset)="resetForm()" >

    <div class="form-group">
        <label>Name</label>
        <input class="form-control" name="name"
               [(ngModel)]="product.name" required />
    </div>

    <div class="form-group">
        <label>Category</label>
        <input class="form-control" name="category"
               [(ngModel)]="product.category" required />
    </div>

    <div class="form-group">
        <label>Price</label>
        <input class="form-control" name="price"
               [(ngModel)]="product.price"
               required pattern="^[0-9\.]+$" />
    </div>
    <button type="submit" class="btn btn-primary"
            [class.btn-warning]="editing" [disabled]="form.invalid">
        {{editing ? "Save" : "Create"}}
    </button>
    <button type="reset" class="btn btn-secondary">Cancel</button>
</form>
```

The most important part of this template is the form, which contains `input` elements for the name, category, and price properties required to create or edit a product. The header at the top of the template and the submit button for the form change their content and appearance based on the editing mode to distinguish between different operations.

Creating the Form Component Styles

To keep the example simple, I have used the basic form validation without any error messages. Instead, I rely on CSS styles that are applied using the Angular validation classes. I added a file called `form.component.css` to the `exampleApp/app/core` folder and defined the styles shown in Listing 22-15.

Listing 22-15. The form.component.css File in the exampleApp/app/core Folder

```
input.ng-dirty.ng-invalid { border: 2px solid #ff0000 }
input.ng-dirty.ng-valid { border: 2px solid #6bc502 }
```

Completing the Core Module

To define the module that contains the components, I added a file called `core.module.ts` to the `exampleApp/app/core` folder and created the Angular module shown in Listing 22-16.

Listing 22-16. The core.module.ts File in the exampleApp/app/core Folder

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
import { SharedState } from "./sharedState.model";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule],
    declarations: [TableComponent, FormComponent],
    exports: [ModelModule, TableComponent, FormComponent],
    providers: [SharedState]
})
export class CoreModule { }
```

The module imports three modules in order to access the core Angular functionality, the Angular forms features, and the application’s data model, created earlier in the chapter. It also sets up a provider for the `SharedState` service.

Creating the Messages Module

The messages module will contain a service that is used to report messages or errors that should be displayed to the user and a component that actually presents them. This is functionality that will be required throughout the application and doesn't really belong in either of the other two modules.

Creating the Message Model and Service

To represent messages that should be displayed to the user, I added a file called `message.model.ts` to the `exampleApp/app/messages` folder and added the code shown in Listing 22-17.

Listing 22-17. The Contents of the message.model.ts File in the exampleApp/app/messages Folder

```
export class Message {

    constructor(private text: string,
        private error: boolean = false) { }
}
```

The `Message` class defines properties that present the text that will be displayed to the user and whether the message represents an error. Next, I created a file called `message.service.ts` in the `exampleApp/app/messages` folder and used it to define the service shown in Listing 22-18, which will be used to register messages that should be displayed to the user.

Listing 22-18. The Contents of the message.service.ts File in the exampleApp/app/messages Folder

```
import { Injectable } from "@angular/core";
import { Message } from "./message.model";

@Injectable()
export class MessageService {
    private handler: (m: Message) => void;

    reportMessage(msg: Message) {
        if (this.handler != null) {
            this.handler(msg);
        }
    }

    registerMessageHandler(handler: (m: Message) => void) {
        this.handler = handler;
    }
}
```

This service acts as a broker between the parts of the application that generate error messages and those that need to receive them. I'll improve the way that this service works in Chapter 23, when I introduce features from the Reactive Extensions package.

Creating the Component and Template

Now that I have a source of messages, I can create a component that will display them to the user. I added a file called `message.component.ts` to the `exampleApp/app/messages` folder and defined the component shown in Listing 22-19.

Listing 22-19. The message.component.ts File in the exampleApp/app/messages Folder

```
import { Component } from "@angular/core";
import { MessageService } from "./message.service";
import { Message } from "./message.model";

@Component({
    selector: "paMessages",
    moduleId: module.id,
    templateUrl: "message.component.html",
})
export class MessageComponent {
    lastMessage: Message;

    constructor(messageService: MessageService) {
        messageService.registerMessageHandler(m => this.lastMessage = m);
    }
}
```

The component receives a `MessageService` object as its constructor argument and uses it to register a handler function that will be invoked when a message is received by the service, assigning the most recent message to a property called `lastMessage`. To provide a template for the component, I created a file called `message.component.html` in the `exampleApp/app/messages` folder and added the markup shown in Listing 22-20, which displays the message to the user.

Listing 22-20. The message.component.html File in the exampleApp/app/messages Folder

```
<div *ngIf="lastMessage"
     class="bg-info p-a-1 text-xs-center"
     [class.bg-danger]="lastMessage.error">
        <h4>{{lastMessage.text}}</h4>
</div>
```

Completing the Message Module

I added a file called `message.module.ts` in the `exampleApp/app/messages` folder and defined the module shown in Listing 22-21.

Listing 22-21. The message.module.ts File in the exampleApp/app/messages Folder

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { MessageComponent } from "./message.component";
import { MessageService } from "./message.service";
```

```
@NgModule({
    imports: [BrowserModule],
    declarations: [MessageComponent],
    exports: [MessageComponent],
    providers: [MessageService]
})
export class MessageModule { }
```

Completing the Project

To give the project a root module, I added a file called `app.module.ts` to the `exampleApp/app` folder and used it to define the Angular module shown in Listing 22-22.

Listing 22-22. The Contents of the app.module.ts File in the exampleApp/app Folder

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ModelModule } from "./model/model.module";
import { CoreModule } from "./core/core.module";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { MessageModule } from "./messages/message.module";
import { MessageComponent } from "./messages/message.component";

@NgModule({
    imports: [BrowserModule, ModelModule, CoreModule, MessageModule],
    bootstrap: [TableComponent, FormComponent, MessageComponent]
})
export class AppModule { }
```

This module imports the feature modules created in this chapter, as well as `BrowserModule`, which provides access to core Angular features. The module specifies three root components, two of which were defined in `CoreModule` and one from `MessageModule`. These will display the product table and form and any messages or errors.

Creating the Angular Bootstrap

To bootstrap the application, I created a file called `main.ts` in the `exampleApp/app` folder and added the statements shown in Listing 22-23.

Listing 22-23. The Contents of the main.ts File in the exampleApp/app Folder

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { AppModule } from './app.module';

platformBrowserDynamic().bootstrapModule(AppModule);
```

The call to the `bootstrapModule` method tells Angular to use the class defined in Listing 22-22 as the root module for the application.

Creating the Reactive Extensions Module

In the previous part of the book, I configured the SystemJS JavaScript module loader so that it resolved all dependencies on the `rxjs` package by loading the `node_modules/rxjs/bundles/Rx.min.js` file. This is an approach that works nicely until you start using the functionality provided by Reactive Extensions directly in your code (which I do in Chapter 23 or start using the Angular router module (which I describe in Chapter 25).

The problem is that the Reactive Extensions package doesn't contain the information that SystemJS loader needs to load and process a module and to address this means generating a custom module file. The `systemjs-builder` package that I added to the project using the `package.json` file is used to build modules and to configure it. I added a file called `rxModuleBuilder.js` to the `exampleApp` folder and added the code shown in Listing 22-24.

Listing 22-24. The Contents of the rxModuleBuilder.js File in the exampleApp Folder

```
var Builder = require("systemjs-builder");

var builder = new Builder("./");
builder.config({
    paths: {
        "rxjs/*": "node_modules/rxjs/*.js"
    },
    map: {
        "rxjs": "node_modules/rxjs"
    },
    packages: {
        "rxjs": { main: "Rx.js", defaultExtension: "js" }
    }
});
builder.bundle("rxjs", "rxjs.module.min.js", {
    normalize: true,
    runtime: false,
    minify: true,
    mangle: false
});
```

This configuration creates a module containing all of the Reactive Extensions functionality, along with the additional information that SystemJS needs to resolve dependencies. Run the following command in the `exampleApp` folder:

```
node ./rxModuleBuilder.js
```

It can take a few minutes to process the package, but when the command finishes, you will see a file called `rxjs.module.min.js` in the `exampleApp` folder. This is the file that will be used in the project to provide access to the Reactive Extensions package.

Creating the HTML Document

To complete the application, I added a file called `index.html` to the `exampleApp` folder and added the HTML elements shown in Listing 22-25.

Listing 22-25. The Contents of the index.html File in the exampleApp Folder

```
<!DOCTYPE html>
<html>
<head>
    <title></title>
    <meta charset="utf-8" />
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/intl/dist/Intl.complete.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="rxjs.module.min.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
</head>
<body class="m-a-1">
    <paMessages></paMessages>
    <div class="col-xs-8 p-a-1">
        <paTable></paTable>
    </div>
    <div class="col-xs-4 p-a-1">
        <paForm></paForm>
    </div>
</body>
</html>
```

The `paTable` and `paForm` elements corresponds to the selectors of the components defined in the core feature module and are laid out side-by-side using Bootstrap CSS classes. The `paMessages` element applies the component from the messages module.

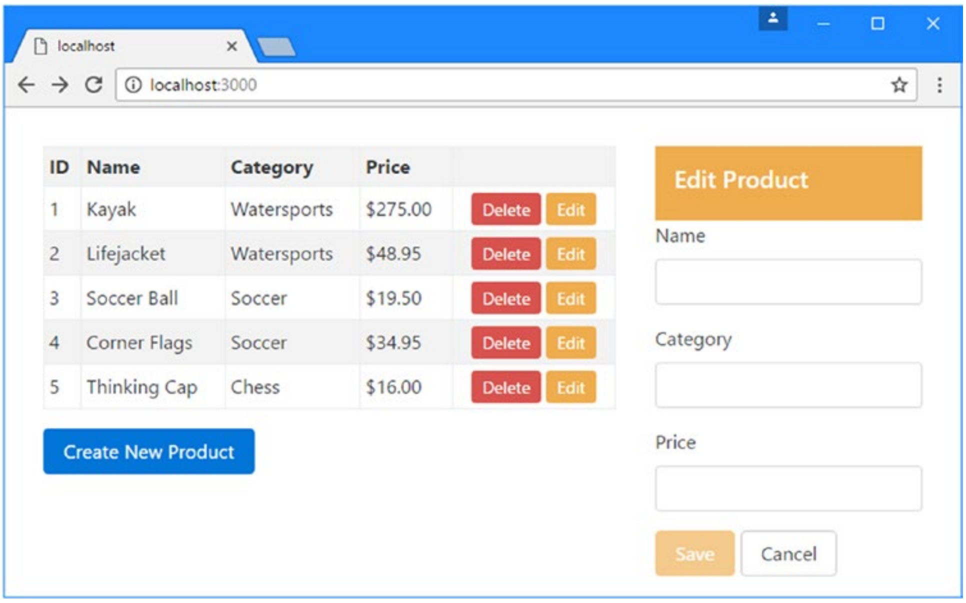
■ **Tip** Notice the script element for the `rxjs.module.min.js` file, which was created in the previous section. Loading the file using a `script` element takes advantage of the information generated using the `systemjs-builder` package.

Running the Example Project

To start the TypeScript compiler and the development HTTP server, run the following command in the `exampleApp` folder:

```
npm start
```

The TypeScript code will be compiled into JavaScript, and the development server will cause a new browser tab or window to open with the content shown in Figure 22-1.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Thinking Cap	Chess	$16.00	Delete Edit

***Figure 22-1.** Running the example application*

Not everything in the example application works at the moment. You can toggle between the two modes of operation by clicking the Create New Product and Edit buttons, but the editing function doesn't work. I complete the core functionality and add new features in the chapters that follow.

Summary

In this chapter, I created the example project that I will use in this part of the book. The basic structure is the same as the example used in earlier chapters but without the redundant code and markup that I used to demonstrate earlier features. In the next chapter, I introduce the Reactive Extensions package, which is used to handle updates in Angular applications.

CHAPTER 23

Using Reactive Extensions

Angular has a lot of features, but the one that grabs the most attention is the way that changes propagate through the application so that filling in a form field or clicking a button causes immediate updates to the application state. But there are limitations to the changes that Angular can detect, and some features require working directly with the library that Angular uses to distribute updates throughout an application. This library is called *Reactive Extensions*, also known as RxJS.

In this chapter, I explain why working with Reactive Extensions is required for advanced projects, introduce the core Reactive Extensions features (known as `Observers` and `Observables` -), and use them to enhance the application so that users can edit existing objects in the model, as well as create new ones. Table 23-1 puts Reactive Extensions into context.

Note The focus on this chapter is on the RxJS features that are most useful in Angular projects. The RxJS package has a lot of features, and if you want more information, you should consult the project homepage at `https://github.com/Reactive-Extensions/RxJS`.

Table 23-1. *Putting the Reactive Extensions Library in Context*

Question	Answer
What is it?	The Reactive Extensions library provides an asynchronous event distribution mechanism that is used extensively inside Angular for change detection and event propagation.
Why is it useful?	RxJS allows for the parts of an application that are not addressed by the standard Angular change detection process to receive notifications of important events and respond appropriately. Since RxJS is required in order to use Angular, its functionality is readily available for use.
How is it used?	An `Observer` is created that collects the events and distributes them to subscribers through an `Observable`. The simplest way to achieve this is to create a `Subject`, which provides both `Observer` and `Observable` functionality. The flow of events to a subscriber can be managed using a set of operators.
Are there any pitfalls or limitations?	Once you have mastered the basics, the RxJS package is easy to use, although there are so many features that it can take some experimentation to find the combination that efficiently achieves a specific outcome.
Are there any alternatives?	RxJS is required to access some Angular features, such as updates to child and view children queries and making asynchronous HTTP requests.

A. Freeman, *Pro Angular*, DOI 10.1007/978-1-4842-2307-9_23

Table 23-2 summarizes the chapter.

Table 23-2. *Chapter Summary*

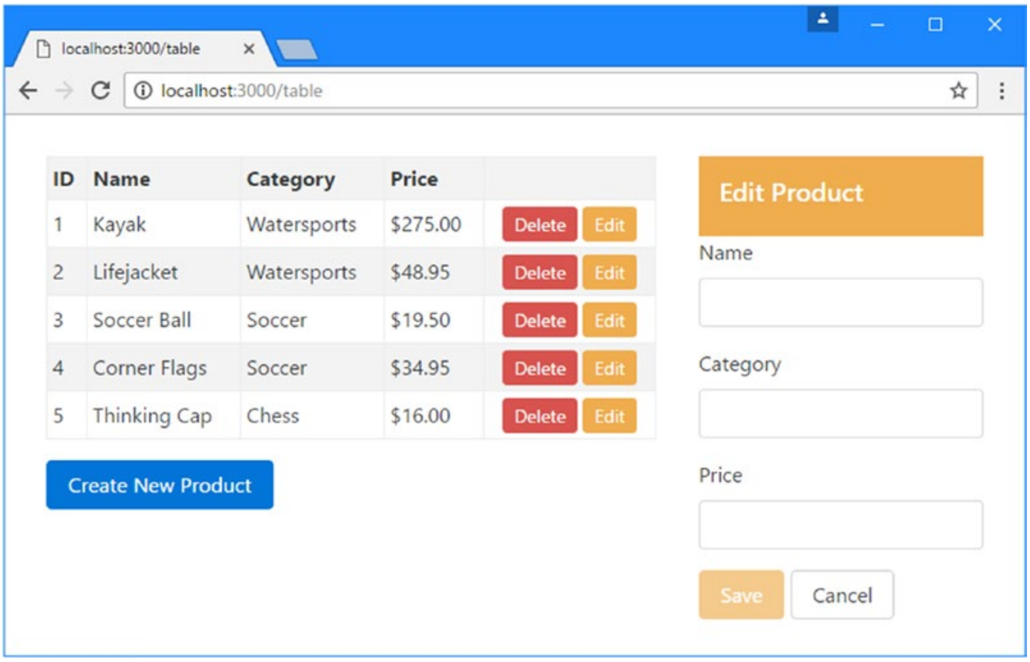
Problem	Solution	Listing
Distribute events in an application	Use Reactive Extensions	1–5
Wait for asynchronous results in a template	Use the `async` pipe	6–9
Use events to enable collaboration between components	Use `Observable`	10–12
Manage the flow of events	Use operators such as `filter` or `map`	13–18

Preparing the Example Project

This chapter uses the `exampleApp` project created in Chapter 22. No changes are required for this chapter. Run the following command in the `exampleApp` folder to start the TypeScript compiler and the HTTP development server:

```
npm start
```

A new browser tab or window will open and show the content illustrated by Figure 23-1.



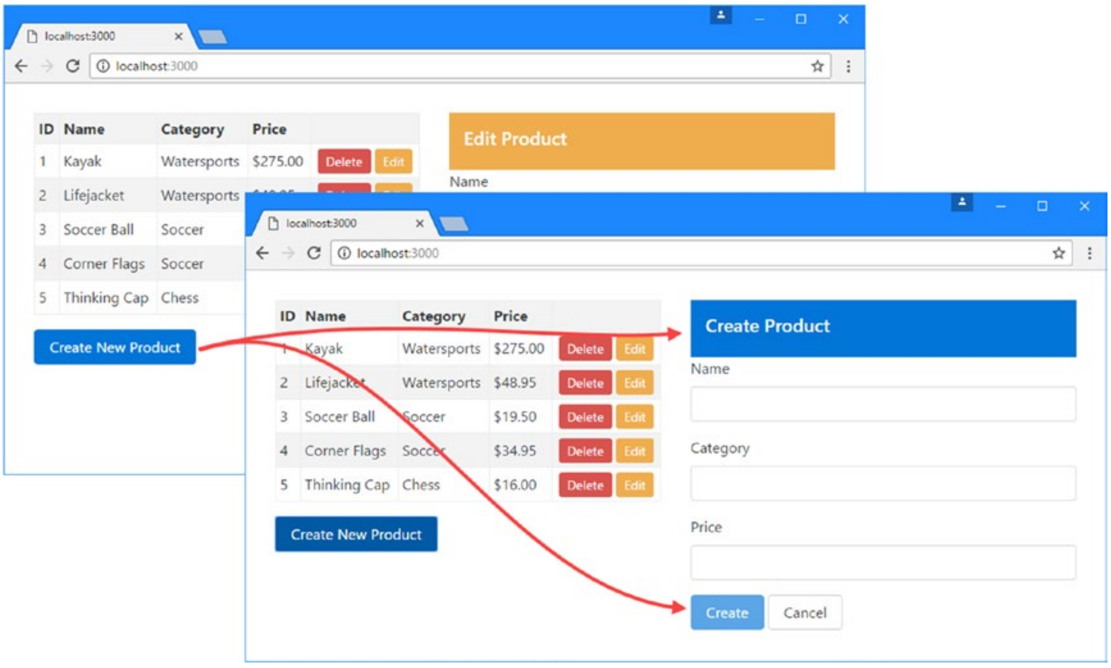
ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Thinking Cap	Chess	$16.00	Delete Edit

Figure 23-1. *Running the example application*

■ **Tip** If you don't want to create the example project step-by-step, the free source download at `apress.com` that accompanies this book contains the project for this chapter (and every other chapter in the book).

Understanding the Problem

Angular excels at detecting changes in the expressions used for data bindings. It does this seamlessly and efficiently, and the result is a framework that makes it easy to create dynamic applications. You can see the change detection at work in the example application by clicking the Create New Product button. The service that provides the shared state information is updated by the table component, which is then reflected in the data bindings that control the appearance of the elements managed by the form component, as shown in Figure 23-2. When you click the Create New Product button, the color of the title and buttons in the form changes immediately.



ID	Name	Category	Price		
1	Kayak	Watersports	$275.00	Delete	Edit
2	Lifejacket	Watersports	$48.95	Delete	Edit
3	Soccer Ball	Soccer	$19.50	Delete	Edit
4	Corner Flags	Soccer	$34.95	Delete	Edit
5	Thinking Cap	Chess	$16.00	Delete	Edit

***Figure 23-2.** Updating data binding expressions*

As the number of objects in an application increases, change detection can spiral out of control and put an enormous drain on an application's performance, especially on less capable devices such as phones and tablets. Rather than keep track of all the objects in the application, Angular focuses on data bindings and, specifically, on working out when property values change.

And that presents a problem, because Angular manages the bindings for the HTML elements automatically, but it doesn't provide any support for responding to service changes within the component itself.

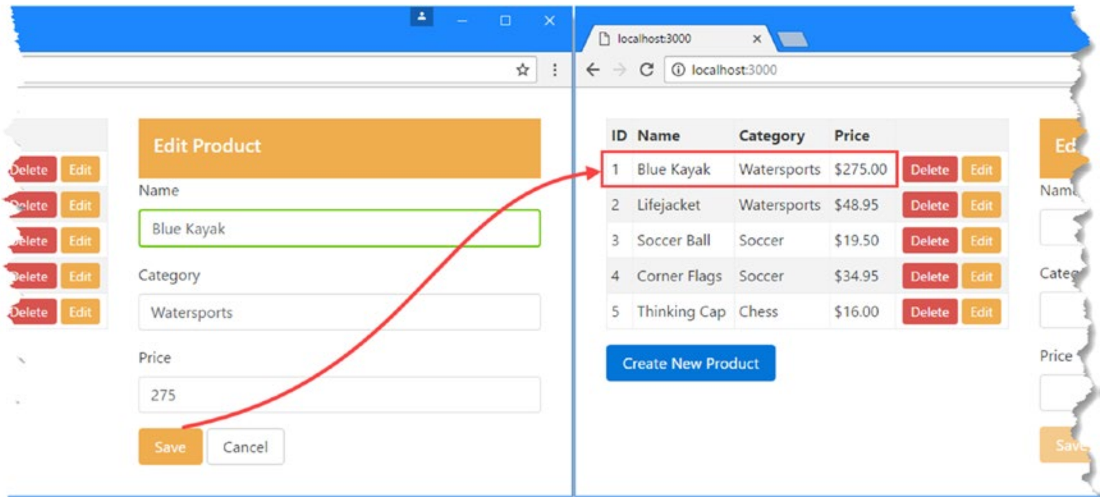
You can see an immediate consequence of the lack of change in the component by clicking one of the Edit buttons in the table. Although the data bindings will update immediately, the component doesn't get a notification when the button is clicked and doesn't know it needs to update the property that will populate the form elements for editing.

The lack of updates means that the form component needs to fall back on the ngDoCheck method, originally described in Chapter 15, to determine when an important change occurs, as shown in Listing 23-1.

Listing 23-1. Monitoring Service Changes in the form.component.ts File

```
import { Component } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model"
import { MODES, SharedState } from "./sharedState.model";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();
    lastId: number;

    constructor(private model: Model,
        private state: SharedState) { }

    get editing(): boolean {
        return this.state.mode == MODES.EDIT;
    }

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.product = new Product();
            form.reset();
        }
    }

    resetForm() {
        this.product = new Product();
    }

    ngDoCheck() {
        if (this.lastId != this.state.id) {
            this.product = new Product();
            if (this.state.mode == MODES.EDIT) {
                Object.assign(this.product, this.model.getProduct(this.state.id));
            }
            this.lastId = this.state.id;
        }
    }
}
```

To see the effect of these changes, click one of the Edit buttons in the table and the form will be populated with the details for editing. When you have finished editing the values in the form, click the Save button and the data model will be updated, reflecting your changes in the table, as shown in Figure 23-3.



Name: Blue Kayak

Category: Watersports

Price: 275

ID	Name	Category	Price
1	Blue Kayak	Watersports	$275.00
2	Lifejacket	Watersports	$48.95
3	Soccer Ball	Soccer	$19.50
4	Corner Flags	Soccer	$34.95
5	Thinking Cap	Chess	$16.00

Figure 23-3. *Updating a product*

The problem with this code is that the ngDoCheck method will be called whenever Angular detects any kind of change in the application. It doesn't matter what happens or where it happens: Angular is going to have to call the ngDoCheck method to give the component a chance to update itself. You can minimize the amount of work that is done in the ngDoCheck method, but as the number of directives and components in the application increases, the number of change events and the number of calls to the ngDoCheck method will increase, which can drag down the performance of the application.

It is also harder than you might think to handle change detection correctly. As an example, try editing a product using the example application, clicking the Save button to store the changes in the model, and then clicking the Edit button again for the same product: nothing will happen. This is a common mistake in implementing the ngDoCheck method, which is called even when a change is triggered by the component itself, confusing the checks in the ngDoCheck method that are trying to avoid doing unnecessary work. Overall, this approach is unreliable, is expensive, and doesn't scale well.

Solving the Problem with Reactive Extensions

The reason that the Reactive Extensions library is useful in Angular applications is because it provides a simple and unambiguous system for sending and receiving notifications. It doesn't sound like a huge achievement, but it underpins most of the built-in Angular functionality, and it can be used directly by applications to avoid the problems that come from trying to implement change detection using ngDoCheck. To prepare for the direct use of Reactive Extensions, Listing 23-2 defines an opaque token that will be used to provide a service that uses Reactive Extensions to distribute updates and changes the SharedState class so that it defines a constructor. These changes will temporarily break the application because Angular will not be able to provide values for the SharedState constructor when it tries to instantiate an instance to use as a service. The application will start working again once the changes required for Reactive Extensions are complete.

Listing 23-2. Defining a Provider Token in the sharedState.model.ts File

```
import { OpaqueToken } from "@angular/core";

export enum MODES {
    CREATE, EDIT
}

export class SharedState {

    constructor(public mode: MODES, public id?: number) { }
}

export const SHARED_STATE = new OpaqueToken("shared_state");
```

Understanding Observables

The key Reactive Extensions building block is `Observable`, which represents an observable sequence of events. An object such as a component can subscribe to an `Observable` and receive a notification each time an event occurs, allowing it to respond only when the event has been observed instead of every time there is a change anywhere in the application.

The basic method provided by an `Observable` is `subscribe`, which accepts three functions as arguments, as described in Table 23-3.

Table 23-3. *The Types of Web Forms Code Nuggets*

Name	Description
`onNext`	This function is invoked when a new event occurs.
`onError`	This function is invoked when an error occurs.
`onCompleted`	This function is invoked when the sequence of events ends.

Only the `onNext` function is required to subscribe to an `Observable`, although it is generally good practice to implement the others to provide error handling and to respond if you expect the sequence of events to come to an end. There won't be an end to the events for this example, but for other uses of `Observable`, such as for handling HTTP responses, knowing when the event sequence has ended can be more useful. Listing 23-3 revises the form component so that it declares a dependency on an `Observable` service.

Listing 23-3. Using an Observable in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { MODES, SharedState, SHARED_STATE } from "./sharedState.model";
import { Observable } from "rxjs/Observable";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model,
        @Inject(SHARED_STATE) private stateEvents: Observable<SharedState>) {

        stateEvents.subscribe((update) => {
            this.product = new Product();
            if (update.id != undefined) {
                Object.assign(this.product, this.model.getProduct(update.id));
            }
            this.editing = update.mode == MODES.EDIT;
        });
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.product = new Product();
            form.reset();
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

The Reactive Extensions NPM package includes individual JavaScript modules for each of the types that it provides so that you can import the `Observable` type from the `rxjs/Observable` module.

To receive notifications, the component declares a dependency on the `SHARED_STATE` service, which is received as an `Observable<SharedState>` object. This object is an `Observerable` whose notifications will be `SharedState` objects, which will represent an edit or create operation started by the user. The component calls the `Observable.subscribe` method, providing a function that receives each `SharedState` object and uses it to update its state.

WHAT ABOUT PROMISES?

You may be used to representing asynchronous activities using `Promise`s. Observables perform the same basic role but are more flexible and have more features. Angular does provide support for working with Promises, which can be useful as you transition to Angular and when working with libraries that rely on Promises, such as jQuery.

Reactive Extensions provides an `Observable.fromPromise` method that will create an `Observable` using a `Promise` as the source of events. There is also an `Observable.toPromise` method if you have an `Observable` and need a `Promise` for some reason.

In addition, there are some Angular features that let you choose which you use, such as the guards feature described in Chapter 27, which supports both.

But the Reactive Extensions library is an important part of working with Angular, and you will encounter it often in the chapters in this part of the book. I recommend that you work with `Observable` when you encounter it and minimize the conversions to and from `Promise`s.

Understanding Observers

The Reactive Extensions `Observer` provides the mechanism by which updates are created, using the methods described in Table 23-4.

Table 23-4. *The Observer Methods*

Name	Description
`next(value)`	This method creates a new event using the specified value.
`error(errorObject)`	This method reports an error, described using the argument, which can be any object.
`complete()`	This method ends the sequence, indicating that no further events will be sent.

Listing 23-4 updates the table component so that it uses an `Observer` to send out events when the user has clicked the Create New Product button or one of the Edit buttons.

Listing 23-4. Using an Observer in the table.component.ts File

```
import { Component, Inject } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { MODES, SharedState, SHARED_STATE } from "./sharedState.model";
import { Observer } from "rxjs/Observer";

@Component({
    selector: "paTable",
    moduleId: module.id,
    templateUrl: "table.component.html"
})
export class TableComponent {

    constructor(private model: Model,
        @Inject(SHARED_STATE) private observer: Observer<SharedState>) { }

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts();
    }
    deleteProduct(key: number) {
        this.model.deleteProduct(key);
    }

    editProduct(key: number) {
        this.observer.next(new SharedState(MODES.EDIT, key));
    }

    createProduct() {
        this.observer.next(new SharedState(MODES.CREATE));
    }
}
```

The component declares a dependency on the SHARED_STATE service, which is received as an Observer<SharedState> object, meaning an Observer will send events that are described using SharedState objects. The editProduct and createProduct methods have been updated so they call the next method on the observer to signal a change in state.

Understanding Subjects

Both of the components have declared dependencies on services using the SHARED_STATE token, but each expects to get a different type: the table component wants to receive an Observer<SharedState> object, while the form component wants an Observable<SharedState> object.

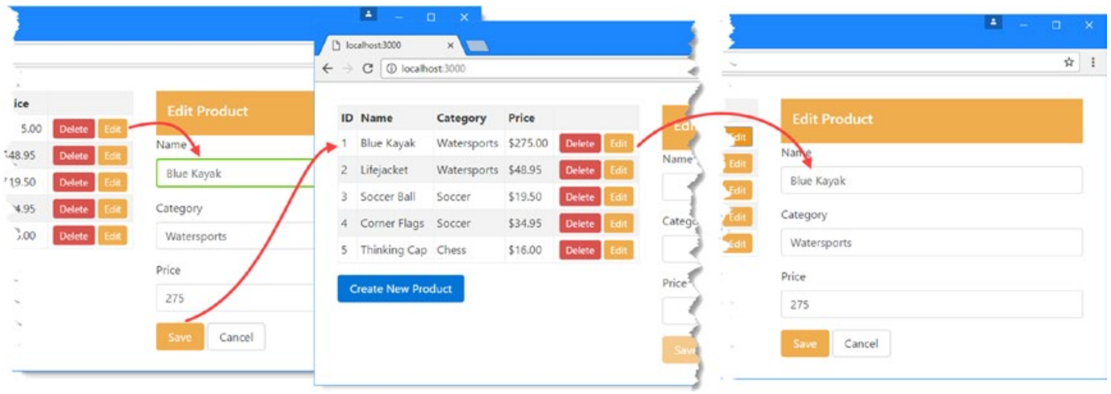
The Reactive Extensions library provides the Subject class, which implements both the Observer and Observable functionality. This makes it easy to create a service that allows events to be produced and consumed with a single object. In Listing 23-5, I have changed the service declared in the @NgModule decorator's providers property to use a Subject object.

Listing 23-5. Changing the Service in the core.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
import { SharedState, SHARED_STATE } from "./sharedState.model";
import { Subject } from "rxjs/Subject";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule],
    declarations: [TableComponent, FormComponent],
    exports: [ModelModule, TableComponent, FormComponent],
    providers: [{ provide: SHARED_STATE, useValue: new Subject<SharedState>() }]
})
export class CoreModule { }
```

The value-based provider tells Angular to use a Subject<SharedState> object to resolve dependencies on the SHARED_STATE token, which will provide the components with the functionality they need to collaborate.

The result is that changing the shared service so that it is a `Subject` allows the table component to emit distinct events that are received by the form component and that are used to update its state without needing to rely on the awkward and expensive `ngDoCheck` method. There is also no need to try to work out which changes have been generated by the local component and which come from elsewhere, since a component that subscribes to an `Observable` knows that all the events it receives must have originated from the `Observer`. This means that niggly problems like not being able to edit the same product twice simply go away, as shown in Figure 23-4.



ID	Name	Category	Price		
1	Blue Kayak	Watersports	$275.00	Delete	Edit
2	Lifejacket	Watersports	$48.95	Delete	Edit
3	Soccer Ball	Soccer	$19.50	Delete	Edit
4	Corner Flags	Soccer	$34.95	Delete	Edit
5	Thinking Cap	Chess	$16.00	Delete	Edit

Edit Product

Name: Blue Kayak

Category: Watersports

Price: 275

Figure 23-4. *The effect of using Reactive Extensions*

THE DIFFERENT TYPES OF SUBJECT

Listing 23-5 uses the `Subject` class, which is the simplest way to create an object that is both an `Observer` and an `Observable`. Its main limitation is that when a new subscriber is created using the `subscribe` method, it won't receive an event until the next time the `next` method is called. This can be unhelpful if you are creating instances of components or directives dynamically and you want them to have some context data as soon as they are created.

The Reactive Extensions library includes some specialized implementations of the `Subject` class that can be used to work around this problem. The `BehaviorSubject` class keeps track of the last event it processed and sends it to new subscribers as soon as they call the `subscribe` method. The `ReplaySubject` class does something similar, except that it keeps track of all of its events and sends them all to new subscribers, allowing them to catch up with any events that were sent before they subscribed.

Using the Async Pipe

Angular includes the `async` pipe, which can be used to consume `Observable` objects directly in a view, selecting the last object received from the event sequence. This is an impure pipe, as described in Chapter 18 because its changes are driven from outside of the view in which it is used, meaning that its `transform` method will be called often, even if a new event has not been received from the Observable. Listing 23-6 shows the addition of the `async` pipe to the view managed by the form component.

Listing 23-6. Using the Async Pipe in the form.component.html File

```
<div class="bg-primary p-a-1" [class.bg-warning]="editing">
    <h5>{{editing  ? "Edit" : "Create"}} Product</h5>
    Last Event: {{ stateEvents | async | json }}
</div>

<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)" (reset)="resetForm()" >

    ...elements omitted for brevity...

</form>
```

The string interpolation binding expression gets the `stateEvents` property from the component, which is the `Observable<SharedState>` object, and passes it to the `async` pipe, which keeps track of the most recent event that has been received. The `async` filter then passes on the event to the `json` pipe, which creates a JSON representation of the event object. The result is that you can keep track of the events that are received by the form component, as shown in Figure 23-5.

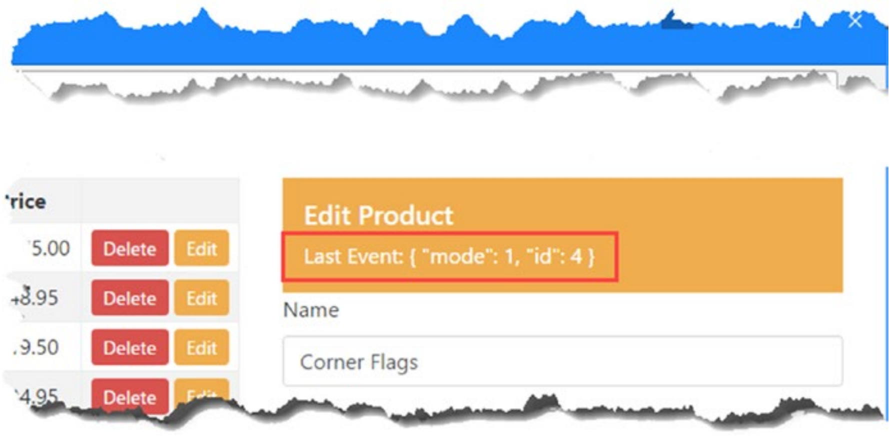


Figure 23-5. *Displaying observable events*

This isn't the most useful display of data, but it does give some useful debugging insight. In this case, the most recent event has a `mode` value of 1, which corresponds to the `Edit` mode, and an `id` value of 4, which is the ID of the Corner Flags product.

Using the Async Pipe with Custom Pipes

The `async` pipe can be used with custom pipes to present the event data in a more user-friendly manner. To demonstrate, I added a file called `state.pipe.ts` to the `exampleApp/app/core` folder and used it to define the pipe shown in Listing 23-7.

Listing 23-7. The Contents of the state.pipe.ts File in the exampleApp/app/core Folder

```
import { Pipe } from "@angular/core";
import { SharedState, MODES } from "./sharedState.model";
import { Model } from "../model/repository.model";

@Pipe({
    name: "formatState",
    pure: true
})
export class StatePipe {

    constructor(private model: Model) { }

    transform(value: any): string {
        if (value instanceof SharedState) {
            let state = value as SharedState;
            return MODES[state.mode] + (state.id != undefined
                ? ` ${this.model.getProduct(state.id).name}` : "");
        } else {
            return "<No Data>"
        }
    }
}
```

In Listing 23-8, I have added the pipe to the set of declarations made by the core module.

■ **Tip** TypeScript enumerations have a useful feature through which the name of a value can be obtained. So, the expression `MODES[1]`, for example, will return `EDIT`, since that is the name of the `MODES` enumeration value at index 1. The pipe in Listing 23-7 uses this feature to present the state update to the user.

Listing 23-8. Registering the Pipe in the core.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
import { SharedState, SHARED_STATE } from "./sharedState.model";
import { Subject } from "rxjs/Subject";
import { StatePipe } from "./state.pipe";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule],
    declarations: [TableComponent, FormComponent, StatePipe],
    exports: [ModelModule, TableComponent, FormComponent],
    providers: [{ provide: SHARED_STATE, useValue: new Subject<SharedState>() }]
})
export class CoreModule { }
```

Listing 23-9 shows the new pipe used to replace the built-in `json` pipe in the template managed by the form component.

Listing 23-9. Applying a Custom Pipe in the form.component.html File

```
<div class="bg-primary p-a-1" [class.bg-warning]="editing">
    <h5>{{editing  ? "Edit" : "Create"}} Product</h5>
    Last Event: {{ stateEvents | async | formatState }}
</div>

<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)" (reset)="resetForm()" >

    ...elements omitted for brevity...

</form>
```

This example demonstrates that events received from `Observable` objects can be processed and transformed just like any other objects, as shown in Figure 23-6, which illustrates how a custom pipe can build on the core functionality provided by the async pipe.

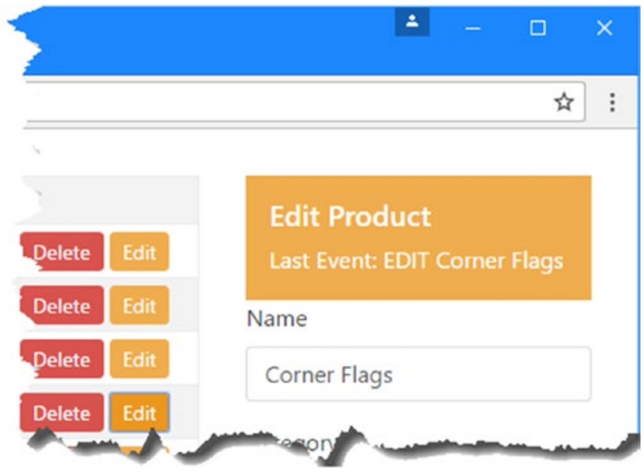


Figure 23-6. *Formatting values received through an observable sequence*

Scaling Up Application Feature Modules

The same Reactive Extensions building blocks can be used anywhere in the application and make it easy to allow building blocks to collaborate, even if the use of Reactive Extensions isn't exposed to all the collaborating parts of the application. As a demonstration, Listing 23-10 shows the addition of a `Subject` to the `MessageService` class to distribute the messages that should be displayed to the user.

Listing 23-10. Using a Subject in the message.service.ts File

```
import { Injectable } from "@angular/core";
import { Message } from "./message.model";
import { Observable } from "rxjs/Observable";
import { Subject } from "rxjs/Subject";

@Injectable()
```

```
export class MessageService {
    private subject = new Subject<Message>();

    reportMessage(msg: Message) {
        this.subject.next(msg);
    }

    get messages(): Observable<Message> {
        return this.subject;
    }
}
```

The previous implementation of the message service supported only a single recipient of the messages that should be displayed to the user. I could have added code that managed multiple recipients, but, given that the application already uses Reactive Extensions, it is much simpler to delegate that work to the `Subject` class, which scales up well and won't require any additional code or testing if there are multiple subscribers in the application.

Listing 23-11 shows the corresponding changes in the message component that will display the most recent message to the user.

Listing 23-11. Observing Messages in the message.component.ts File

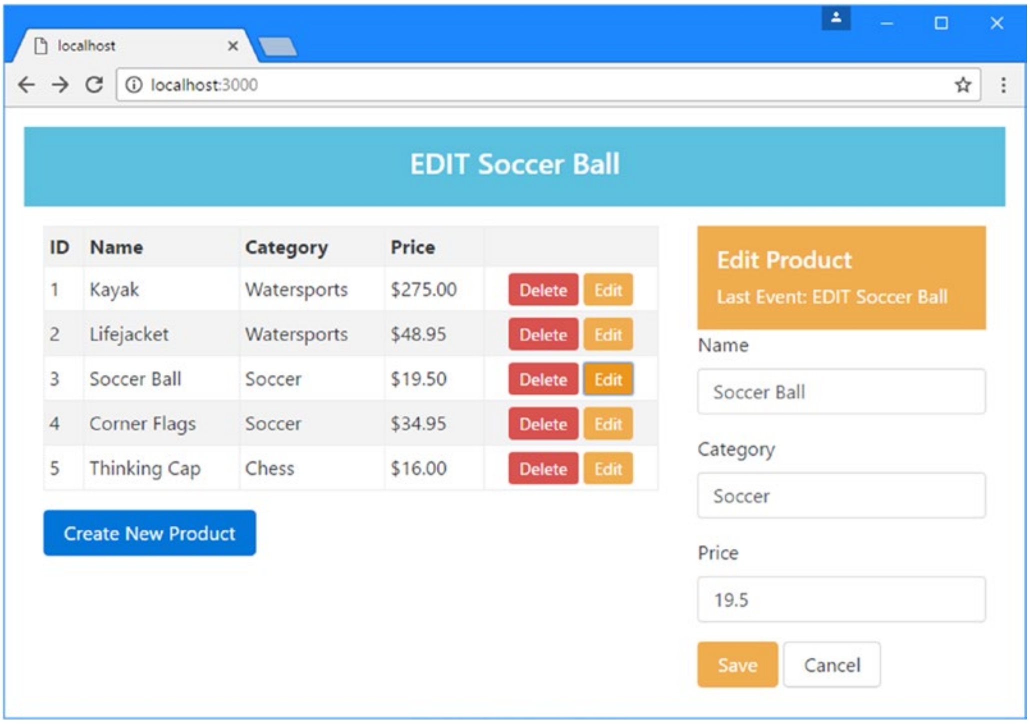
```
import { Component } from "@angular/core";
import { MessageService } from "./message.service";
import { Message } from "./message.model";
import { Observable } from "rxjs/Observable";

@Component({
    selector: "paMessages",
    moduleId: module.id,
    templateUrl: "message.component.html",
})
export class MessageComponent {
    lastMessage: Message;

    constructor(messageService: MessageService) {
        messageService.messages.subscribe(m => this.lastMessage = m);
    }
}
```

The final step is to generate some messages to display. In Listing 23-12, I have modified the configuration of the core feature module so that the `SHARED_STATE` provider uses a factory function to create the `Subject` that is used to distribute state change events and adds a subscription that feeds the events into the message service.

Listing 23-12. Feeding the Message Service in the core.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
import { SharedState, SHARED_STATE } from "./sharedState.model";
import { Subject } from "rxjs/Subject";
import { StatePipe } from "./state.pipe";
import { MessageModule } from "../messages/message.module";
import { MessageService } from "../messages/message.service";
import { Message } from "../messages/message.model";
import { Model } from "../model/repository.model";
import { MODES } from "./sharedState.model";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule, MessageModule],
    declarations: [TableComponent, FormComponent, StatePipe],
    exports: [ModelModule, TableComponent, FormComponent],
    providers: [{
        provide: SHARED_STATE,
        deps: [MessageService, Model],
        useFactory: (messageService, model) => {
            let subject = new Subject<SharedState>();
            subject.subscribe(m => messageService.reportMessage(
                    new Message(MODES[m.mode] + (m.id != undefined
                        ? ` ${model.getProduct(m.id).name}` : "")))
                );
            return subject;
        }
    }]
})
export class CoreModule { }
```

The code is a little messy, but the result is that every state change event sent by the table component is displayed by the message component, as shown in Figure 23-7. Reactive Extensions makes it easy to wire up parts of the application, and the reason that the code in the listing is so dense is because it is also using the `Model` service to look up names from the data model to make the events easier to read.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Thinking Cap	Chess	$16.00	Delete Edit

Last Event: EDIT Soccer Ball

Name: Soccer Ball

Category: Soccer

Price: 19.5

Figure 23-7. *Using Reactive Extensions in the Message service*

Going Beyond the Basics

The examples in the previous sections cover the basic use of `Observable`, `Observer`, and `Subject`. There is, however, a lot more functionality available when working with Reactive Extensions that can be used in advanced or complex applications. The full set of operations is described at `http://github.com/Reactive-Extensions/RxJS`, but in this chapter I demonstrate a small number of the features that you are most likely to require in an Angular application, as described in Table 23-5. The methods described in the table are used to control the way that events are received from an `Observable` object.

Table 23-5. *Useful Reactive Extensions Methods for Selecting Events*

Name	Description
`filter`	This method invokes a function to evaluate each event received from the `Observable` and discards those for which the function returns `false`.
`map`	This method invokes a function to transform each event received from the `Observable` and passes on the object that the function returns.
`distinctUntilChanged`	This method suppresses events until the event object changes.
`skipWhile`	This method filters events until a specified condition is satisfied, after which they are forwarded to the subscriber.
`takeWhile`	This method passes on events to the subscriber until a specified condition is satisfied, after which events are filtered.

Filtering Events

The `filter` method accepts a method that is used to inspect each object that is received from the `Observable` and select only those that are required. Listing 23-13 demonstrates the use of the `filter` method to filter out the events that relate to a specific product.

Listing 23-13. Filtering Events in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { MODES, SharedState, SHARED_STATE } from "./sharedState.model";
import { Observable } from "rxjs/Observable";
import "rxjs/add/operator/filter";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model,
        @Inject(SHARED_STATE) private stateEvents: Observable<SharedState>) {

        stateEvents
            .filter(state => state.id != 3)
            .subscribe((update) => {
                this.product = new Product();
                if (update.id != undefined) {
                    Object.assign(this.product, this.model.getProduct(update.id));
                }
                this.editing = update.mode == MODES.EDIT;
            });
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.product = new Product();
            form.reset();
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

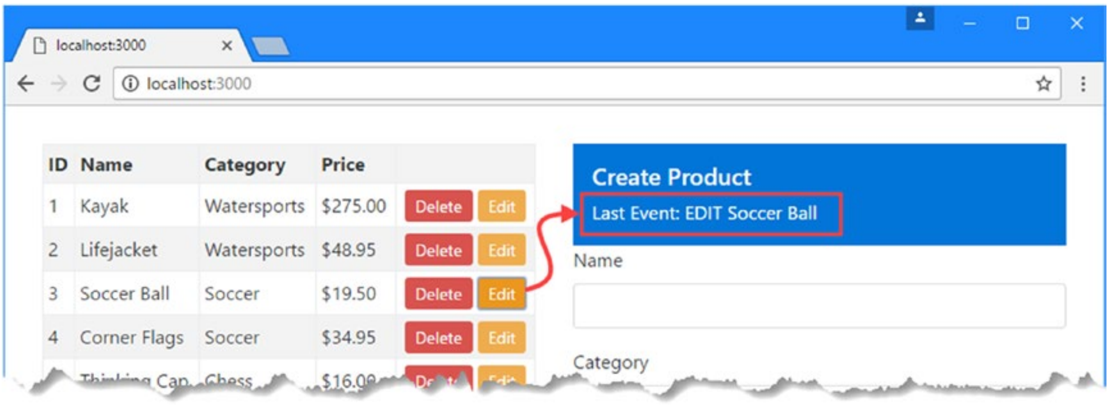
To use the methods described in Table 23-5, an `import` statement for the corresponding file in the `rxjs` package is required, like this:

```
...
import "rxjs/add/operator/filter";
...
```

The `node_modules/add/operator` directory provides the definitions of these methods and includes type information for their use in TypeScript. The TypeScript compiler always looks in the `node_modules` folder when it is trying to resolve a reference, and it is omitted from the `import` statement.

In the case of the example, the `rxjs/add/operator/filter.ts` file extends the `Observable` definition to add a method called `filter`, which can be called on an `Observable` object to select the events that will be passed on to the function provided using the `subscribe` method.

You can see the effect by clicking the Edit button for the Soccer Ball product, which has the ID that the filter function is checking for. The `async` pipe shows that an EDIT event has been sent through the shared service, but the `filter` method prevents it from being received by the component's `subscribe` function. The result is that the form doesn't reflect the change in state and isn't populated with the selected product information, as shown in Figure 23-8.



ID	Name	Category	Price		
1	Kayak	Watersports	$275.00	Delete	Edit
2	Lifejacket	Watersports	$48.95	Delete	Edit
3	Soccer Ball	Soccer	$19.50	Delete	Edit
4	Corner Flags	Soccer	$34.95	Delete	Edit
	Thinking Cap	Chess	$16.00		

Figure 23-8. *Filtering events*

Transforming Events

The `map` method is used to transform the objects received from an `Observable`. You can use this method to transform event objects in any way, and the result from the function replaces the event object. Listing 23-14 uses the `map` method to change the value of an event object property.

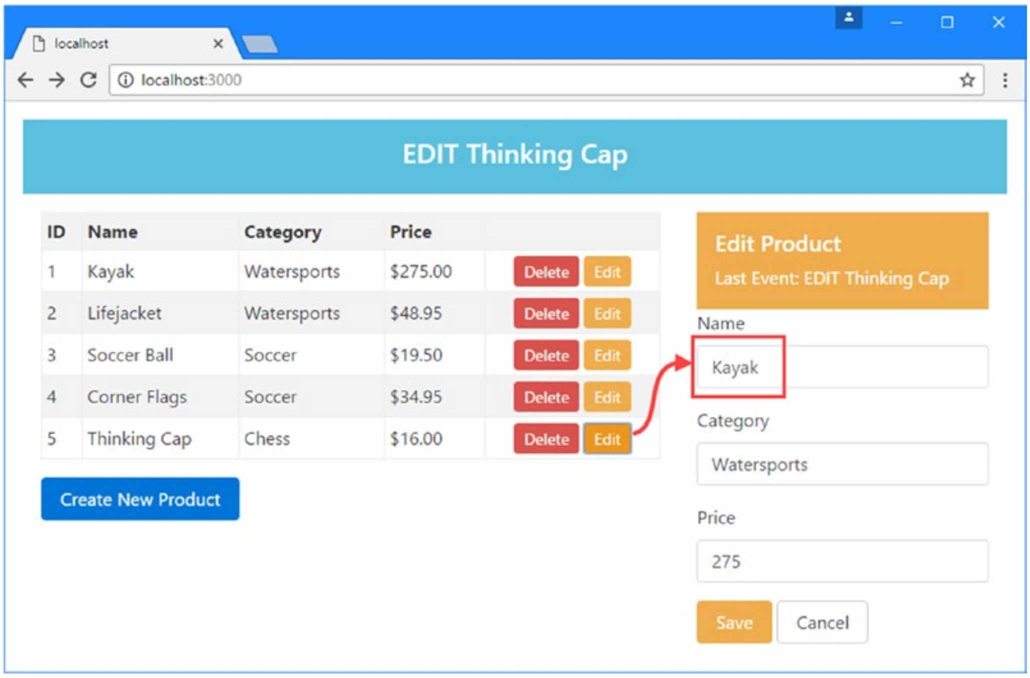
Listing 23-14. Transforming Events in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { MODES, SharedState, SHARED_STATE } from "./sharedState.model";
import { Observable } from "rxjs/Observable";
import "rxjs/add/operator/filter";
import "rxjs/add/operator/map";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model,
        @Inject(SHARED_STATE) private stateEvents: Observable<SharedState>) {

        stateEvents
            .map(state => new SharedState(state.mode, state.id == 5 ? 1 : state.id))
            .filter(state => state.id != 3)
            .subscribe((update) => {
                this.product = new Product();
                if (update.id != undefined) {
                    Object.assign(this.product, this.model.getProduct(update.id));
                }
                this.editing = update.mode == MODES.EDIT;
            });
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.product = new Product();
            form.reset();
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

The function passed to the map method in this example looks for SharedState objects that have an id value of 5 and, when found, changes the value to 1. The result is that clicking the Edit button for the Thinking Cap product selects the Kayak product for editing, as shown in Figure 23-9.

■ **Caution** When using the map method, do not modify the object that is received as the argument to the function. This object is passed to all the subscribers in turn, and any changes you make will affect subsequent subscribers. This means that some subscribers will receive the unmodified object, and some will receive the object returned by the map function. Instead, create a new object, as shown in Listing 23-14.

Notice that the methods used to prepare and create a subscription on an `Observable` object can be chained together. In the example, the result from the `map` method is used as the input for the `filter` method, whose results are then passed to the `subscribe` method's function. Chaining methods together in this way allows complex rules to be created for the way that events are processed and received.



EDIT Thinking Cap

ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Thinking Cap	Chess	$16.00	Delete Edit

Create New Product

Edit Product
Last Event: EDIT Thinking Cap

Name: Kayak
Category: Watersports
Price: 275

Save Cancel

Figure 23-9. *Transforming events*

Using Different Event Objects

The `map` method can be used to produce any object and is not limited to changing property values on the object it receives. In Listing 23-15, I have used the `map` method to produce a number whose value encodes the operation and the object to which it applies.

Listing 23-15. Projecting a Different Type in the form.component.ts File

```
...
constructor(private model: Model,
    @Inject(SHARED_STATE) private stateEvents: Observable<SharedState>) {

    stateEvents
        .map(state => state.mode == MODES.EDIT ? state.id : -1)
        .filter(id => id != 3)
        .subscribe((id) => {
            this.editing = id != -1;
            this.product = new Product();
            if (id != -1) {
                Object.assign(this.product, this.model.getProduct(id))
                **}**
            });
}
...
```

There is no advantage in making a simple data type represent and operation and specify its target. In fact, it generally causes problems because it means that the component assumes that there will never be an object in the model whose `id` property is `-1`. But as a simple example, it demonstrates how the map method can project different types and how those types are then passed along the chain of Reactive Extensions methods, meaning that the `number` values produced by the `map` method are received as the values to be processed by the `filter` method and, in turn, the `subscribe` method, the functions for which have both been updated to work with the new data values.

Receiving Only Distinct Events

The `distinctUntilChanged` method filters the sequence of events so that only distinct values are passed along to the subscriber. To see the kind of problem that this can be used to solve, click the Edit button for the Kayak product and change the value of the `Category` field. Without clicking the Save button, click the Kayak's Edit button again and you will see your edits discarded. In Listing 23-16, I have added the `distinctUntilChanged` method to the chain of methods so that it applies to the `number` values produced by the `map` method. Only different values will be forwarded to the `filter` and `subscribe` methods.

Listing 23-16. Preventing Duplicate Events in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { MODES, SharedState, SHARED_STATE } from "./sharedState.model";
import { Observable } from "rxjs/Observable";
import "rxjs/add/operator/filter";
import "rxjs/add/operator/map";
import "rxjs/add/operator/distinctUntilChanged";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model,
        @Inject(SHARED_STATE) private stateEvents: Observable<SharedState>) {

        stateEvents
            .map(state => state.mode == MODES.EDIT ? state.id : -1)
            .distinctUntilChanged()
            .filter(id => id != 3)
            .subscribe((id) => {
                this.editing = id != -1;
                this.product = new Product();
                if (id != -1) {
                    Object.assign(this.product, this.model.getProduct(id))
                }
            });
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.product = new Product();
            form.reset();
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

If you repeat the Kayak editing process, you will see that the changes are no longer discarded when you click the Edit button for the product that is being edited, since this will produce the same value as the previous event. Editing a different product will cause the `map` method to emit a different `number` value, which will be passed on by the `distinctUntilChanged` method.

Using a Custom Equality Checker

The `distinctUntilChanged` method can make easy comparisons between simple datatypes like number, but it doesn't know how to compare objects and will assume that any two objects are different. To address this, you can specify a comparison function that will be used to check whether events are distinct, as shown in Listing 23-17.

Listing 23-17. Using a Equality Checker in the form.component.ts File

```
...
constructor(private model: Model,
    @Inject(SHARED_STATE) private stateEvents: Observable<SharedState>) {

    stateEvents
        .distinctUntilChanged((firstState, secondState) =>
            firstState.mode == secondState.mode && firstState.id == secondState.id)
        .subscribe(update => {
            this.product = new Product();
            if (update.id != undefined) {
                Object.assign(this.product, this.model.getProduct(update.id));
            }
            this.editing = update.mode == MODES.EDIT;
        });
}
...
```

This listing removes the map and filter methods and provides the distinctUntilChanged method with a function that compares SharedState objects by comparing their mode and id properties. Distinct objects are passed onto the function provided to the subscribe method.

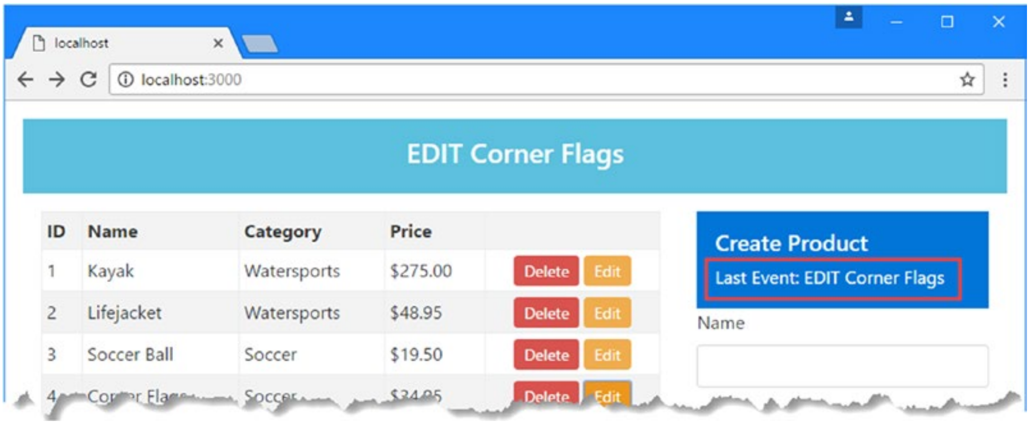
Taking and Skipping Events

The skipWhile and takeWhile methods are used to specify conditions that will cause events to be filtered or passed on to the subscriber. These methods must be used carefully because it is easy to specify conditions that will permanently filter events from the subscriber. In Listing 23-18, I have used the skipWhile method to filter events until the user clicks the Create New Product button, after which events will be passed on.

Listing 23-18. Skipping Events in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { MODES, SharedState, SHARED_STATE } from "./sharedState.model";
import { Observable } from "rxjs/Observable";
import "rxjs/add/operator/filter";
import "rxjs/add/operator/map";
import "rxjs/add/operator/distinctUntilChanged";
import "rxjs/add/operator/skipWhile";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model,
        @Inject(SHARED_STATE) private stateEvents: Observable<SharedState>) {

        stateEvents
            .skipWhile(state => state.mode == MODES.EDIT)
            .distinctUntilChanged((firstState, secondState) =>
                firstState.mode == secondState.mode
                    && firstState.id == secondState.id)
            .subscribe(update => {
                this.product = new Product();
                if (update.id != undefined) {
                    Object.assign(this.product, this.model.getProduct(update.id));
                }
                this.editing = update.mode == MODES.EDIT;
            });
    }

    editing: boolean = false;
    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.product = new Product();
            form.reset();
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

Clicking the Edit buttons in the table will still generate events, which will be displayed by the `async` pipe, which is subscribed to the `Subject` without any filtering or skipping. But the form component doesn't receive those events, as shown in Figure 23-10, since its subscription is filtered by the `skipWhile` method until an event whose `mode` property isn't `MODES.EDIT` is received. Clicking the Create New Product button generates an event that ends the skipping, after which the component will receive all events.



EDIT Corner Flags

ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit

Create Product

Last Event: EDIT Corner Flags

Name

Figure 23-10. Skipping events

Summary

In this chapter, I introduced the Reactive Extensions package and explained how it can be used to handle changes in the parts of the application that are not managed by the Angular change-detection process. I demonstrated the use of `Observable`, `Observer`, and `Subject` objects to distribute events in an application, showed you how the built-in `async` pipe works, and introduced some of the most useful operators that the Reactive Extensions library provides for controlling the flow of events to a subscriber. In the next chapter, I explain how to make asynchronous HTTP requests in Angular applications and how to consume RESTful web services.

CHAPTER 24

Making Asynchronous HTTP Requests

All the examples since Chapter 11 have relied on static data that has been hardwired into the application. In this chapter, I demonstrate how to use asynchronous HTTP requests, often called Ajax requests, to interact with a web service to get real data into an application. Table 24-1 puts HTTP requests in context.

Table 24-1. *Putting Asynchronous HTTP Requests in Context*

Question	Answer
What are they?	Asynchronous HTTP requests are HTTP requests sent by the browser on behalf of the application. The term *asynchronous* refers to the fact that the application continues to operate while the browser is waiting for the server to respond.
Why are they useful?	Asynchronous HTTP requests allow Angular applications to interact with web services so that persistent data can be loaded into the application and changes can be sent to the server and saved.
How are they used?	Requests are made using the `Http` class, which is delivered as a service through dependency injection. This class provides an Angular-friendly wrapper around the browser's `XMLHttpRequest` feature.
Are there any pitfalls or limitations?	Using the Angular HTTP feature requires the use of Reactive Extensions `Observable` objects, as described in Chapter 23.
Are there any alternatives?	You can work directly with the browser's `XMLHttpRequest` object if you prefer, and some applications—those that don't need to deal with persistent data—can be written without making HTTP requests at all.

PROBLEMS WITH HTTP SERVERS

In the first edition of this book, I picked a package called Deployd to provide the RESTful web service. This turned out to be a poor decision because it didn't work properly for some readers. As a consequence, I wrote some replacement chapters that used `parse.com`, a commercial API hosting platform owned by Facebook. I thought that would be a solid platform for long-term use, but Facebook recently announced the closure of `parse.com`.

For this edition, I am relying on an excellent package called `json-server`, and I am hopeful that there won't be any problems this time, just as long as you use the package versions that are shown in Listing 24-1.

If you do encounter problems, then please check `apress.com` to see whether there are any replacement chapters available, similar to the ones that I wrote for the previous edition. If not or you need some additional help getting everything working, then send me an e-mail at `adam@adam-freeman.com` and I will endeavor to assist.

Table 24-2 summarizes the chapter.

Table 24-2. *Chapter Summary*

Problem	Solution	Listing
Send HTTP requests in an Angular application	Use the `Http` service.	1–8
Perform REST operations	Use the HTTP method and URL to specify an operation and a target for that operation.	9–11
Make cross-origin requests	The `Http` service supports CORS automatically but JSONP requests are also supported.	12–13
Include headers in a request	Set the `headers` property in the `Request` object.	14–15
Respond to an HTTP error	Create an error handler class.	16–19

Preparing the Example Project

The features described in this chapter rely on the Angular HTTP module, which must be added to the application. Listing 24-1 shows the addition of the Angular JavaScript module to the package list.

Listing 24-1. Adding Packages and a Script in the package.json File

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/forms": "2.2.0",
    "@angular/http": "2.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4",
    "intl": "1.2.4"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.2",
    "typings": "1.3.2",
    "concurrently": "2.2.0",
    "systemjs-builder": "0.15.32",
    "json-server": "0.8.21"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" \"npm run json\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "json": "json-server --p 3500 restData.js",
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

The JavaScript module named `@angular/http` provides the features that this chapter requires and is added to the `dependencies` section of the file. The other changes in the `package.json` file add the `json-server` package to the project and add a script that runs it. This package makes it easy to create web services, which will provide a back end to which the examples in this chapter can send HTTP requests.

Configuring the JavaScript Module Loader

The next step is to update the SystemJS configuration file so that it is able to resolve dependencies on the forms module, as shown in Listing 24-2.

Listing 24-2. Adding the HTTP Module in the systemjs.config.js File

```
(function (global) {

    var paths = {
        "@angular/*": "node_modules/@angular/*"
    }

    var packages = { "app": {} };
    var angularModules = ["common", "compiler",
     "core", "platform-browser", "platform-browser-dynamic", "forms", "http"];

    angularModules.forEach(function (pkg) {
        packages["@angular/" + pkg] = {
            main: "/bundles/" + pkg + ".umd.min.js"
        };
    });

    System.config({ paths: paths, packages: packages });

})(this);
```

Configuring the Model Feature Module

The @angular/http JavaScript module contains an Angular module called HttpModule, which must be imported into the application in either the root module or one of the feature modules. I only need the HTTP functionality in the data model, so Listing 24-3 shows the changes to the model.module.ts file in the exampleApp/app/model folder.

Listing 24-3. Importing a Module in the model.module.ts File

```
import { NgModule } from "@angular/core";
import { HttpModule } from "@angular/http"
import { StaticDataSource } from "./static.datasource";
import { Model } from "./repository.model";

@NgModule({
    imports: [HttpModule],
    providers: [Model, StaticDataSource]
})
export class ModelModule { }
```

The json entry in the scripts section of Listing 24-1 tells the json-server package that it should listen for HTTP requests on port 3500 and that it should get its data from a file called restData.js. To provide the data, I added a file called restData.js to the exampleApp folder and added the code shown in Listing 24-4.

Listing 24-4. The Contents of the restData.js File in the exampleApp Folder

```
module.exports = function () {
    var data = {
        products: [
            { id: 1, name: "Kayak", category: "Watersports", price: 275 },
            { id: 2, name: "Lifejacket", category: "Watersports", price: 48.95 },
            { id: 3, name: "Soccer Ball", category: "Soccer", price: 19.50 },
            { id: 4, name: "Corner Flags", category: "Soccer", price: 34.95 },
            { id: 5, name: "Stadium", category: "Soccer", price: 79500 },
            { id: 6, name: "Thinking Cap", category: "Chess", price: 16 },
            { id: 7, name: "Unsteady Chair", category: "Chess", price: 29.95 },
            { id: 8, name: "Human Chess Board", category: "Chess", price: 75 },
            { id: 9, name: "Bling Bling King", category: "Chess", price: 1200 }
        ]
    }
    return data
}
```

The `json-server` package can work with JSON or JavaScript files. If you use a JSON file, then its contents will be modified to reflect changes requests made by clients. I have chosen the JavaScript option, which allows data to be generated programmatically and means that restarting the process will return to the original data.

Updating the Form Component

In Chapter 23, I configured the component that manages the HTML form to ignore events generated by the table component until the first time that the Create New Product button is clicked. To avoid confusing results, Listing 24-5 disables the `skipWhile` and `distinctUntilChanged` methods that were applied to the `Observable`.

Listing 24-5. Disabling Event Skipping in the form.component.ts File

```
...
constructor(private model: Model,
    @Inject(SHARED_STATE) private stateEvents: Observable<SharedState>) {

    stateEvents
        //.skipWhile(state => state.mode == MODES.EDIT)
        //.distinctUntilChanged((firstState, secondState) =>
        //    firstState.mode == secondState.mode
        //    && firstState.id == secondState.id)
        .subscribe(update => {
            this.product = new Product();
            if (update.id != undefined) {
                Object.assign(this.product, this.model.getProduct(update.id));
            }
            this.editing = update.mode == MODES.EDIT;
        });
}
...
```

Running the Example Project

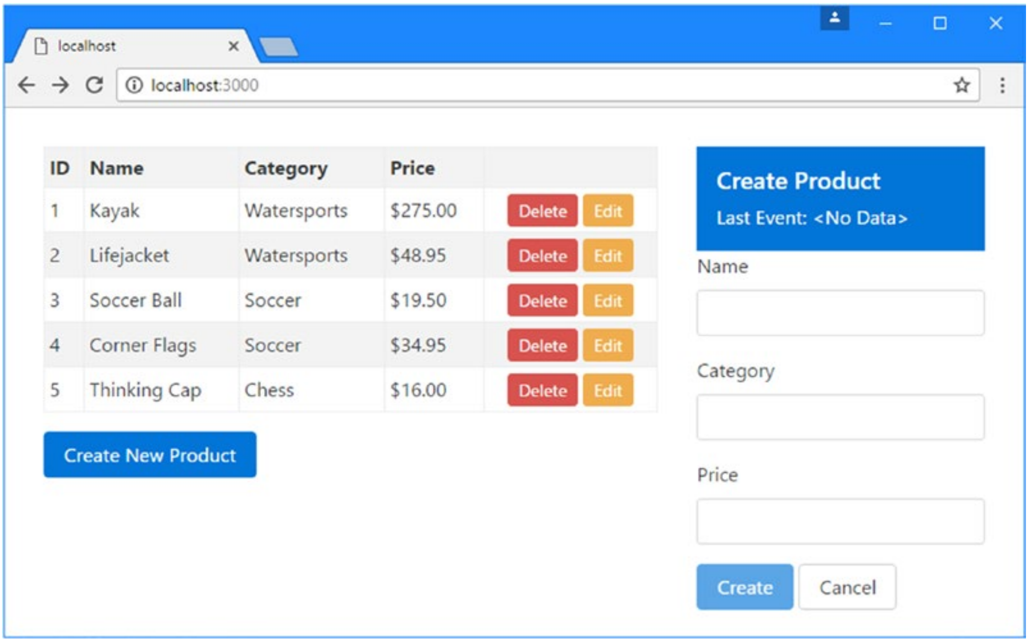
Save the changes and run the following command in the `exampleApp` folder to download and install the Angular `Http` module and the `json-server` package:

```
npm install
```

Once the update has been completed, run the following command to start the TypeScript compiler, the development HTTP server, and the RESTful web service:

```
npm start
```

A new browser window or tab will open and show the content illustrated in Figure 24-1.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Thinking Cap	Chess	$16.00	Delete Edit

Figure 24-1. *Running the example application*

To test the RESTful web services, request the following URL in the browser window:

```
http://localhost:3500/products/2
```

The server will respond with the following data:

```
{ "id": 2, "name": "Lifejacket", "category": "Watersports", "price": 48.95 }
```

Understanding RESTful Web Services

The most common approach for delivering data to an application is to use the *Representational State Transfer* pattern, known as REST, to create a data web service. There is no detailed specification for REST, which leads to a lot of different approaches that fall under the RESTful banner. There are, however, some unifying ideas that are useful in web application development.

The core premise of a RESTful web service is to embrace the characteristics of HTTP so that request methods—also known as *verbs*—specify an operation for the server to perform, and the request URL specifies one or more data objects to which the operation will be applied.

As an example, here is a URL that might refer to a specific product in the example application:

```
http://localhost:3500/products/2
```

The first segment of the URL—products—is used to indicate the collection of objects that will be operated on and allows a single server to provide multiple services, each of which with its own data. The second segment—2—selects an individual object within the products collection. In the example, it is the value of the id property that uniquely identifies an object and that would be used in the URL, in this case, specifying the Lifejacket object.

The HTTP verb or method used to make the request tells the RESTful server what operation should be performed on the specified object. When you tested the RESTful server in the previous section, the browser sent an HTTP GET request, which the server interprets as an instruction to retrieve the specified object and send it to the client. It is for this reason that the browser displayed a JSON representation of the Lifejacket object.

Table 24-3 shows the most common combination of HTTP methods and URLs and explains what each of them does when sent to a RESTful server.

Table 24-3. *Common HTTP Verbs and Their Effect in a RESTful Web Service*

Verb	URL	Description
GET	/products	This combination retrieves all the objects in the products collection.
GET	/products/2	This combination retrieves the object whose id is 2 from the products collection.
POST	/products	This combination is used to add a new object to the products collection. The request body contains a JSON representation of the new object.
PUT	/products/2	This combination is used to replace the object in the products collection whose id is 2. The request body contains a JSON representation of the replacement object.
PATCH	/products/2	This combination is used to update a subset of the properties of the object in the products collection whose id is 2. The request body contains a JSON representation of the properties to update and the new values.
DELETE	/products/2	This combination is used to delete the product whose id is 2 from the products collection.

Caution is required because there can be considerable differences in the way that some RESTful web services work, caused by differences in the frameworks used to create them and the preferences of the development team. It is important to confirm how a web service uses verbs and what is required in the URL and request body to perform operations.

Some common variations include web services that won't accept any request bodies that contain id values (to ensure they are generated uniquely by the server's data store) and web services that don't support all of the verbs (it is common to ignore PATCH requests and only accept updates using the PUT verb).

Replacing the Static Data Source

The best place to start with HTTP requests is to replace the static data source in the example application with one that retrieves data from the RESTful web service. This will provide a foundation for describing how Angular supports HTTP requests and how they can be integrated into an application.

Creating the New Data Source Service

To create a new data source, I added a file called `rest.datasource.ts` in the `exampleApp/app/model` folder and added the statements shown in Listing 24-6.

Listing 24-6. The Contents of the rest.datasource.ts File in the exampleApp/app/model Folder

```
import { Injectable, Inject, OpaqueToken } from "@angular/core";
import { Http } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import "rxjs/add/operator/map";

export const REST_URL = new OpaqueToken("rest_url");

@Injectable()
export class RestDataSource {

    constructor(private http: Http,
        @Inject(REST_URL) private url: string) { }

    getData(): Observable<Product[]> {
        return this.http.get(this.url).map(response => response.json());
    }
}
```

This is a simple-looking class, but there are some important features at work, which I described in the sections that follow.

Setting Up the HTTP Request

Angular provides the ability to make asynchronous HTTP requests through the `Http` class, which is defined in the `@angular/http` JavaScript module and is provided as a service in the `HttpModule` feature module. The data source declared a dependency on the `Http` class using its constructor, like this:

```
...
constructor(private http: Http, @Inject(REST_URL) private url: string) { }
...
```

The other constructor argument is used so that the URL that requests are sent to doesn't have to be hardwired into the data source. I'll create a provider using the `REST_URL` opaque token when I configure the feature module. The `Http` object received through the constructor is used to make an HTTP GET request in the data source's `getData` method, like this:

```
...
getData(): Observable<Product[]> {
    return this.http.get(this.url).map(response => response.json());
}
...
```

The `Http` class defines a set of methods for making HTTP requests, each of which uses a different HTTP verb, as described in Table 24-4.

■ **Tip** The methods in Table 24-4 accept an optional configuration object, as demonstrated in the "Configuring Request Headers" section.

Table 24-4. *The Http Methods*

Name	Description
`get(url)`	This method sends a GET request to the specified URL.
`post(url, body)`	This method sends a POST request using the specified object as the body.
`put(url, body)`	This method sends a PUT request using the specified object as the body.
`patch(url, body)`	This method sends a PATCH request using the specified object as the body.
`delete(url)`	This method sends a DELETE request to the specified URL.
`head(url)`	This method sends a HEAD request, which has the same effect as a GET request except that the server will return only the headers and not the request body.
`options(url)`	This method sends an OPTIONS request to the specified URL.
`request(request)`	This method can be used to send a request with any verb, as described in the "Consolidating HTTP Requests" section.

Processing the Response

The methods described in Table 24-4 return a Reactive Extensions `Observable<Response[]>` object, as described in Chapter 23, which sends an event when the response is received from the server.

The `Response` class, which is also defined in the `@angular/http` JavaScript module, is used to represent the response from the server. Table 24-5 describes the most useful methods and properties defined by the `Response` class.

Table 24-5. *Useful Response Methods and Properties*

Name	Description
`ok`	This `boolean` property returns true if the response status code is between 200 and 299, indicating a successful request.
`status`	This `number` property returns the status code from the response.
`statusText`	This `string` property returns the descriptive status code message from the response.
`url`	This `string` property returns the requested URL.
`totalBytes`	This `number` property returns the expected size of the response.
`headers`	This property returns a `Headers` object, which provides access to the response headers. See the "Configuring Request Headers" section for details of the Headers class.
`json()`	This method treats the response data as JSON and attempts to parse it to create JavaScript objects.
`text()`	This method returns the response data as a `string`.
`blob()`	This method returns the response data as a binary object.
`arrayBuffer()`	This method returns the response data as an array buffer.

The RESTful web server returns JSON data, which has become the de facto standard used by web services, and the json method is used to parse the response and create an array of JavaScript objects.

```
...
getData(): Observable<Product[]> {
    return this.http.get(this.url).map(response => response.json());
}
...
```

The effect is that the Observable<Response> returned by the Http.get method is transformed into an Observable<Product[]> by the combination of the Observable.map method and the Response.json method, with the array of objects being sent to the Observer object's subscribers.

■ **Caution** The methods in Table 24-4 prepare an HTTP request, but it isn't sent to the server until the Observer object's subscribe method is invoked. Be careful, though, because the request will be sent once per call to the subscribe method, which makes it easy to inadvertently send the same request multiple times.

Configuring the Data Source

The next step is to configure a provider for the new data source and to create a value-based provider to configure it with a URL to which requests will be sent. Listing 24-7 shows the changes to the model.module.ts file.

Listing 24-7. Configuring the Data Source in the model.module.ts File

```
import { NgModule } from "@angular/core";
import { HttpModule } from "@angular/http"
//import { StaticDataSource } from "./static.datasource";
import { Model } from "./repository.model";
import { RestDataSource, REST_URL } from "./rest.datasource";

@NgModule({
    imports: [HttpModule],
    providers: [Model, RestDataSource,
        { provide: REST_URL, useValue: `http://${location.hostname}:3500/products` }]
})
export class ModelModule { }
```

The two new providers enable the RestDataSource class as a service and use the REST_URL opaque token to configure the URL for the web service. I removed the provider for the StaticDataSource class, which is no longer required.

ISOLATING A DATA SOURCE FOR UNIT TESTING

Data sources that make network requests can be hard to isolate for unit testing because it is hard to differentiate between the behavior of the data source class and any unexpected effects caused by the network and the server.

There is an NPM package available that provides an in-memory API service that can be used to simulate HTTP requests using data that has been defined locally. This provides a way to isolate a data source class and ensure that only its behavior is being tested. The package is called `angular-in-memory-web-api`, and it is described at `https://github.com/angular/in-memory-web-api`.

Using the REST Data Source

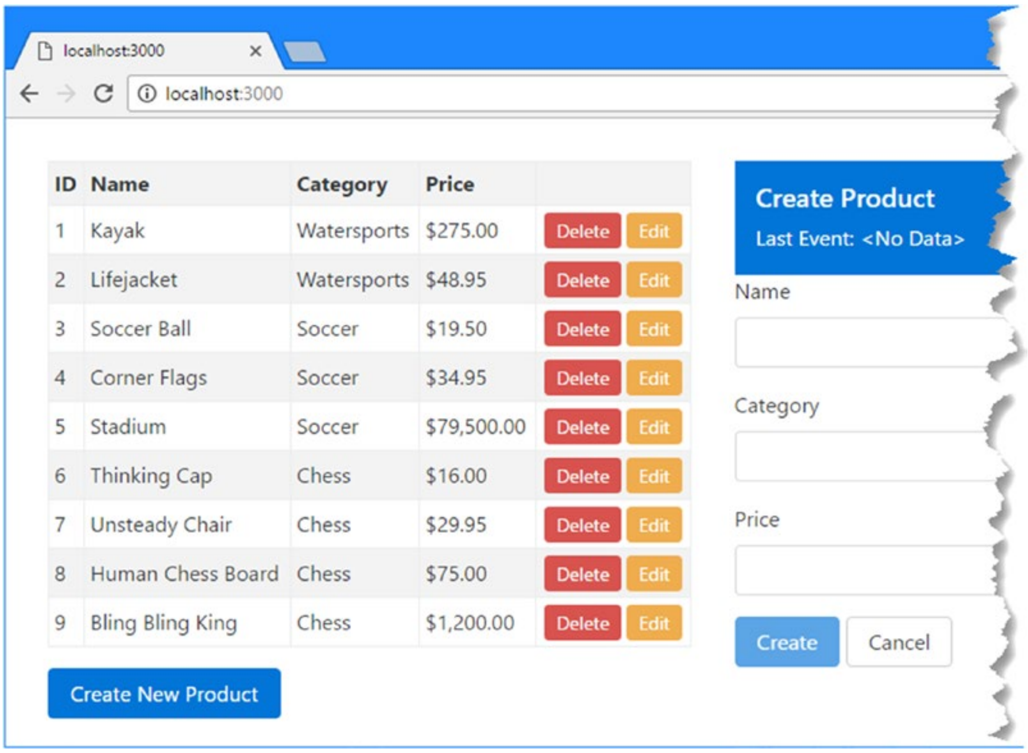
The final step is to update the repository class so that it declares a dependency on the new data source and uses it to get the application data, as shown in Listing 24-8.

Listing 24-8. Using the New Data Source in the repository.model.ts File

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";
//import { StaticDataSource } from "./static.datasource";
import { Observable } from "rxjs/Observable";
import { RestDataSource } from "./rest.datasource";

@Injectable()
export class Model {
    private products: Product[] = new Array<Product>();
    private locator = (p: Product, id: number) => p.id == id;

    constructor(private dataSource: RestDataSource) {
        //this.products = new Array<Product>();
        //this.dataSource.getData().forEach(p => this.products.push(p));
        this.dataSource.getData().subscribe(data => this.products = data);
    }

    getProducts(): Product[] {
        return this.products;
    }

    getProduct(id: number): Product {
        return this.products.find(p => this.locator(p, id));
    }

    saveProduct(product: Product) {
        if (product.id == 0 || product.id == null) {
            product.id = this.generateID();
            this.products.push(product);
        } else {
            let index = this.products
                .findIndex(p => this.locator(p, product.id));
            this.products.splice(index, 1, product);
        }
    }

    deleteProduct(id: number) {
        let index = this.products.findIndex(p => this.locator(p, id));
        if (index > -1) {
            this.products.splice(index, 1);
        }
    }

    private generateID(): number {
        let candidate = 100;
        while (this.getProduct(candidate) != null) {
            candidate++;
        }
        return candidate;
    }
}
```

The constructor dependency has changed so that the repository will receive a `RestDataSource` object when it is created. Within the constructor, the data source's `getData` method is called, and the `subscribe` method is used to receive the data objects that are returned from the server and process them.

When you save the changes, the browser will reload the application, and the new data source will be used. An asynchronous HTTP request will be sent to the RESTful web service, which will return the larger set of data objects shown in Figure 24-2.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Create New Product

Create Product
Last Event: <No Data>

Name

Category

Price

Create Cancel

Figure 24-2. *Getting the application data*

Saving and Deleting Data

The data source is able to get data from the server, but it also needs to send data the other way, persisting changes that the user makes to objects in the model and storing new objects that are created. Listing 24-9 adds methods to the data source class to send HTTP requests to save or update objects using the Angular `Http` class.

Listing 24-9. Sending Data in the rest.datasource.ts File

```
import { Injectable, Inject, OpaqueToken } from "@angular/core";
import { Http } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import "rxjs/add/operator/map";

export const REST_URL = new OpaqueToken("rest_url");

@Injectable()
export class RestDataSource {

    constructor(private http: Http,
        @Inject(REST_URL) private url: string) { }
    getData(): Observable<Product[]> {
        return this.http.get(this.url)
            .map(response => response.json());
    }

    saveProduct(product: Product): Observable<Product> {
        return this.http.post(this.url, product)
            .map(response => response.json());
    }

    updateProduct(product: Product): Observable<Product> {
        return this.http.put(`${this.url}/${product.id}`, product)
            .map(response => response.json());
    }

    deleteProduct(id: number): Observable<Product> {
        return this.http.delete(`${this.url}/${id}`)
            .map(response => response.json());
    }
}
```

The saveProduct, updateProduct, and deleteProduct methods follow the same pattern: they call one of the Http class methods, use the map method to process the Response object that the HTTP request produces, and return an Observable<Product> as the result. The difference between the methods is in the URL that the requests are sent to.

When saving a new object, the ID of the object is generated by the server so that it is unique and clients don't inadvertently use the same ID for different objects. In this situation, the POST method is used, and the request is sent to the /products URL.

When updating or deleting an existing object, the ID is already known, and a PUT request is sent to a URL that includes the ID. So, a request to update the object whose ID is 2, for example, is sent to the /products/2 URL. Similarly, to remove that object, a DELETE request would be sent to the same URL.

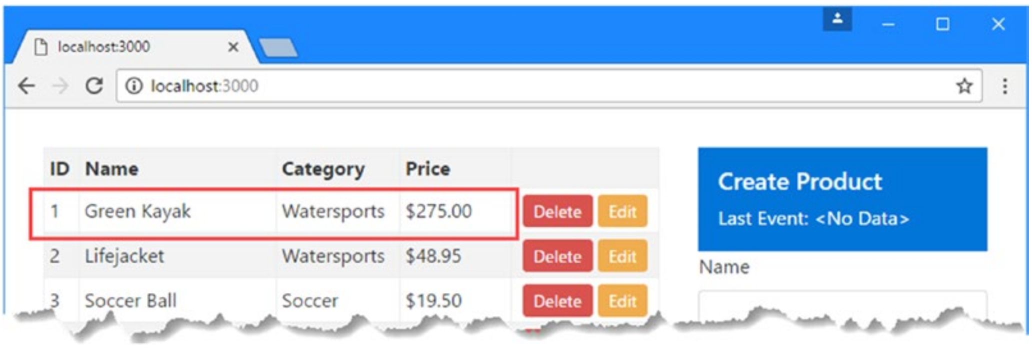
What these methods have in common is that the server is the authoritative data store and the response from the server contains the official version of the object that has been saved by the server. It is this object that is returned as the results from these methods, provided through the Observable<Product>.

Listing 24-10 shows the corresponding changes in the repository class that take advantage of the new data source features.

Listing 24-10. Using the Data Source Features in the repository.model.ts File

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";
import { Observable } from "rxjs/Observable";
import { RestDataSource } from "./rest.datasource";

@Injectable()
export class Model {
    private products: Product[] = new Array<Product>();
    private locator = (p: Product, id: number) => p.id == id;

    constructor(private dataSource: RestDataSource) {
        this.dataSource.getData().subscribe(data => this.products = data);
    }
    getProducts(): Product[] {
        return this.products;
    }

    getProduct(id: number): Product {
        return this.products.find(p => this.locator(p, id));
    }

    saveProduct(product: Product) {
        if (product.id == 0 || product.id == null) {
            this.dataSource.saveProduct(product)
                .subscribe(p => this.products.push(p));
        } else {
            this.dataSource.updateProduct(product).subscribe(p => {
                let index = this.products
                    .findIndex(item => this.locator(item, p.id));
                this.products.splice(index, 1, p);
            });
        }
    }

    deleteProduct(id: number) {
        this.dataSource.deleteProduct(id).subscribe(() => {
            let index = this.products.findIndex(p => this.locator(p, id));
            if (index > -1) {
                this.products.splice(index, 1);
            }
        });
    }
}
```

The changes use the data source to send updates to the server and use the results to update the locally stored data so that it is displayed by the rest of the application. To test the changes, click the Edit button for the Kayak product and change its name to Green Kayak. Click the Save button and the browser will send an HTTP PUT request to the server, which will return a modified object that is added to the repository's `products` array and is displayed in the table, as shown in Figure 24-3.



ID	Name	Category	Price
1	Green Kayak	Watersports	$275.00
2	Lifejacket	Watersports	$48.95
3	Soccer Ball	Soccer	$19.50

Figure 24-3. *Sending a PUT request to the server*

You can check that the server has stored the changes by using the browser to request `http://localhost/products/1`, which will produce the following representation of the object:

```
{
  "id": 1,
  "name": "Green Kayak",
  "category": "Watersports",
  "price": 275
}
```

Consolidating HTTP Requests

Each of the methods in the data source class duplicates the same basic pattern of sending an HTTP request and then parsing the JSON response from the server. This means that any change to the way that HTTP requests are made has to be repeated in four different places, ensuring that the requests that use the GET, POST, PUT, and DELETE verbs are all correctly updated.

The `Http` class defines the `request` method, which allows the HTTP verb to be specified as an argument. Listing 24-11 uses the `request` method to consolidate the HTTP requests to remove duplication in the data source class.

Listing 24-11. Consolidating HTTP Requests in the rest.datasource.ts File

```
import { Injectable, Inject, OpaqueToken } from "@angular/core";
import { Http, Request, RequestMethod } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import "rxjs/add/operator/map";

export const REST_URL = new OpaqueToken("rest_url");

@Injectable()
export class RestDataSource {

    constructor(private http: Http,
        @Inject(REST_URL) private url: string) { }

    getData(): Observable<Product[]> {
        return this.sendRequest(RequestMethod.Get, this.url);
    }

    saveProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Post, this.url, product);
    }

    updateProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Put,
            `${this.url}/${product.id}`, product);
    }
    deleteProduct(id: number): Observable<Product> {
        return this.sendRequest(RequestMethod.Delete, `${this.url}/${id}`);
    }

    private sendRequest(verb: RequestMethod,
                        url: string, body?: Product): Observable<Product> {
        return this.http.request(new Request({
            method: verb,
            url: url,
            body: body
        })).map(response => response.json());
    }
}
```

The request method accepts a Request object that describes the HTTP request that should be sent. The process for creating a Request object is a little odd because it relies on an interface called RequestArgs to define configuration properties, which can be expressed as an object literal as the argument to the Request method, like this:

```
...
return this.http.request(new Request({
    method: verb,
    url: url,
    body: body
})).map(response => response.json());
...
```

Table 24-6 describes the properties that can be specified to configure the request.

Table 24-6. *The RequestArgs Properties*

Name	Description
method	This property sets the HTTP verb/method that will be used for the request, specified as a string or as a value from the RequestMethod enum.
url	This property specifies the URL to which the request will be sent.
headers	This property returns a Headers object that allows the request headers to be specified, as described in the “Configuring Request Headers” section.
body	This property is used to set the request body. The object assigned to this property will be serialized as JSON when the request is sent.
withCredentials	When true, this property is used to include authentication cookies when making cross-site requests. This setting must be used only with servers that include the Access-Control-Allow-Credentials header in responses, as part of the Cross-Origin Resource Sharing (CORS) specification. See the “Making Cross-Origin Requests” section for details.

In the listing, I use the method, url, and body properties to configure all the requests that are needed, consolidating the use of the Http object in a single method.

Making Cross-Origin Requests

By default, browsers enforce a security policy that only allows JavaScript code to make asynchronous HTTP requests within the same *origin* as the document that contains them. This policy is intended to reduce the risk of cross-site scripting (CSS) attacks, where the browser is tricked into executing malicious code. The details of this attack are beyond the scope of this book, but there is a nice article available at `http://en.wikipedia.org/wiki/Cross-site_scripting` that provides a good introduction to the topic.

For Angular developers, the same-origin policy can be a problem when using web services because they are typically outside of the origin that contains the application's JavaScript code. Two URLs are considered to be in the same origin if they have the same protocol, host, and port and have different origins if this is not the case. The URL for the HTML file that contains the example application's JavaScript code is `http://localhost:3000/index.html`. Table 24-7 summarizes how similar URLs have the same or different origins, compared with the application's URL.

Table 24-7. *URLs and Their Origins*

URL	Origin Comparison
`http://localhost:3000/otherfile.html`	Same origin
`http://localhost:3000/app/main.js`	Same origin
`https://localhost:3000/index.html`	Different origin; protocol differs
`http://localhost:3500/products`	Different origin; port differs
`http://angular.io/index.html`	Different origin; host differs

As the table shows, the URL for the RESTful web service, `http://localhost:3500/products`, has a different origin because it uses a different port from the main application.

HTTP requests made using the Angular `Http` class will automatically use Cross-Origin Resource Sharing (CORS) to send requests to different origins. With CORS, the browser includes headers in the asynchronous HTTP request that provide the server with the origin of the JavaScript code. The response from the server includes headers that tell the browser whether it is willing to accept the request. The details of CORS are outside the scope of this book, but there is an introduction to the topic at `https://en.wikipedia.org/wiki/Cross-origin_resource_sharing`, and the CORS specification is available at `http://www.w3.org/TR/cors`.

For the Angular developer, CORS is something that is taken care of automatically, just as long as the server that receives asynchronous HTTP requests supports the specification. The `json-server` package that has been providing the RESTful web service for the examples supports CORS and will accept requests from any origin, which is why the examples have been working. If you want to see CORS in action, use the browser's F12 developer tools to watch the network requests that are made when you edit or create a product. You may see a request made using the `OPTIONS` verb, known as the preflight request, which the browser uses to check that it is allowed to make the POST or PUT request to the server. This request and the subsequent request that sends the data to the server will contain an `Origin` header, and the response will contain one or more `Access-Control-Allow` headers, through which the server sets out what it is willing to accept from the client.

All of this happens automatically, and the only configuration option is the `withCredentials` property that was described in Table 24-6. When this property is `true`, the browser will include authentication cookies, and headers from the origin will be included in the request to the server.

Using JSONP Requests

CORS is available only if the server to which the HTTP requests are sent supports it. For servers that don't implement CORS, Angular also provides support for *JSONP*, which allows a more limited form of cross-origin requests.

JSONP works by adding a `script` element to the Document Object Model that specifies the cross-origin server in its `src` attribute. The browser sends a GET request to the server, which returns JavaScript code that, when executed, provides the application with the data it requires. JSONP is, essentially, a hack that works around the browser's same-origin security policy. JSONP can be used only to make GET requests, and it presents greater security risks than CORS. As a consequence, JSONP should be used only when CORS isn't available.

The Angular support for JSONP is defined in a feature module called `JsonpModule`, which is defined in the `@angular/http` JavaScript module. To enable JSONP, Listing 24-12 adds `JsonpModule` to the set of imports for the model module.

Listing 24-12. Enabling JSONP in the model.module.ts File

```
import { NgModule } from "@angular/core";
import { HttpModule, JsonpModule } from "@angular/http"
import { Model } from "./repository.model";
import { RestDataSource, REST_URL } from "./rest.datasource";

@NgModule({
    imports: [HttpModule, JsonpModule],
    providers: [Model, RestDataSource,
        { provide: REST_URL, useValue: `http://${location.hostname}:3500/products` }]
})
export class ModelModule { }
```

Angular provides support for JSONP through a `Jsonp` service defined in the `@angular/http` module. This service takes care of managing the JSONP HTTP request and processing the response, which can otherwise be a tedious and error-prone process. Listing 24-13 shows the data source using JSONP to request the initial data for the application.

■ **Tip** The `Jsonp` class defines the same set of methods as the `Http` class but supports only GET requests. An error will occur if you try to send any other request type.

Listing 24-13. Making a JSONP Request in the rest.datasource.ts File

```
import { Injectable, Inject, OpaqueToken } from "@angular/core";
import { Http, Request, RequestMethod, Jsonp } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import "rxjs/add/operator/map";

export const REST_URL = new OpaqueToken("rest_url");

@Injectable()
export class RestDataSource {

    constructor(private http: Http, private jsonp: Jsonp,
        @Inject(REST_URL) private url: string) { }
    getData(): Observable<Product[]> {
        return this.jsonp.get(this.url + "?callback=JSONP_CALLBACK")
            .map(response => response.json());
    }

    saveProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Post, this.url, product);
    }

    updateProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Put,
            `${this.url}/${product.id}`, product);
    }

    deleteProduct(id: number): Observable<Product> {
        return this.sendRequest(RequestMethod.Delete, `${this.url}/${id}`);
    }

    private sendRequest(verb: RequestMethod,
        url: string, body?: Product): Observable<Product> {
        return this.http.request(new Request({
            method: verb,
            url: url,
            body: body
        })).map(response => response.json());
    }
}
```

When you use JSONP, the URL you request must include a `callback` parameter, and it must be set to `JSONP_CALLBACK`, like this:

```
...
return this.jsonp.get(this.url + "?callback=JSONP_CALLBACK")
    .map(response => response.json());
...
```

When Angular makes the HTTP request, it replaces `JSONP_CALLBACK` with the name of a dynamically generated function. If you look at the network requests that the browser makes, you will see that the initial request is sent to a URL like this one:

```
http://localhost:3500/products?callback=__ng_jsonp__.__req0.finished
```

The server uses the value of the `callback` parameter to generate a JavaScript file that invokes the named function and passes it the data from the model, like this:

```
typeof __ng_jsonp__.__req0.finished === 'function'
     &&__ng_jsonp__.__req0.finished([
  { "id": 1, "name": "Green Kayak", "category": "Watersports", "price": 275 },
  { "id": 2,"name": "Lifejacket", "category": "Watersports", "price": 48.95 },
  { ...other objects omitted for brevity... }
]);
```

The browser loads the JavaScript file generated by the server and executes the function, which Angular uses to receive the data into the application. JSONP is a more limited way to make cross-origin requests, and, unlike CORS, it skirts around the browser's security policy, but it can be a useful fallback in a pinch.

Configuring Request Headers

If you are using a commercial RESTful web service, you will often have to set a request header to provide an API key so that the server can associate the request with your application for the purposes of access control and billing. You can set this kind of header—or any other header—by configuring the `RequestArgs` configuration object that is passed to the `request` method, as shown in Listing 24-14. This listing also returns to using the `Http` class for all requests, rather than JSONP.

Listing 24-14. Setting a Request Header in the rest.datasource.ts File

```
import { Injectable, Inject, OpaqueToken } from "@angular/core";
import { Http, Request, RequestMethod, Headers } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import "rxjs/add/operator/map";

export const REST_URL = new OpaqueToken("rest_url");

@Injectable()
export class RestDataSource {

    constructor(private http: Http,
        @Inject(REST_URL) private url: string) { }

    getData(): Observable<Product[]> {
        return this.sendRequest(RequestMethod.Get, this.url);
    }

    saveProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Post, this.url, product);
    }

    updateProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Put,
            `${this.url}/${product.id}`, product);
    }

    deleteProduct(id: number): Observable<Product> {
        return this.sendRequest(RequestMethod.Delete, `${this.url}/${id}`);
    }

    private sendRequest(verb: RequestMethod,
        url: string, body?: Product): Observable<Product> {
        return this.http.request(new Request({
            method: verb,
            url: url,
            body: body,
            headers: new Headers({
                "Access-Key": "<secret>",
                "Application-Name": "exampleApp"
            })
        })).map(response => response.json());
    }
}
```

The headers property is set to a Headers object, which can be created using a map object of properties that correspond to header names and the values that should be used for them. If you use the browser's F12 developer tools to inspect the asynchronous HTTP requests, you will see that the two headers specified in the listing are sent to the server along with the standard headers that the browser creates, like this:

```
...
Accept:*/*
Accept-Encoding:gzip, deflate, sdch, br
Accept-Language:en-US,en;q=0.8
access-key:<secret>
application-name:exampleApp
Connection:keep-alive
...
```

The header names are sent in lowercase, but HTTP header names are case-insensitive. If you have more complex demands for request headers, then you can use the methods defined by the Headers class, as described in Table 24-8.

Table 24-8. *The Headers Methods*

Name	Description
`get(name)`	Returns the first value for the specified header
`getAll(name)`	Returns all the values for the specified header
`has(name)`	Returns `true` if the collection contains the specified header
`set(header, value)`	Replaces all existing values for the specified header with a single value
`set(header, values)`	Replaces all existing values for the specified header with an array of values
`append(name, value)`	Appends a value to the list of values for the specified header
`delete(name)`	Removes the specified header from the collection
`toJson()`	Returns a JSON representation of all the headers and values

HTTP headers can have multiple values, which is why there are methods that append values for headers or replace all the values in the collection. Listing 24-15 creates an empty Headers object and populates it with headers that have multiple values.

Listing 24-15. Setting Multiple Header Values in the rest.datasource.ts File

```
...
private sendRequest(verb: RequestMethod,
        url: string, body?: Product): Observable<Product> {

    let headers = new Headers();
    headers.set("Access-Key", "<secret>");
    headers.set("Application-Names", ["exampleApp", "proAngular"]);

    return this.http.request(new Request({
        method: verb,
        url: url,
        body: body,
        headers: headers
    })).map(response => response.json());
}
...
```

When the browser sends requests to the server, they will include the following headers:

```
...
Accept:*/*
Accept-Encoding:gzip, deflate, sdch, br
Accept-Language:en-US,en;q=0.8
access-key:<secret>
application-names:exampleApp,proAngular
Connection:keep-alive
...
```

Handling Errors

At the moment, there is no error handling in the application, which means that Angular doesn't know what to do if there is a problem with an HTTP request. To make it easy to generate an error, I have added a button to the product table that will lead to an HTTP request to delete an object that doesn't exist at the server, as shown in Listing 24-16.

Listing 24-16. Adding an Error Button in the table.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm" (click)="editProduct(item.id)">
                Edit
            </button>
        </td>
    </tr>

</table>
<button class="btn btn-primary" (click)="createProduct()">
    Create New Product
</button>
<button class="btn btn-danger" (click)="deleteProduct(-1)">
    Generate HTTP Error
</button>
```

The button element invokes the component's deleteProduct method with an argument of -1. The component will ask the repository to delete this object, which will lead to an HTTP DELETE request being sent to /products/-1, which does not exist. If you open the browser's JavaScript console and click the new button, you will see the response from the server displayed, like this:

```
EXCEPTION: Response with status: 404 Not Found for URL: http://localhost:3500/products/-1
```

Improving on this situation means detecting this kind of error when one occurs and notifying the user, who won't typically be looking at the JavaScript console. A real application might also respond to errors by logging them so they can be analyzed later, but I am going to keep things simple and just display an error message.

Generating User-Ready Messages

The first step in handling errors is to convert the HTTP exception into something that can be displayed to the user. The default error message, which is the one written to the JavaScript console, contains too much information to display to the user. Users don't need to know the URL that the request was sent to; just having a sense of the kind of problem that has occurred will be enough.

The best way to transform error messages is to use the catch and throw methods defined by the Observable class. The catch method is used to receive any errors that occur within an Observable sequence, and the throw method is used to create a new Observable that just contains the error. Listing 24-17 applies both methods to the data source.

■ **Tip** Notice that the throw method is imported from rxjs/add/observable.

Listing 24-17. Transforming Errors in the rest.datasource.ts File

```
import { Injectable, Inject, OpaqueToken } from "@angular/core";
import { Http, Request, RequestMethod, Headers, Response } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import "rxjs/add/operator/map";
import "rxjs/add/operator/catch";
import "rxjs/add/observable/throw";

export const REST_URL = new OpaqueToken("rest_url");

@Injectable()
export class RestDataSource {

    constructor(private http: Http,
        @Inject(REST_URL) private url: string) { }

    getData(): Observable<Product[]> {
        return this.sendRequest(RequestMethod.Get, this.url);
    }

    saveProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Post, this.url, product);
    }

    updateProduct(product: Product): Observable<Product> {
        return this.sendRequest(RequestMethod.Put,
            `${this.url}/${product.id}`, product);
    }

    deleteProduct(id: number): Observable<Product> {
        return this.sendRequest(RequestMethod.Delete, `${this.url}/${id}`);
    }

    private sendRequest(verb: RequestMethod,
        url: string, body?: Product): Observable<Product> {

        let headers = new Headers();
        headers.set("Access-Key", "<secret>");
        headers.set("Application-Names", ["exampleApp", "proAngular"]);

        return this.http.request(new Request({
            method: verb,
            url: url,
            body: body,
            headers: headers
        })).map(response => response.json())
            .catch((error: Response) => Observable.throw(
                `Network Error: ${error.statusText} (${error.status})`));
    }
}
```

The function passed to the catch method is invoked when there is an error and receives the Response object that describes the outcome. The Observable.throw method creates a new observable that contains just an error object, which in this case is used to generate an error message that contains the HTTP status code and status text from the response.

If you save the changes and then click the Generate HTTP Error button again, the error message will still be written to the browser's JavaScript console but will have changed to the format produced by the catch/throw methods:

```
EXCEPTION: Network Error: Not Found (404)
```

Handling the Errors

The errors have been transformed but not handled, which is why they are still being reported as exceptions in the browser's JavaScript console.

There are two ways in which the errors can be handled. The first is to provide an error-handling function to the subscribe method for the Observable objects created by the Http object. This is a useful way to localize the error and provide the repository with the opportunity to retry the operation or try to recover in some other way.

The second approach is to replace the built-in Angular error-handling feature, which responds to any unhandled errors in the application and, by default, writes them to the console. It is this feature that writes out the messages shown in the previous sections.

For the example application, I want to override the default error handler with one that uses the message service. I created a file called errorHandler.ts in the exampleApp/app/messages folder and used it to define the class shown in Listing 24-18.

Listing 24-18. The Contents of the errorHandler.ts File in the exampleApp/app/messages Folder

```
import { ErrorHandler, Injectable } from "@angular/core";
import { MessageService } from "./message.service";
import { Message } from "./message.model";

@Injectable()
export class MessageErrorHandler implements ErrorHandler {

    constructor(private messageService: MessageService) {
    }

    handleError(error) {
        let msg = error instanceof Error ? error.message : error.toString();
        setTimeout(() => this.messageService
            .reportMessage(new Message(msg, true)), 0);
    }
}
```

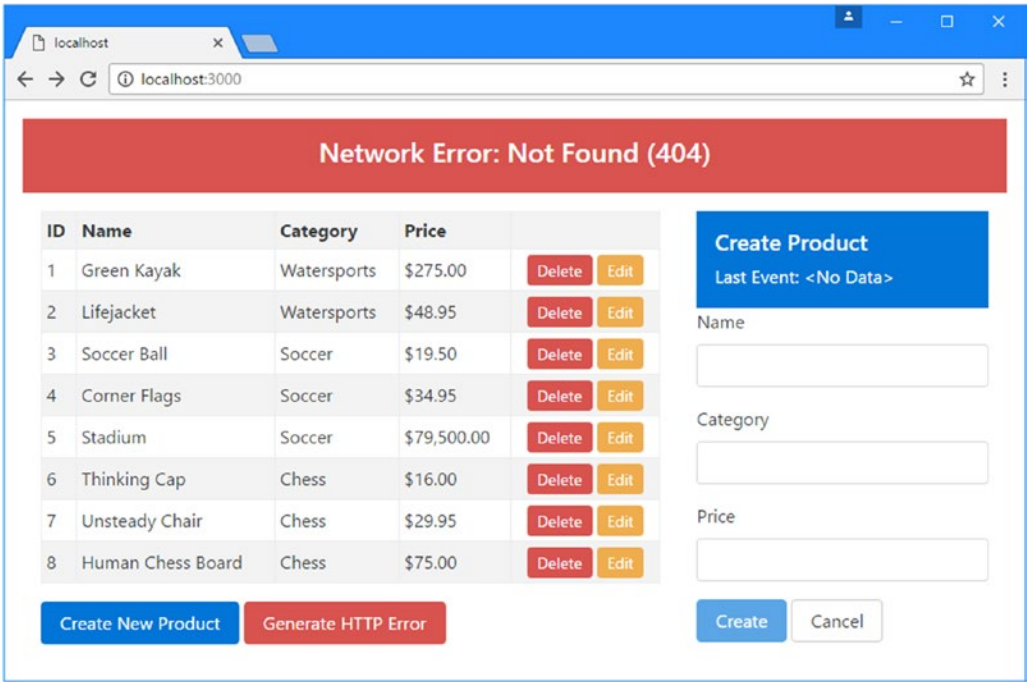
The ErrorHandler class is defined in the @angular/core module and responds to errors through a handleError method. The class shown in the listing replaces the default implementation of this method with one that uses the MessageService to report an error. The setTimeout function ensures that the message is displayed to the user, working around a wrinkle in the way that Angular handles updates.

To replace the default ErrorHandler, I used a class provider in the message module, as shown in Listing 24-19.

Listing 24-19. Replacing the Default Error Handler in the message.module.ts File

```
import { NgModule, ErrorHandler } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { MessageComponent } from "./message.component";
import { MessageService } from "./message.service";
import { MessageErrorHandler } from "./errorHandler";

@NgModule({
    imports: [BrowserModule],
    declarations: [MessageComponent],
    exports: [MessageComponent],
    providers: [MessageService,
        { provide: ErrorHandler, useClass: MessageErrorHandler }]
})
export class MessageModule { }
```

The error handling function uses the MessageService to report an error message to the user. Once these changes have been saved, clicking the Generate HTTP Error button produces an error that the user can see, as shown in Figure 24-4.



ID	Name	Category	Price	
1	Green Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit

Figure 24-4. *Handling an HTTP error*

Summary

In this chapter, I explained how to make asynchronous HTTP request in Angular applications. I introduced RESTful web services and the methods provided by the Angular `Http` class that can be used into interact with them. I explained how the browser restricts requests to different origins and how Angular supports CORS and JSONP to make requests outside of the application's origin. In the next chapter, I introduce the URL routing feature, which allows for navigation around complex applications.

CHAPTER 25

Routing and Navigation: Part 1

The Angular routing feature allows applications to change the components and templates that are displayed to the user by responding to changes to the browser's URL. This allows complex applications to be created that adapt the content they present in an open and flexible way, with minimal coding. To support this feature, there are data bindings and services that can be used to change the browser's URL, allowing the user to navigate around the application.

Routing is useful as the complexity of a project increases because it allows the structure of an application to be defined separately from the components and directives, meaning that changes to the structure can be made in the routing configuration and do not have to be applied to the individual components.

In this chapter, I demonstrate how the basic routing system works and apply it to the example application. In Chapters 26 and 27, I explain the more advanced routing features. Table 25-1 puts routing in context.

Table 25-1. *Putting Routing and Navigation in Context*

Question	Answer
What is it?	Routing uses the browser's URL to manage the content displayed to the user.
Why is it useful?	Routing allows the structure of an application to be kept apart from the components and templates in the application. Changes to the structure of the application are made in the routing configuration rather than in individual components and directives.
How is it used?	The routing configuration is defined as a set of fragments that are used to match the browser's URL and select a component whose template is displayed as the content of an HTML element called `router-outlet`.
Are there any pitfalls or limitations?	The routing configuration can become unmanageable, especially if the URL schema is being defined gradually, on an ad hoc basis.
Are there any alternatives?	You don't have to use the routing feature. You could achieve similar results by creating a component whose view selects the content to display to the user with the `ngIf` or `ngSwitch` directive, although this approach becomes more difficult than using routing as the size and complexity of an application increases.

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Table 25-2 summarizes the chapter.

■ **Note** The examples in this chapter require the Reactive Extensions module created using the `systemjs-builder` package in Chapter 22. If you have not prepared this file, then you should do so now or, alternatively, download the project for this chapter from `apress.com`.

Table 25-2. *Chapter Summary*

Problem	Solution	Listing
Use URL navigation to select the content shown to users	Use URL routing	1–9
Navigate using an HTML element	Apply the `routerLink` attribute	10–12
Respond to route changes	Use the routing services to receive notifications	13
Include information in URLs	Use route parameters	14–20
Navigate using code	Use the `Router` service	21
Receive notifications of routing activity	Handle the routing events	22–23

Preparing the Example Project

The features used in this chapter rely on the Angular Router module, which must be added to the application. Listing 25-1 shows the addition of the module to the package list.

■ **Caution** Notice the version number for this package is higher than for the other Angular packages. This oddity arose because the way the routing feature works was substantially revised during development of Angular 2.

Listing 25-1. Adding the Router Package to the package.json File

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/forms": "2.2.0",
    "@angular/http": "2.2.0",
    "@angular/router": "3.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4",
    "intl": "1.2.4",
    "html5-history-api": "4.2.7"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.2",
    "typings": "1.3.2",
    "concurrently": "2.2.0",
    "systemjs-builder": "0.15.32",
    "json-server": "0.8.21"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" \"npm run json\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "json": "json-server --p 3500 restData.js",
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

The Angular routing features depend on the JavaScript History API, which is not supported by older browsers, so I have added the `html5-history-api` package to the application to provide a polyfill for the missing API.

■ **Tip** You can download the projects for all the chapters in this book from `apress.com`.

The Angular router module must also be registered with the SystemJS JavaScript module loader, as shown in Listing 25-2.

Listing 25-2. Adding the Router Module in the systemjs.config.js File

```
(function (global) {

    var paths = {
        "@angular/*": "node_modules/@angular/*"
    }

    var packages = { "app": {} };

    var angularModules = ["common", "compiler",
     "core", "platform-browser", "platform-browser-dynamic", "forms",
     "http", "router"];
    angularModules.forEach(function (pkg) {
        packages["@angular/" + pkg] = {
            main: "/bundles/" + pkg + ".umd.min.js"
        };
    });

    System.config({ paths: paths, packages: packages });

})(this);
```

Disabling the State Change Event Display

The application is configured to display the state change events sent from the table component to the product component in two places: through the message service and in the form component's template. These messages are no longer required, and Listing 25-3 removes the event display from the component's template.

Listing 25-3. Removing the Event Display in the form.component.html File

```
<div class="bg-primary p-a-1" [class.bg-warning]="editing">
    <h5>{{editing  ? "Edit" : "Create"}} Product</h5>
    <!--Last Event: {{ stateEvents | async | formatState }}-->
</div>

<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)" (reset)="resetForm()" >

    <div class="form-group">
        <label>Name</label>
        <input class="form-control" name="name"
               [(ngModel)]="product.name" required />
    </div>

    <div class="form-group">
        <label>Category</label>
        <input class="form-control" name="category"
               [(ngModel)]="product.category" required />
    </div>

    <div class="form-group">
        <label>Price</label>
        <input class="form-control" name="price"
               [(ngModel)]="product.price"
               required pattern="^[0-9\.]+$" />
    </div>

    <button type="submit" class="btn btn-primary"
            [class.btn-warning]="editing" [disabled]="form.invalid">
        {{editing ? "Save" : "Create"}}
    </button>
    <button type="reset" class="btn btn-secondary">Cancel</button>
</form>
```

Listing 25-4 disables the code that pushes the state change events into the message service.

Listing 25-4. Disabling State Change Events in the core.model.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule, Model } from "model/module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
import { Product } from "model/module";
import { SharedState, SHARED_STATE } from "./sharedState.model";
import { Subject } from "rxjs/Subject";
import { StatePipe } from "./state.pipe";
import { MessageModule, MessageService, Message } from "messages/module";
import { MODES } from "./sharedState.model";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule, MessageModule],
    declarations: [TableComponent, FormComponent, StatePipe],
    exports: [ModelModule, TableComponent, FormComponent],
    providers: [{
        provide: SHARED_STATE,
        deps: [MessageService, Model],
        useFactory: (messageService, model) => {
            return new Subject<SharedState>();
            //subject.subscribe(m => messageService.reportMessage(
            //    new Message(MODES[m.mode] + (m.id != undefined
            //        ? ` ${model.getProduct(m.id).name}` : "")))
            //);
            //return subject;
        }
    }]
})
export class CoreModule { }
```

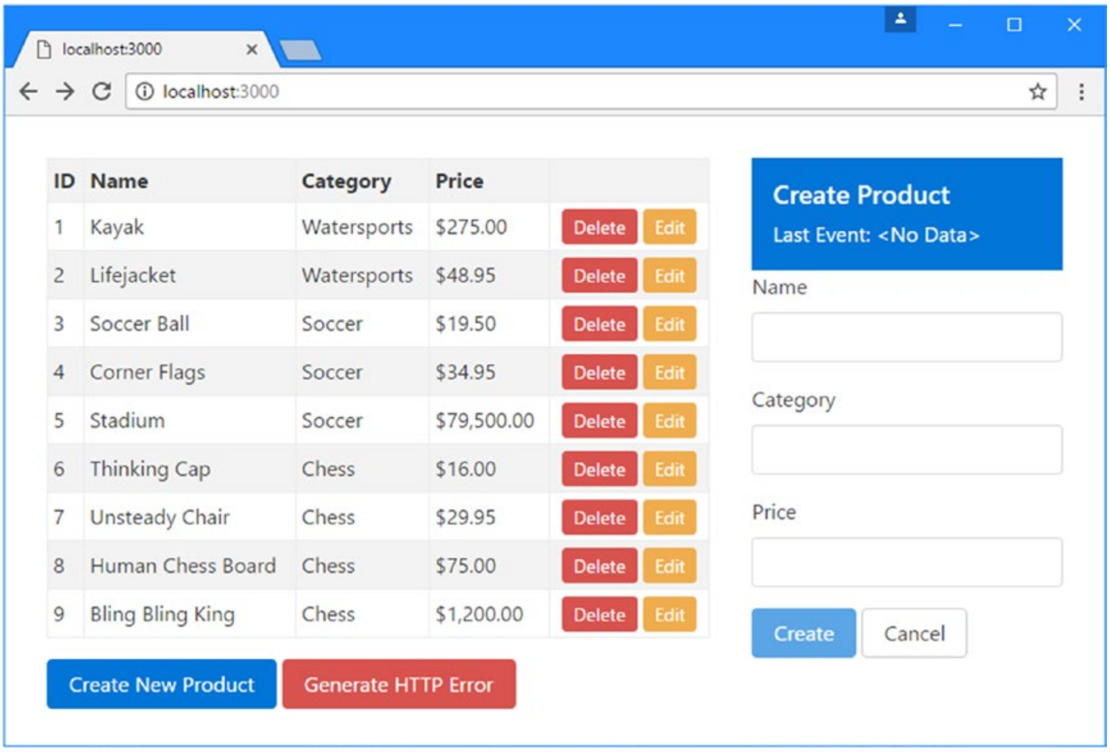
Save the changes and run the following command in the exampleApp folder to download and install the Angular module:

```
npm install
```

Once the update has been completed, run the following command in the exampleApp folder to start the TypeScript compiler, the development HTTP server, and the RESTful web service:

```
npm start
```

A new browser window or tab will open, and you will see the content shown in Figure 25-1.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Figure 25-1. *Running the example application*

Getting Started with Routing

At the moment, all the content in the application is visible to the user all of the time. For the example application, this means that both the table and the form are always visible and it is up to the user to keep track of which part of the application they are using for the task at hand.

That's fine for a simple application, but it becomes unmanageable in a complex project, which can have many areas of functionality that would be overwhelming if they were all displayed at the same time.

URL routing adds structure to an application using a natural and well-understood aspect of web applications: the URL. In this section, I am going to introduce URL routing by applying it to the example application so that either the table or the form is visible, with the active component being chosen based on the user's actions. This will provide a good basis for explaining how routing works and set the foundation for more advanced features.

Creating a Routing Configuration

The first step when applying routing is to define the *routes*, which are mappings between URLs and the components that will be displayed to the user. Routing configurations are conventionally defined in a file called `app.routing.ts`, defined in the app folder. I created this file and added the statements shown in Listing 25-5.

Listing 25-5. The Contents of the app.routing.ts File in the exampleApp/app Folder

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";

const routes: Routes = [
    { path: "form/edit", component: FormComponent },
    { path: "form/create", component: FormComponent },
    { path: "", component: TableComponent }]

export const routing = RouterModule.forRoot(routes);
```

The `Routes` class defines a collection of routes, each of which tells Angular how to handle a specific URL. This example uses the most basic properties, where the `path` specifies the URL and the `component` property specifies the component that will be displayed to the user.

The `path` property is specific relative to the rest of the application, which means that the configuration in Listing 25-5 sets up the routes shown in Table 25-3.

Table 25-3. *The Routes Created in the Example*

URL	Displayed Component
`http://localhost:3000/form/edit`	FormComponent
`http://localhost:3000/form/create`	FormComponent
`http://localhost:3000/`	TableComponent

The routes are packaged into a module using the `RouterModule.forRoot` method. The `forRoot` method produces a module that includes the routing service. There is also a `forChild` method that doesn't include the service and that is demonstrated in Chapter 26, where I explain how to create routes for feature modules.

Although the `path` and `component` properties are the most commonly used when defining routes, there are a range of additional properties that can be used to define routes with advanced features. These properties are described in Table 25-4, along with details of where they are described.

***Table 25-4.** The Routes Properties Used to Define Routes*

Name	Description
`path`	This property specifies the path for the route.
`component`	This property specifies the component that will be selected when the activate URL matches the `path`.
`pathMatch`	This property tells Angular how to match the current URL to the `path` property. There are two allowed values: `full`, which requires the `path` value to completely match the URL, and `prefix`, which allows the `path` value to match the URL, even if the URL contains additional segments that are not part of the `path` value. This property is required when using the `redirectTo` property, as demonstrated in Chapter 26.
`redirectTo`	This property is used to create a route that redirects the browser to a different URL when activated. See Chapter 26 for details.
`children`	This property is used to specify child routes, which display additional components in nested `router-outlet` elements contained in the template of the activate component, as demonstrated in Chapter 26.
`outlet`	This property is used to support multiple outlet elements, as described in Chapter 27.
`resolve`	This property is used to define work that must be completed before a route can be activated, as described in Chapter 27.
`canActivate`	This property is used to control when a route can be activated, as described in Chapter 27.
`canActivateChild`	This property is used to control when a child route can be activated, as described in Chapter 27.
`canDeactivate`	This property is used to control when a route can be deactivated so that a new route can be activated, as described in Chapter 27.
`loadChildren`	This property is used to configure a module that is loaded only when it is needed, as described in Chapter 27.
`canLoad`	This property is used to control when an on-demand module can be loaded.

UNDERSTANDING ROUTE ORDERING

The order in which routes are defined is significant. Angular compares the URL to which the browser has navigated with the path property of each route in turn until it finds a match. This means that the most specific routes should be defined first, with the routes that follow decreasing in specificity. This isn't a big deal for the routes in Listing 25-5, but it becomes significant when using route parameters (described in the "Using Route Parameters" section of this chapter) or adding child routes (described in Chapter 26).

If you find that your routing configuration doesn't result in the behavior you expect, then the order in which the routes have been defined is the first thing to check.

Creating the Routing Component

When using routing, the root component is dedicated to managing the navigation between different parts of the application. I added a file called `app.component.ts` in the `exampleApp/app` folder and defined the component shown in Listing 25-6.

Listing 25-6. The Contents of the app.component.ts File in the exampleApp/app File

```
import { Component } from "@angular/core";

@Component({
    selector: "app",
    moduleId: module.id,
    templateUrl: "app.component.html"
})
export class AppComponent { }
```

This component is a vehicle for its template, which I created by adding a file called `app.component.html` to the `exampleApp/app` folder and adding the elements shown in Listing 25-7.

Listing 25-7. The Contents of the app.component.html File in the exampleApp/app File

```
<paMessages></paMessages>
<router-outlet></router-outlet>
```

The `paMessages` element displays any messages and errors in the application. For the purposes of routing, it is the `router-outlet` element—known as the *outlet*—that is important because it tells Angular that this is where the component matched by the routing configuration should be displayed.

Updating the Root Module

The next step is to update the root module so that the new root component is used to bootstrap the application, as shown in Listing 25-8, which also imports the module that contains the routing configuration.

Listing 25-8. Enabling Routing in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ModelModule } from "./model/model.module";
import { CoreModule } from "./core/core.module";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { MessageModule } from "./messages/message.module";
import { MessageComponent } from "./messages/message.component";
import { routing } from "./app.routing";
import { AppComponent } from "./app.component";

@NgModule({
    imports: [BrowserModule, CoreModule, MessageModule, routing],
    declarations: [AppComponent],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

Completing the Configuration

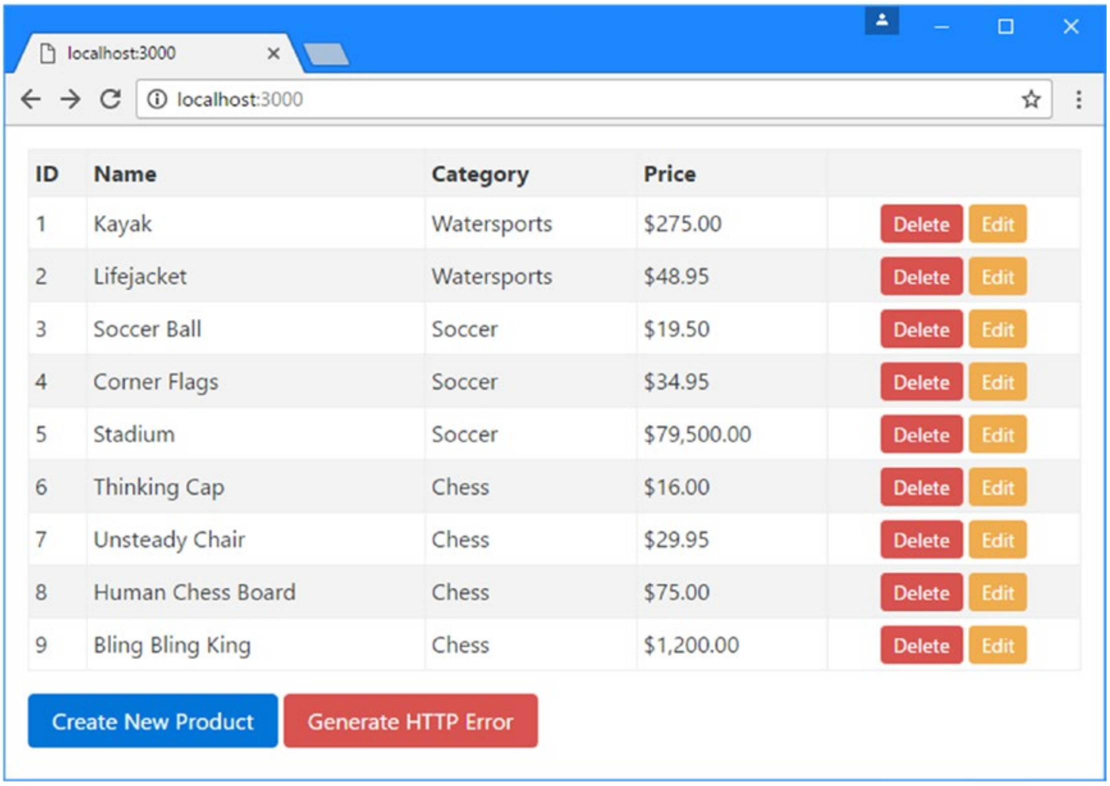
The final step to apply routing to the application is to update the `index.html` file, as shown in Listing 25-9.

Listing 25-9. Configuring Routing in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <base href="/">
    <title></title>
    <meta charset="utf-8" />
    <script src="node_modules/html5-history-api/history.min.js"></script>
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/intl/dist/Intl.complete.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="rxjs.module.min.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
</head>
<body class="m-a-1">
    <app></app>
</body>
</html>
```

The `base` element sets the URL against which the routing paths in Listing 25-5 are applied. The `app` element applies the new root component, whose template contains the `router-outlet` element. The new `script` element in the listing loads the polyfill for the History API so that the application will run correctly on older browsers.

When you save the changes and the browser reloads the application, you will see just the product table, as illustrated by Figure 25-2. The default URL for the application, `http://localhost:3000`, corresponds to the route that shows the product table.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Figure 25-2. *Using routing to display components to the user*

Adding Navigation Links

The basic routing configuration is in place, but there is no way to navigate around the application: nothing happens when you click the Create New Product or Edit button.

The next step is to add links to the application that will change the browser's URL and, in doing so, trigger a routing change that will display a different component to the user. Listing 25-10 adds these links to the table component's template.

Listing 25-10. Adding Navigation Links in the table.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
```

```
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm" (click)="editProduct(item.id)"
                    routerLink="/form/edit">
                Edit
            </button>
        </td>
    </tr>
</table>
<button class="btn btn-primary" (click)="createProduct()" routerLink="/form/create">
    Create New Product
</button>
<button class="btn btn-danger" (click)="deleteProduct(-1)">
    Generate HTTP Error
</button>
```

The routerLink attribute applies a directive from the routing package that performs the navigation change. This directive can be applied to any element, although it is typically applied to button and anchor (a) elements. The expression for the routeLink directive applied to the Edit buttons tells Angular to target the /form/edit route:

```
...
<button class="btn btn-warning btn-sm" (click)="editProduct(item.id)"
        routerLink="/form/edit">
    Edit
</button>
...
```

The same directive applied to the Create New Product button tells Angular to target the /create route.

```
...
<button class="btn btn-primary" (click)="createProduct()" routerLink="/form/create">
    Create New Product
</button>
...
```

The routing links added to the table component's template will allow the user to navigate to the form. The addition to the form component's template shown in Listing 25-11 will allow the user to navigate back again using the Cancel button.

Listing 25-11. Adding a Navigation Link in the form.component.html File

```
<div class="bg-primary p-a-1" [class.bg-warning]="editing">
    <h5>{{editing  ? "Edit" : "Create"}} Product</h5>
</div>
<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)" (reset)="resetForm()" >

    <div class="form-group">
        <label>Name</label>
        <input class="form-control" name="name"
               [(ngModel)]="product.name" required />
    </div>
    <div class="form-group">
        <label>Category</label>
        <input class="form-control" name="category"
               [(ngModel)]="product.category" required />
    </div>

    <div class="form-group">
        <label>Price</label>
        <input class="form-control" name="price"
               [(ngModel)]="product.price"
               required pattern="^[0-9\.]+$" />
    </div>

    <button type="submit" class="btn btn-primary"
            [class.btn-warning]="editing" [disabled]="form.invalid">
        {{editing ? "Save" : "Create"}}
    </button>
    <button type="reset" class="btn btn-secondary" routerLink="/">Cancel</button>
</form>
```

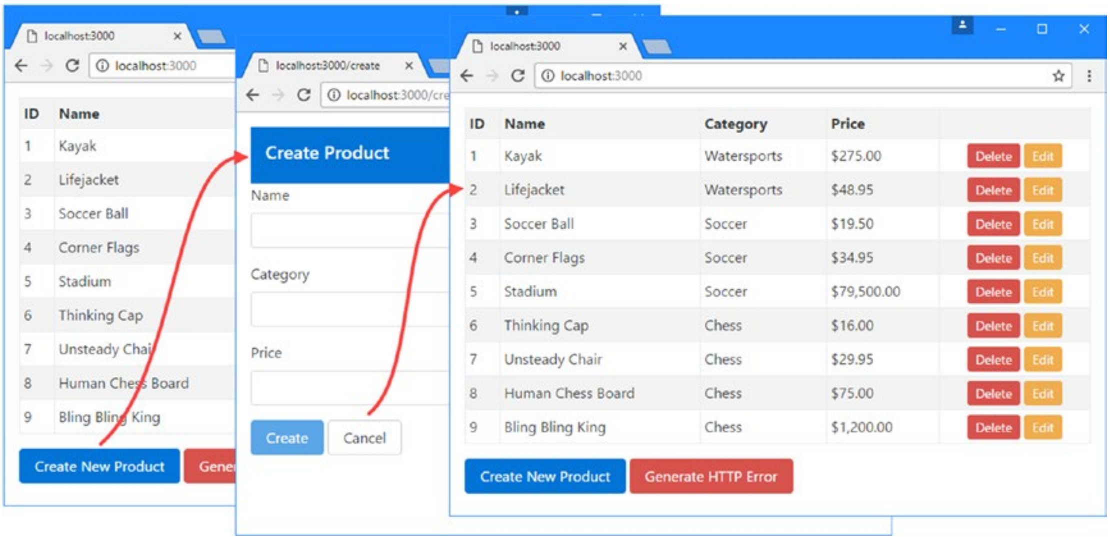
The value assigned to the routerLink attribute targets the route that displays the product table. Listing 25-12 updates the feature module that contains the template so that it imports the RouterModule, which is the Angular module that contains the directive that selects the routerLink attribute.

Listing 25-12. Enabling the Routing Directive in the core.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
import { SharedState, SHARED_STATE } from "./sharedState.model";
import { Subject } from "rxjs/Subject";
import { StatePipe } from "./state.pipe";
import { MessageModule } from "../messages/message.module";
import { MessageService } from "../messages/message.service";
import { Message } from "../messages/message.model";
import { Model } from "../model/repository.model";
import { MODES } from "./sharedState.model";
import { RouterModule } from "@angular/router";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule, MessageModule, RouterModule],
    declarations: [TableComponent, FormComponent, StatePipe],
    exports: [ModelModule, TableComponent, FormComponent],
    providers: [{
        provide: SHARED_STATE,
        deps: [MessageService, Model],
        useFactory: (messageService, model) => {
            return new Subject<SharedState>();
        }
    }]
})
export class CoreModule { }
```

Understanding the Effect of Routing

When all the changes have been saved, you will be able to navigate around the application using the Edit, Create New Product, and Cancel buttons, as shown in Figure 25-3.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Figure 25-3. *Using routes to navigate around the application*

Not all the features in the application work yet, but this is a good time to explore the effect of adding routing to the application. Enter the root URL for the application (`http://localhost:3000`) and then click the Create New Product button. When you clicked the button, the Angular routing system changed the URL that the browser displays to this:

```
http://localhost:3000/form/create
```

If you watch the output from the development HTTP server during the transition, you will notice that no requests are received by the server for new content. This change is done entirely within the Angular application and does not produce any new HTTP requests.

The new URL is processed by the Angular routing system, which is able to match the new URL to this route from the `app.routing.ts` file.

```
...
{ path: "form/create", component: FormComponent },
...
```

The routing system takes into account the base element in the index.html file when it matches the URL to a route. The base element is configured with an href value of / that is combined with the path in the route to make a match when the URL is /form/create.

The component property tells the Angular routing system that it should display the FormComponent to the user. A new instance of the FormComponent class is created, and its template content is used as the content for the router-outlet element in the root component's template.

If you click the Cancel button below the form, then the process is repeated, but this time, the browser returns to the root URL for the application, which is matched by the route whose path component is the empty string.

```
{ path: "", component: TableComponent }
```

This route tells Angular to display the TableComponent to the user. A new instance of the TableComponent class is created, and its template is used as the content of the router-outlet element, displaying the model data to the user.

This is the essence of routing: the browser's URL changes, which causes the routing system to consult its configuration to determine which component should be displayed to the user. There are lots of options and features available, but this is the core purpose of routing, and you won't go too far wrong if you keep this in mind.

THE PERILS OF CHANGING THE URL MANUALLY

The routerLink directive sets the URL using a JavaScript API that tells the browser that this is a change relative to the current document and not a change that requires an HTTP request to the server.

If you enter a URL that matches the routing system into the browser window, you will see an effect that looks like the expected change but is actually something else entirely. Keep one eye on the output from the development HTTP server while manually entering the following URL into the browser:

```
http://localhost:3000/form/create
```

Rather than handling the change within the Angular application, the browser sends an HTTP request to the server, which reloads the application. Once the application is loaded, the routing system inspects the browser's URL, matches one of the routes in the configuration, and then displays the FormComponent.

The reason this works is because the lite-server package, which provides the development HTTP server capability, will return the contents of the index.html file for URLs that don't correspond to files on the disk. As an example, request this URL:

```
http://localhost:3000/this/does/not/exist
```

The browser will display an error because the request has provided the browser with the contents of the index.html file, which it has used to load and start the example Angular application. When the routing system inspects the URL, it finds no matching route and creates an error.

There are two important points to note. The first is that when you test your application's routing configuration, you should keep an eye on the HTTP requests that the browser is making because you will sometimes see the right result for the wrong reasons. On a fast machine, you may not even realize that the application has been reloaded and restarted by the browser.

Second, you must remember that the URL must be changed using the `routerLink` directive (or one of similar features provided by the router module) and not manually using the browser's URL bar.

Finally, since users won't know about the difference between programmatic and manual URL changes, your routing configuration should be able to deal with URLs that don't correspond to routes, as described in Chapter 26.

Completing the Routing Implementation

Adding routing to the application is a good start, but a lot of the application features just don't work. For example, clicking an Edit button displays the form, but it isn't populated, and it doesn't show the color cue that indicates editing. In the sections that follow, I use features provided by the routing system to finish wiring up the application so that everything works as expected.

Handling Route Changes in Components

The form component isn't working properly because it isn't being notified that the user has clicked a button to edit a product. This problem occurs because the routing system creates new instances of component classes only when it needs them, which means the `FormComponent` object is created only after the Edit button is clicked. If you click the Cancel button under the form and then click an Edit button in this table again, a second instance of the `FormComponent` will be created.

This leads to a timing issue in the way that the product component and the table component communicate, via a Reactive Extensions `Subject`. A `Subject` only passes on events to subscribers that arrive after the `subscribe` method has been called. The introduction of routing means that the `FormComponent` object is created after the event describing the edit operation has already been sent.

This problem could be solved by replacing the `Subject` with a `BehaviorSubject`, which sends the most recent event to subscribers when they call the subscribe method. But a more elegant approach—especially since this is a chapter on the routing system—is to use the URL to collaborate between components.

Angular provides a service that components can receive to get details of the current route. The relationship between the service and the types that it provides access to may seem complicated at first, but it will make sense as you see how the examples unfold and some of the different ways that routing can be used.

The class on which components declare a dependency is called `ActivatedRoute`. For the purposes of this section, it defines one important property, which is described in Table 25-5. There are other properties, too, which are described later in the chapter but which you can ignore for the moment.

Table 25-5. *The ActivatedRoute Property*

Name	Description
`snapshot`	This property returns an `ActivatedRouteSnapshot` object that describes the current route.

The `snapshot` property returns an instance of the `ActivatedRouteSnapshot` class, which provides information about the route that led to the current component being displayed to the user using the properties described in Table 25-6.

Table 25-6. *The Basic ActivatedRouteSnapshot Properties*

Name	Description
`url`	This property returns an array of `UrlSegment` objects, each of which describes a single segment in the URL that matched the current route.
`params`	This property returns a `Params` object, which describes the URL parameters, indexed by name.
`queryParams`	This property returns a `Params` object, which describes the URL query parameters, indexed by name.
`fragment`	This property returns a `string` containing the URL fragment.

The `url` property is the one that is most important for this example because it allows the component to inspect the segments of the current URL and extract the information from them required to perform an operation. The `url` property returns an array of `UrlSegment` objects, which provide the properties described in Table 25-7.

Table 25-7. *The URLSegment Properties*

Name	Description
`Path`	This property returns a string that contains the segment value.
`parameters`	This property returns an indexed collection of parameters, as described in the "Using Route Parameters" section.

To determine what route has been activated by the user, the form component can declare a dependency on `ActivatedRoute` and then use the object it receives to inspect the segments of the URL, as shown in Listing 25-13.

Listing 25-13. Inspecting the Active Route in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
//import { MODES, SharedState, SHARED_STATE } from "./sharedState.model";
//import { Observable } from "rxjs/Observable";
//import "rxjs/add/operator/filter";
//import "rxjs/add/operator/map";
//import "rxjs/add/operator/distinctUntilChanged";
//import "rxjs/add/operator/skipWhile";
import { ActivatedRoute } from "@angular/router";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();
    constructor(private model: Model, activeRoute: ActivatedRoute) {
        this.editing = activeRoute.snapshot.url[1].path == "edit";
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.product = new Product();
            form.reset();
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

The component no longer uses Reactive Extensions to receive events. Instead, it inspects the second segment of the active route's URL to set the value of the `editing` property, which determines whether it should display its create or edit mode. If you click an Edit button in the table, you will now see the correct coloring displayed, as shown in Figure 25-4.

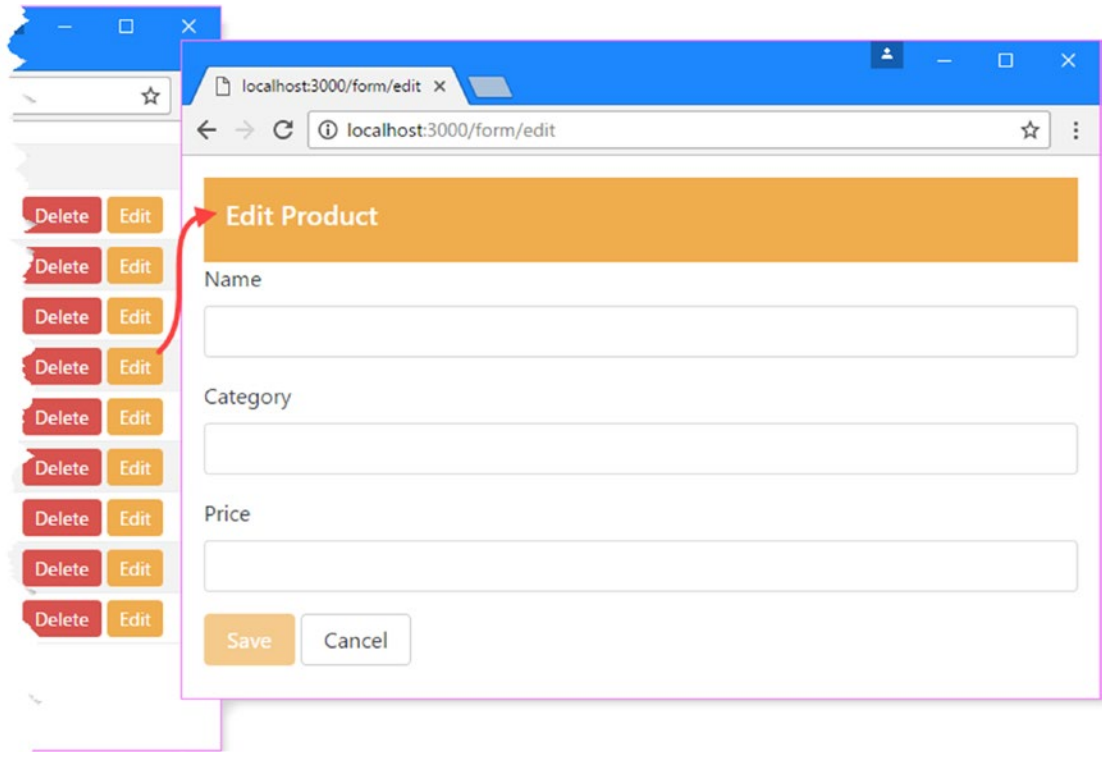


Figure 25-4. *Using the active route in a component*

UNDERSTANDING THE URL ENTRY PROBLEM

The development HTTP server used in this book, `lite-server`, has a feature that returns the contents of the `index.html` file when the browser requests a URL that doesn't match a file in the project. Combined with the automatic browser reload feature, this means you can cause the application to start at a specific URL. As an example, if you click one of the Edit buttons in the previous example, the browser will navigate to the `/form/edit` URL. When you modify a file, the browser will be automatically reloaded and ask the HTTP server for the `/form/edit` URL, which doesn't correspond to a file in the `exampleApp` folder and for which the HTTP server will respond with the contents of the `index.html` file.

This can be a useful feature because it prevents 404 - Not Found errors when the application navigates to a route that has yet to be implemented. But it can also cause problems because the application hasn't gone through the sequence of navigation steps from the root URL required to set up state data required for the route that the browser jumps to.

In Chapter 27, I show you how to use a feature called *route guarding* to prevent this behavior. Until then, some of the examples that follow won't work as expected unless you explicitly request the `http://localhost:3000` URL and then navigate using the buttons in the application layout.

Using Route Parameters

When I set up the routing configuration for the application, I defined two routes that targeted the form component, like this:

```
...
{ path: "form/edit", component: FormComponent },
{ path: "form/create", component: FormComponent },
...
```

When Angular is trying to match a route to a URL, it looks at each segment in turn and checks to see that it matches the URL that is being navigated to. Both of these URLs are made up of *static segments*, which means they have to match the navigated URL exactly before Angular will activate the route.

Angular routes can be more flexible and include route *parameters*, which allow any value for a segment to match the corresponding segment in the navigated URL. This means routes that target the same component with similar URLs can be consolidated into a single route, as shown in Listing 25-14.

Listing 25-14. Consolidating Routes in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";

const routes: Routes = [
    { path: "form/:mode", component: FormComponent },
    { path: "", component: TableComponent }
]

export const routing = RouterModule.forRoot(routes);
```

The second segment of the modified URL defines a route parameter, denoted by the colon (the `:` character) followed by a name. In this case, the route parameter is called `mode`. This route will match any URL that has two segments where the first segment is `form`, as summarized in Table 25-8. The content of the second segment will be assigned to a parameter called `mode`.

Table 25-8. *URL Matching with the Route Parameter*

URL	Result
`http://localhost:3000/form`	No match—too few segments
`http://localhost:3000/form/create`	Matches, with `create` assigned to the `mode` parameter
`http://localhost:3000/form/london`	Matches, with `london` assigned to the `mode` parameter
`http://localhost:3000/product/edit`	No match—first segment is not `form`
`http://localhost:3000/form/edit/1`	No match—too many segments

Using route parameters make it simpler to handle routes programmatically because the value of the parameter can be obtained using its name, as shown in Listing 25-15.

Listing 25-15. Reading a Route Parameter in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute } from "@angular/router";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model, activeRoute: ActivatedRoute) {
        this.editing = activeRoute.snapshot.params["mode"] == "edit";
    }

    // ...methods and property omitted for brevity...
}
```

The component doesn't need to know the structure of the URL to get the information it needs. Instead, it can use the `params` property provided by the `ActivatedRouteSnapshot` class to get a collection of the parameter values, indexed by name. The component gets the value of the `mode` parameter and uses it to set the `editing` property.

Using Multiple Route Parameters

To tell the form component which product has been selected when the user clicks an Edit button, I need to use a second route parameter. Since Angular matches URLs based on the number of segments they contain, this means I need to split up the routes that target the form component again, as shown in Listing 25-16. This cycle of consolidating and then expanding routes is typical of most development projects as you increase the amount of information that is included in routed URLs to add functionality to the application.

Listing 25-16. Adding a Route in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";

const routes: Routes = [
    { path: "form/:mode/:id", component: FormComponent },
    { path: "form/:mode", component: FormComponent },
    { path: "", component: TableComponent }]

export const routing = RouterModule.forRoot(routes);
```

The new route will match any URL that has three segments where the first segment is `form`. To create URLs that target this route, I need to use a different approach for the `routerLink` expressions in the template because I need to generate the third segment dynamically for each Edit button in the product table, as shown in Listing 25-17.

Listing 25-17. Generating Dynamic URLs in the table.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm" (click)="editProduct(item.id)"
                    [routerLink]="['/form', 'edit', item.id]">
                Edit
            </button>
        </td>
    </tr>
</table>
<button class="btn btn-primary" (click)="createProduct()" routerLink="/form/create">
    Create New Product
```

```
</button>
<button class="btn btn-danger" (click)="deleteProduct(-1)">
    Generate HTTP Error
</button>
```

The `routerLink` attribute is now enclosed in square brackets, telling Angular that it should treat the attribute value as a data binding expression. The expression is set out as an array, with each element containing the value for one segment. The first two segments are literal strings and will be included in the target URL without modification. The third segment will be evaluated to include the `id` property value for the current `Product` object being processed by the `ngIf` directive, just like the other expressions in the template. The `routerLink` directive will combine the individual segments to create a URL such as `/form/edit/2`.

Listing 25-18 shows how the form component gets the value of the new route parameter and uses it to select the product that is to be edited.

Listing 25-18. Using the New Route Parameter in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute } from "@angular/router";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model, activeRoute: ActivatedRoute) {
        this.editing = activeRoute.snapshot.params["mode"] == "edit";
        let id = activeRoute.snapshot.params["id"];
        if (id != null) {
            Object.assign(this.product, model.getProduct(id) || new Product());
        }
    }

    // ...methods and property omitted for brevity...
}
```

When the user clicks an Edit button, the routing URL that is activated tells the form component that an edit operation is required and which product is to be modified, allowing the form to be populated correctly, as shown in Figure 25-5.

■ **Tip** Notice that I check to confirm that I have been able to retrieve a `Product` object from the data model in Listing 25-18 and create a new object if that isn't the case. This is important because the data in the model is obtained asynchronously and may not have arrived by the time that the form component is displayed if the user requests the URL directly. This can also be a problem in development, where a change to the code in the application triggers a recompilation followed by a reload of whatever URL you navigated to before making the change. The result is an error as Angular tries to navigate directly to a route that you expected would not be required until after the data model had been populated. In Chapter 27, I explain how you can stop routes being activated until a specific condition is true, such as the arrival of the data.

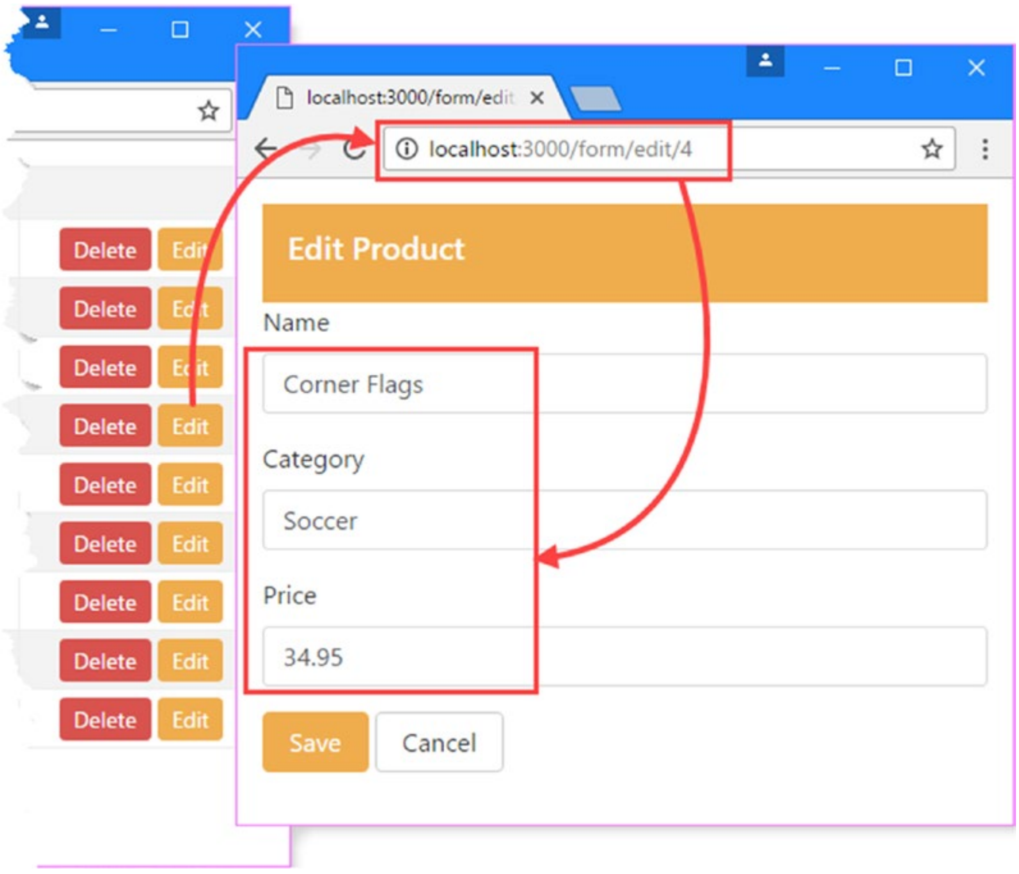


Figure 25-5. *Using URLs segments to provide information*

Using Optional Route Parameters

Optional route parameters allow URLs to include additional information to provide hints or guidance to the rest of the application but which is not essential for the application to work.

This type of route parameter is expressed using URL matrix notation, which isn't part of the specification for URLs but which browsers support nonetheless. Here is an example of a URL that has optional route parameters:

```
http://localhost:3000/form/edit/2;name=Lifejacket;price=48.95
```

The optional route parameters are separated by semicolons (the ; character), and this URL includes optional parameters called name and price.

As a demonstration of how to use optional parameters, Listing 25-19 shows the addition of an optional route parameter that includes the object to be edited as part of the URL. This information isn't essential because the form component can get data from the model, but receiving the data via the routing URL would avoid some work.

Listing 25-19. Using an Optional Route Parameter in the table.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm" (click)="editProduct(item.id)"
                [routerLink]="['/form', 'edit', item.id,
                    {name: item.name, category: item.category, price: item.price}]">
                Edit
            </button>
        </td>
    </tr>
</table>
<button class="btn btn-primary" (click)="createProduct()" routerLink="/form/create">
    Create New Product
</button>
<button class="btn btn-danger" (click)="deleteProduct(-1)">
    Generate HTTP Error
</button>
```

The optional values are expressed as literal objects, where property names identify the optional parameter. In this example, there are `name`, `category`, and `price` properties, and their values are set using the object being processed by the `ngIf` directive. The optional parameters will produce a URL like this one:

```
http://localhost:3000/form/edit/5;name=Stadium;category=Soccer;price=79500
```

Listing 25-20 shows how the form component checks to see whether the optional parameters are present. If they have been included in the URL, then the parameter values are used to avoid a request to the data model.

Listing 25-20. Receiving Optional Route Parameters in the form.component.ts File

```
...
constructor(private model: Model, activeRoute: ActivatedRoute) {
    this.editing = activeRoute.snapshot.params["mode"] == "edit";
    let id = activeRoute.snapshot.params["id"];
    if (id != null) {
        let name = activeRoute.snapshot.params["name"];
        let category = activeRoute.snapshot.params["category"];
        let price = activeRoute.snapshot.params["price"];

        if (name != null && category != null && price != null) {
            this.product.id = id;
            this.product.name = name;
            this.product.category = category;
            this.product.price = Number.parseFloat(price);
        } else {
            Object.assign(this.product, model.getProduct(id) || new Product());
        }
    }
}
...
```

Optional route parameters are accessed in the same way as required parameters, and it is the responsibility of the component to check to see whether they are present and to proceed anyway if they are not part of the URL. In this case, the component is able to fall back to querying the data model if the URL does not contain the optional parameters it looks for.

Navigating in Code

Using the `routerLink` attribute makes it easy to set up navigation in templates, but applications will often need to initiate navigation on behalf of the user within a component or directive.

To give access to the routing system to building blocks such as directives and components, Angular provides the `Router` class, which is available as a service through dependency injection and whose most useful methods and properties are described in Table 25-9.

Table 25-9. *Selected Router Methods and Properties*

Name	Description
`navigated`	This `boolean` property returns `true` if there has been at least one navigation event and `false` otherwise.
`url`	This property returns the active URL.
`isActive(url, exact)`	This method returns `true` if the specified URL is the URL defined by the active route. The `exact` argument specified whether all the segments in the specified URL must match the current URL for the method to return `true`.
`events`	This property returns an `Observable<Event>` that can be used to monitor navigation changes. See the "Receiving Navigation Events" section for details.
`navigateByUrl(url, extras)`	This method navigates to the specified URL. The result of the method is a `Promise`, which resolves with `true` when the navigation is successful and `false` when it is not and which is rejected when there is an error.
`navigate(commands, extras)`	This method navigates using an array of segments. The extras object can be used to specify whether the change of URL is relative to the current route. The result of the method is a `Promise`, which resolves with `true` when the navigation is successful and `false` when it is not and which is rejected when there is an error.

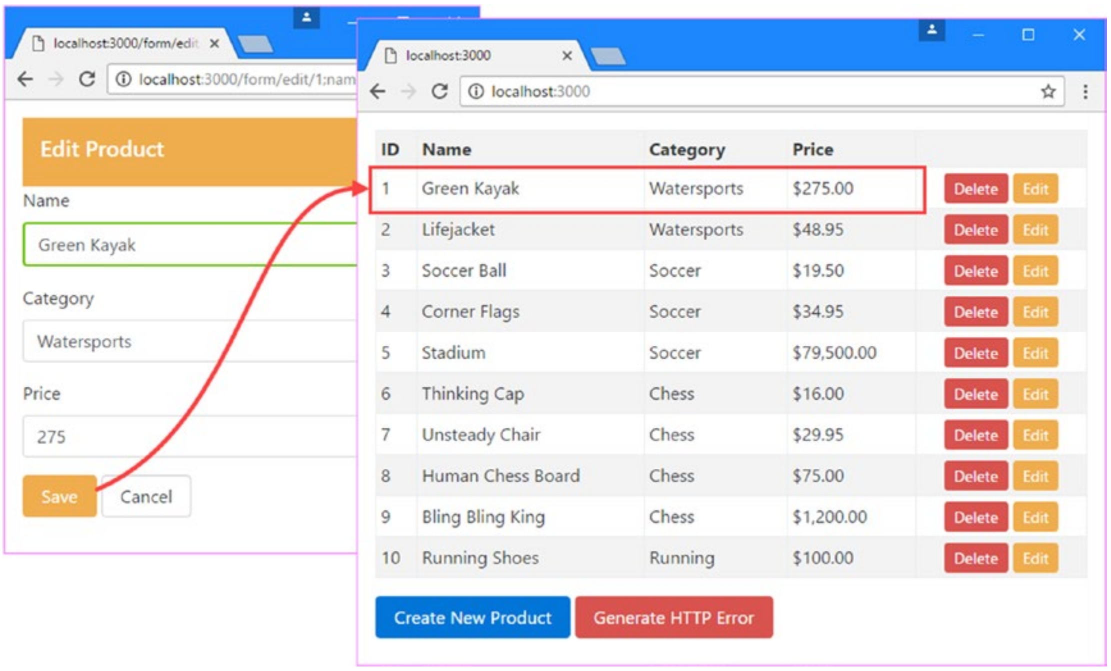
The `navigate` and `navigateByUrl` methods make it easy to perform navigation inside a building block such as a component. Listing 25-21 shows the use of the `Router` in the form component to redirect the application back to the table after a product has been created or updated.

Listing 25-21. Navigating Programmatically in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute, Router } from "@angular/router";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model, activeRoute: ActivatedRoute,
                private router: Router) {

        this.editing = activeRoute.snapshot.params["mode"] == "edit";
        let id = activeRoute.snapshot.params["id"];
        if (id != null) {
            let name = activeRoute.snapshot.params["name"];
            let category = activeRoute.snapshot.params["category"];
            let price = activeRoute.snapshot.params["price"];

            if (name != null && category != null && price != null) {
                this.product.id = id;
                this.product.name = name;
                this.product.category = category;
                this.product.price = Number.parseFloat(price);
            } else {
                Object.assign(this.product, model.getProduct(id) || new Product());
            }
        }
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            //this.product = new Product();
            //form.reset();
            this.router.navigateByUrl("/");
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

The component receives the `Router` object as a constructor argument and uses it in the `submitForm` method to navigate back to the application's root URL. The two statements that have been commented out in the `submitForm` method are no longer required because the routing system will destroy the form component once it is no longer on display, which means that resetting the form's state is not required.

The result is that clicking the Save or Create button in the form will cause the application to display the product table, as shown in Figure 25-6.



Name: Green Kayak

Category: Watersports

Price: 275

ID	Name	Category	Price
1	Green Kayak	Watersports	$275.00
2	Lifejacket	Watersports	$48.95
3	Soccer Ball	Soccer	$19.50
4	Corner Flags	Soccer	$34.95
5	Stadium	Soccer	$79,500.00
6	Thinking Cap	Chess	$16.00
7	Unsteady Chair	Chess	$29.95
8	Human Chess Board	Chess	$75.00
9	Bling Bling King	Chess	$1,200.00
10	Running Shoes	Running	$100.00

Figure 25-6. *Navigating programmatically*

Receiving Navigation Events

In many applications, there will be components or directives that are not directly involved in the application's navigation but that still need to know when navigation occurs. The example application contains an example in the message component, which displays notifications and errors to the user. This component always displays the most recent message, even when that information is stale and unlikely to be helpful to the user. To see the problem, click the Generate HTTP Error button and then click the Create New Product button or one of the Edit buttons; the error message remains on display even though you have navigated elsewhere in the application.

The `events` property defined by the `Router` class returns an `Observable<Event>`, which emits a sequence of `Event` objects that describe changes from the routing system. There are five types of event provided through the observer, as described in Table 25-10.

Table 25-10. *The Types of Event Provided by the Router.events Observer*

Name	Description
`NavigationStart`	This event is sent when the navigation process starts.
`RoutesRecognized`	This event is sent when the routing system matches the URL to a route.
`NavigationEnd`	This event is sent when the navigation process completes successfully.
`NavigationError`	This event is sent when the navigation process produces an error.
`NavigationCancel`	This event is sent when the navigation process is canceled.

All the event classes define an id property, which returns a number that is incremented each for each navigation, and a url property that returns the target URL. The RoutesRecognized and NavigationEnd events also define a urlAfterRedirects property that returns the URL that has been navigated to.

To address the issue with the messaging system, Listing 25-22 subscribes to the observer provided by the Router.events property and clears the message displayed to the user when the NavigationEnd or NavigationCancel event is received.

Listing 25-22. Responding to Navigation Events in the message.component.ts File

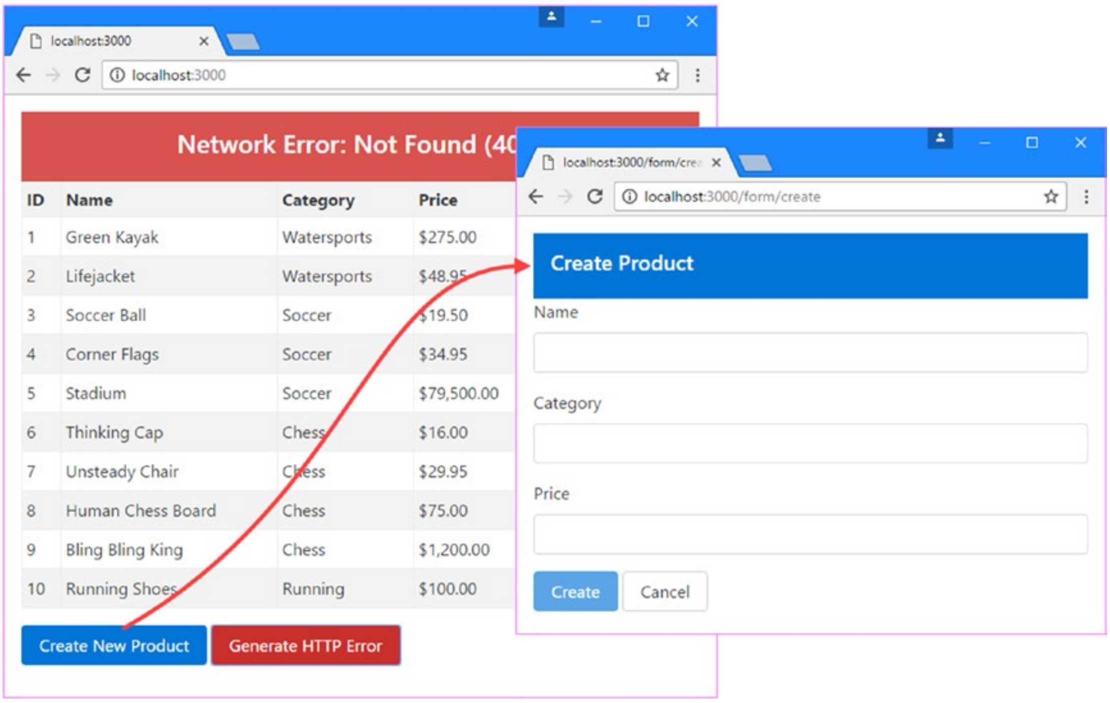
```
import { Component } from "@angular/core";
import { MessageService } from "./message.service";
import { Message } from "./message.model";
import { Observable } from "rxjs/Observable";
import { Router, NavigationEnd, NavigationCancel } from "@angular/router";
import "rxjs/add/operator/filter";

@Component({
    selector: "paMessages",
    moduleId: module.id,
    templateUrl: "message.component.html",
})
export class MessageComponent {
    lastMessage: Message;

    constructor(messageService: MessageService, router: Router) {
        messageService.messages.subscribe(m => this.lastMessage = m);
        router.events
            .filter(e => e instanceof NavigationEnd || e instanceof NavigationCancel)
            .subscribe(e => { this.lastMessage = null; });
    }
}
```

The filter method is used to select one type of event from the observer, and the subscribe method updates the lastMessage property, which will clear the message displayed by the component. Listing 25-23 imports the routing functionality into the message module. (This isn't required to make the application work since the root module already imports the routing feature, but it is good practice to have each module import all the features it requires.)

Listing 25-23. Importing the Routing Module in the message.module.ts File

```
import { NgModule, ErrorHandler } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { MessageComponent } from "./message.component";
import { MessageService } from "./message.service";
import { MessageErrorHandler } from "./errorHandler";
import { RouterModule } from "@angular/router";

@NgModule({
    imports: [BrowserModule, RouterModule],
    declarations: [MessageComponent],
    exports: [MessageComponent],
    providers: [MessageService,
        { provide: ErrorHandler, useClass: MessageErrorHandler }]
})
export class MessageModule { }
```

The result of these changes is that messages are shown to the user only until the next navigation event, as shown in Figure 25-7.



Network Error: Not Found (40

ID	Name	Category	Price
1	Green Kayak	Watersports	$275.00
2	Lifejacket	Watersports	$48.95
3	Soccer Ball	Soccer	$19.50
4	Corner Flags	Soccer	$34.95
5	Stadium	Soccer	$79,500.00
6	Thinking Cap	Chess	$16.00
7	Unsteady Chair	Chess	$29.95
8	Human Chess Board	Chess	$75.00
9	Bling Bling King	Chess	$1,200.00
10	Running Shoes	Running	$100.00

Create Product

Name	
Category	
Price	

Figure 25-7. *Responding to navigation events*

Removing the Event Bindings and Supporting Code

One of the benefits that using the routing system is that it can simplify applications, replacing event bindings and the methods they invoke with navigation changes. The final changes to complete the routing implementation are to remove the last traces of the previous mechanism that was used to coordinate between components. Listing 25-24 comments out the event bindings from the table component's template, which were used to respond when the user clicked the Create New Product or Edit button. (The event binding for the Delete buttons is still required.)

Listing 25-24. Removing Event Bindings in the table.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm"
                [routerLink]="['/form', 'edit', item.id,
                    {name: item.name, category: item.category, price: item.price}]">
                Edit
            </button>
        </td>
    </tr>
</table>
<button class="btn btn-primary" routerLink="/form/create">
    Create New Product
</button>
<button class="btn btn-danger" (click)="deleteProduct(-1)">
    Generate HTTP Error
</button>
```

Listing 25-25 shows the corresponding changes in the component, which remove the methods that the event bindings invoked and the dependency on the service that was used to signal when a product should be edited or created.

Listing 25-25. Removing Event Handling Code in the table.component.ts File

```
import { Component, Inject } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
//import { MODES, SharedState, SHARED_STATE } from "./sharedState.model";
//import { Observer } from "rxjs/Observer";

@Component({
    selector: "paTable",
    moduleId: module.id,
    templateUrl: "table.component.html"
})
export class TableComponent {

    constructor(private model: Model,
        /*@Inject(SHARED_STATE) private observer: Observer<SharedState>*/) { }

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }
    getProducts(): Product[] {
        return this.model.getProducts();
    }

    deleteProduct(key: number) {
        this.model.deleteProduct(key);
    }

    //editProduct(key: number) {
    //    this.observer.next(new SharedState(MODES.EDIT, key));
    //}

    //createProduct() {
    //    this.observer.next(new SharedState(MODES.CREATE));
    //}
}
```

The service used for coordination by the components is no longer required, and Listing 25-26 disables it from the core module.

Listing 25-26. Removing the Shared State Service in the core.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
//import { SharedState, SHARED_STATE } from "./sharedState.model";
import { Subject } from "rxjs/Subject";
import { StatePipe } from "./state.pipe";
import { MessageModule } from "../messages/message.module";
import { MessageService } from "../messages/message.service";
import { Message } from "../messages/message.model";
import { Model } from "../model/repository.model";
//import { MODES } from "./sharedState.model";
import { RouterModule } from "@angular/router";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule, MessageModule, RouterModule],
    declarations: [TableComponent, FormComponent, StatePipe],
    exports: [ModelModule, TableComponent, FormComponent],
    //providers: [{
    //    provide: SHARED_STATE,
    //    deps: [MessageService, Model],
    //    useFactory: (messageService, model) => {
    //        return new Subject<SharedState>();
    //    }
    //}]
})
export class CoreModule { }
```

The result is that the coordination between the table and form components is handled entirely through the routing system, which is now responsible for displaying the components and managing the navigation between them.

Summary

In this chapter, I introduced the Angular routing feature and demonstrated how to navigate to a URL in an application in order to select the content that is displayed to the user. I showed you how to create navigation links in templates, how to perform navigation in a component or directive, and how to respond to navigation changes programmatically. In the next chapter, I continue describing the Angular routing system.

CHAPTER 26

Routing and Navigation: Part 2

In the previous chapter, I introduced the Angular URL routing system and explained how it can be used to control the components that are displayed to the user. The routing system has a lot of features, which I continue to describe in this chapter and in Chapter 27. This emphasis on this chapter is about creating more complex routes, including routes that will match any URL, routes that redirect the browser to other URLs, routes that navigate within a component, and routes that select multiple components. Table 26-1 summarizes the chapter.

Table 26-1. *Chapter Summary*

Problem	Solution	Listing
Match multiple URLs with a single route	Use routing wildcards	1–10
Redirect one URL to another	Use a redirection route	11
Navigate within a component	Use a relative URL	12
Receive notifications when the activated URL changes	Use the `Observable` objects provided by the `ActivatedRoute` class	13
Style an element when a specific route is active	Use the `routerLinkActive` attribute	14–17
Use the routing system to displayed nested components	Define child routes and use the `router-outlet` element	18–22

Preparing the Example Project

For this chapter, I will continue using the `exampleApp` that was created in Chapter 22 and has been modified in each subsequent chapter. To prepare for this chapter, I have added two methods to the repository class, as shown in Listing 26-1.

Tip The examples in this chapter rely on the Reactive Extensions package created in Chapter 22. If you don't want to create the project yourself, you can get the example application, including the Reactive Extensions module, as part of the free source code download that accompanies this book from `apress.com`.

Listing 26-1. Adding Methods in the repository.model.ts File

```
import { Injectable } from "@angular/core";
import { Product } from "./product.model";
import { Observable } from "rxjs/Observable";
import { RestDataSource } from "./rest.datasource";

@Injectable()
export class Model {
    private products: Product[] = new Array<Product>();
    private locator = (p: Product, id: number) => p.id == id;

    constructor(private dataSource: RestDataSource) {
        this.dataSource.getData().subscribe(data => this.products = data);
    }

    getProducts(): Product[] {
        return this.products;
    }

    getProduct(id: number): Product {
        return this.products.find(p => this.locator(p, id));
    }

    getNextProductId(id: number): number {
        let index = this.products.findIndex(p => this.locator(p, id));
        if (index > -1) {
            return this.products[this.products.length > index + 2
                ? index + 1 : 0].id;
        } else {
            return id || 0;
        }
    }

    getPreviousProductid(id: number): number {
        let index = this.products.findIndex(p => this.locator(p, id));
        if (index > -1) {
            return this.products[index > 0
                ? index - 1 : this.products.length - 1].id;
        } else {
            return id || 0;
        }
    }

    saveProduct(product: Product) {
        if (product.id == 0 || product.id == null) {
            this.dataSource.saveProduct(product)
                .subscribe(p => this.products.push(p));
        } else {
            this.dataSource.updateProduct(product).subscribe(p => {
                let index = this.products
                    .findIndex(item => this.locator(item, p.id));
                this.products.splice(index, 1, p);
            });
        }
    }

    deleteProduct(id: number) {
        this.dataSource.deleteProduct(id).subscribe(() => {
            let index = this.products.findIndex(p => this.locator(p, id));
            if (index > -1) {
                this.products.splice(index, 1);
            }
        });
    }
}
```

The new methods accept an ID value, locate the corresponding product, and then return the IDs of the next and previous objects in the array that the repository uses to collect the data model objects. I will use this feature later in the chapter to allow the user to page through the set of objects in the data model.

To simplify the example, Listing 26-2 removes the statements in the form component that receive the details of the product to edit using optional route parameters.

Listing 26-2. Removing Optional Route Parameters in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute, Router } from "@angular/router";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model, activeRoute: ActivatedRoute,
        private router: Router) {

        this.editing = activeRoute.snapshot.params["mode"] == "edit";
        let id = activeRoute.snapshot.params["id"];
        if (id != null) {
            Object.assign(this.product, model.getProduct(id) || new Product());
        }
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.router.navigateByUrl("/");
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

Listing 26-3 removes the optional parameters from the table component's template so they are not included in the navigation URLs for the Edit buttons.

Listing 26-3. Removing Optional Route Parameters in the table.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm"
                [routerLink]="['/form', 'edit', item.id]">
                Edit
            </button>
        </td>
    </tr>
</table>
<button class="btn btn-primary" routerLink="/form/create">
    Create New Product
</button>
<button class="btn btn-danger" (click)="deleteProduct(-1)">
    Generate HTTP Error
</button>
```

Adding Components to the Project

I need to add some components to the application to demonstrate some of the features covered in this chapter. These components are simple because I am focusing on the routing system, rather than adding useful features to the application. I created a file called `productCount.component.ts` to the `exampleApp/app/core` folder and used it to define the component shown in Listing 26-4.

■ **Tip** You can omit the selector attribute from the `@Component` decorator if a component is only going to be displayed through the routing system. I tend to add it anyway so that I can apply the component using an HTML element as well.

Listing 26-4. The productCount.component.ts File in the exampleApp/app/core Folder

```
import { Component, KeyValueDiffer,
         KeyValueDiffers, ChangeDetectorRef } from "@angular/core";
import { Model } from "../model/repository.model";

@Component({
    selector: "paProductCount",
    template: `<div class="bg-info p-a-1">There are {{count}} products</div>`
})
export class ProductCountComponent {
    private differ: KeyValueDiffer;
    count: number = 0;

    constructor(private model: Model,
        private keyValueDiffers: KeyValueDiffers,
        private changeDetector: ChangeDetectorRef) {}

    ngOnInit() {
        this.differ = this.keyValueDiffers
            .find(this.model.getProducts())
            .create(this.changeDetector);
    }

    ngDoCheck() {
        if (this.differ.diff(this.model.getProducts()) != null) {
            this.updateCount();
        }
    }

    private updateCount() {
        this.count = this.model.getProducts().length;
    }
}
```

This component uses an inline template to display the number of products in the data model, which is updated when the data model changes. Next, I added a file called `categoryCount.component.ts` in the `exampleApp/app/core` folder and defined the component shown in Listing 26-5.

Listing 26-5. The categoryCount.component.ts File in the exampleApp/app/core Folder

```
import { Component, KeyValueDiffer,
         KeyValueDiffers, ChangeDetectorRef } from "@angular/core";
import { Model } from "../model/repository.model";

@Component({
    selector: "paCategoryCount",
    template: `<div class="bg-primary p-a-1">There are {{count}} categories</div>`
})
export class CategoryCountComponent {
    private differ: KeyValueDiffer;
    count: number = 0;

    constructor(private model: Model,
        private keyValueDiffers: KeyValueDiffers,
        private changeDetector: ChangeDetectorRef) { }

    ngOnInit() {
        this.differ = this.keyValueDiffers
            .find(this.model.getProducts())
            .create(this.changeDetector);
    }

    ngDoCheck() {
        if (this.differ.diff(this.model.getProducts()) != null) {
            this.count = this.model.getProducts()
                .map(p => p.category)
                .filter((category, index, array) => array.indexOf(category) == index)
                .length;
        }
    }
}
```

This component uses a differ to track changes in the data model and count the number of unique categories, which is displayed using a simple inline template. For the final component, I added a file called `notFound.component.ts` in the exampleApp/app/core folder and used it to define the component shown in Listing 26-6.

Listing 26-6. The notFound.component.ts File in the exampleApp/app/core Folder

```
import { Component } from "@angular/core";

@Component({
    selector: "paNotFound",
    template: `<h3 class="bg-danger p-a-1">Sorry, something went wrong</h3>
               <button class="btn btn-primary" routerLink="/">Start Over</button>`
})
export class NotFoundComponent {}
```

This component displays a static message that will be shown when something goes wrong with the routing system. Listing 26-7 adds the new components to the core module.

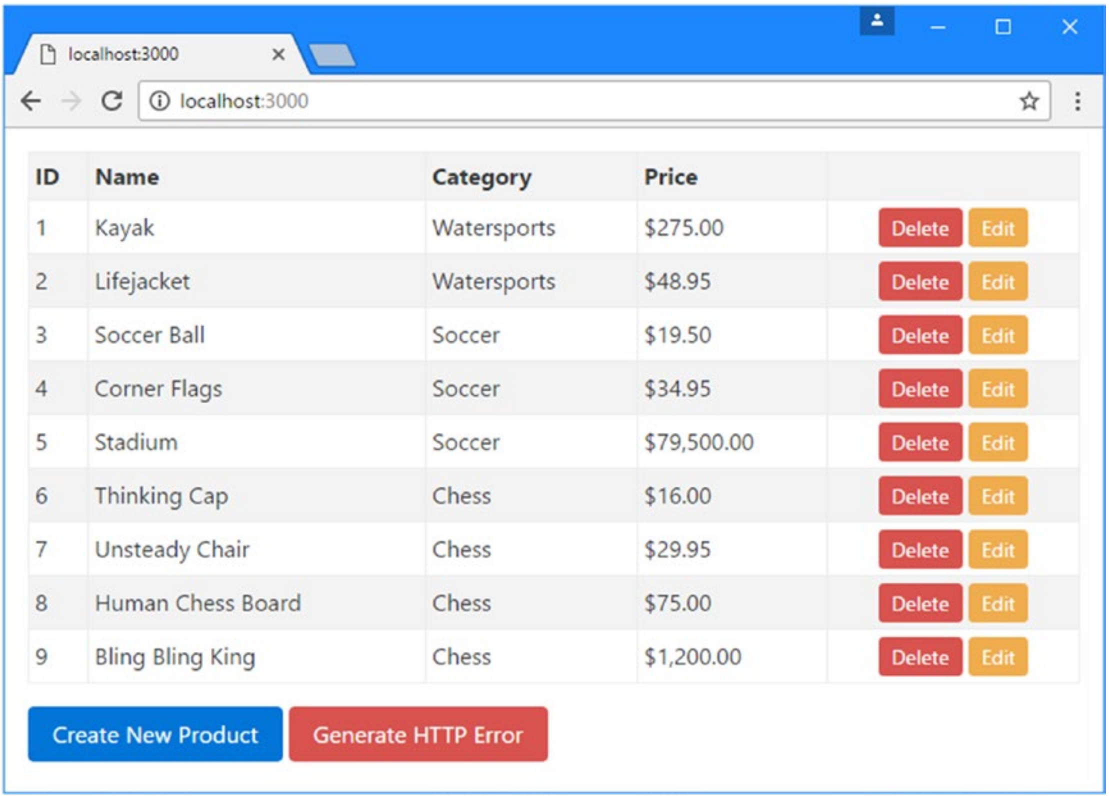
Listing 26-7. Declaring Components in the core.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
import { Subject } from "rxjs/Subject";
import { StatePipe } from "./state.pipe";
import { MessageModule } from "../messages/message.module";
import { MessageService } from "../messages/message.service";
import { Message } from "../messages/message.model";
import { Model } from "../model/repository.model";
import { RouterModule } from "@angular/router";
import { ProductCountComponent } from "./productCount.component";
import { CategoryCountComponent } from "./categoryCount.component";
import { NotFoundComponent } from "./notFound.component";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule, MessageModule, RouterModule],
    declarations: [TableComponent, FormComponent, StatePipe,
        ProductCountComponent, CategoryCountComponent, NotFoundComponent],
    exports: [ModelModule, TableComponent, FormComponent]
})
export class CoreModule { }
```

Save the changes shown and run the following command in the exampleApp folder to start the TypeScript compiler, the development HTTP server, and the RESTful web service:

```
npm start
```

A new browser tab or window will open and you will see the content shown in Figure 26-1.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Figure 26-1. *Running the example application*

Using Wildcards and Redirections

The routing configuration in an application can quickly become complex and contain redundancies and oddities to cater for the structure of an application. Angular provides two useful tools that can help simplify routes and also deal with problems when they arise, as described in the following sections.

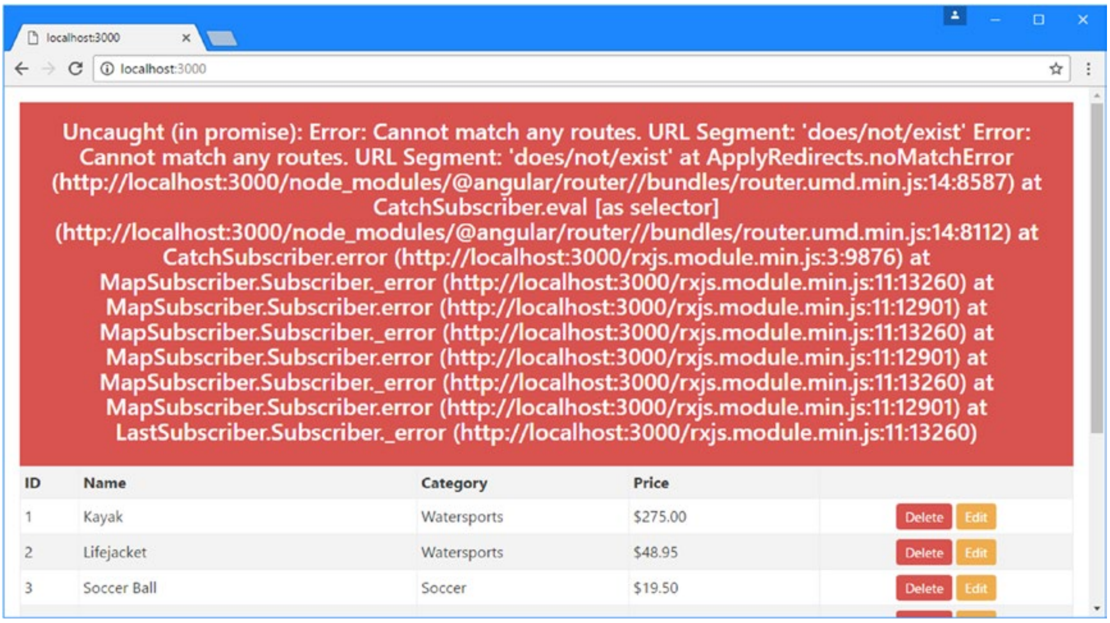
Using Wildcards in Routes

The Angular routing system supports a special path, denoted by two asterisks (the ** characters), that allows routes to match any URL. The basic use for the wildcard path is to deal with navigation that would otherwise create a routing error. Listing 26-8 adds a button to the table component's template that navigates to a route that hasn't been defined by the application's routing configuration.

Listing 26-8. Adding a Button That Generates an Error in the table.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm" (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm"
                [routerLink]="['/form', 'edit', item.id]">
                Edit
            </button>
        </td>
    </tr>
</table>
<button class="btn btn-primary" routerLink="/form/create">
    Create New Product
</button>
<button class="btn btn-danger" (click)="deleteProduct(-1)">
    Generate HTTP Error
</button>
<button class="btn btn-danger" routerLink="/does/not/exist">
    Generate Routing Error
</button>
```

Clicking the button will ask the application to navigate to the URL /does/not/exist, for which there is no route configured. When a URL doesn't match a URL, an error is thrown, which is then picked up and processed by the error handling class, which leads to a warning being displayed by the message component, as shown in Figure 26-2.



Uncaught (in promise): Error: Cannot match any routes. URL Segment: 'does/not/exist' Error: Cannot match any routes. URL Segment: 'does/not/exist' at ApplyRedirects.noMatchError (http://localhost:3000/node_modules/@angular/router//bundles/router.umd.min.js:14:8587) at CatchSubscriber.eval [as selector] (http://localhost:3000/node_modules/@angular/router//bundles/router.umd.min.js:14:8112) at CatchSubscriber.error (http://localhost:3000/rxjs.module.min.js:3:9876) at MapSubscriber.Subscriber._error (http://localhost:3000/rxjs.module.min.js:11:13260) at MapSubscriber.Subscriber.error (http://localhost:3000/rxjs.module.min.js:11:12901) at MapSubscriber.Subscriber._error (http://localhost:3000/rxjs.module.min.js:11:13260) at MapSubscriber.Subscriber.error (http://localhost:3000/rxjs.module.min.js:11:12901) at MapSubscriber.Subscriber._error (http://localhost:3000/rxjs.module.min.js:11:13260) at MapSubscriber.Subscriber.error (http://localhost:3000/rxjs.module.min.js:11:12901) at LastSubscriber.Subscriber._error (http://localhost:3000/rxjs.module.min.js:11:13260)

ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit

Figure 26-2. *The default navigation error*

This isn't a useful way to deal with an unknown route because the user won't know what routes are and may not realize that the application was trying to navigate to the problem URL.

A better approach is to use the wildcard route to handle navigation for URLs that have not been defined and select a component that will present a more useful message to the user, as illustrated in Listing 26-9.

Listing 26-9. Adding a Wildcard Route in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";

const routes: Routes = [
    { path: "form/:mode/:id", component: FormComponent },
    { path: "form/:mode", component: FormComponent },
    { path: "", component: TableComponent },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

The new route in the listing uses the wildcard to select the `NotFoundComponent`, which displays the message shown in Figure 26-3 when the Generate Routing Error button is clicked.

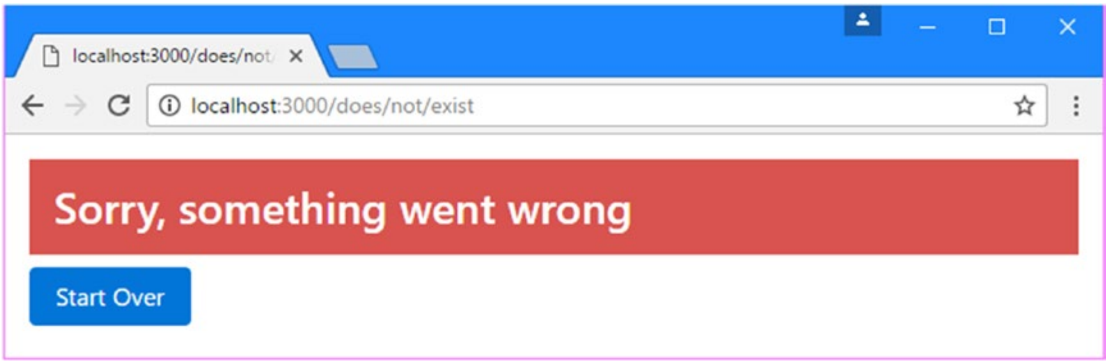


Figure 26-3. *Using a wildcard route*

Clicking the Start Over button navigates to the / URL, which will select the table component for display.

EMPTY PATHS VERSUS WILDCARDS

It is easy to get confused between the way that the last two routes in Listing 26-9 work.

```
...
{ path: "", component: TableComponent },
{ path: "**", component: NotFoundComponent }
...
```

The first route uses the *empty path*, which matches a single empty segment. This will match a route only if the segment is empty. For this route, this means that it will only match the `http://localhost:3000/` URL, but there will be other examples later in the chapter that use the empty path to match segments from more complex URLs.

The second route uses the *wildcard path*, which matches any URL. The order of routes is important because Angular evaluates them in the order they are defined. The wildcard path must always be used in the last route that is defined because any subsequent routes will never be reached.

It can be easy to get these paths confused, and it is important to remember that the empty path is strict in what it will match (a single, empty segment), while the wildcard path is liberal and will match any number of segments, regardless of what they contain.

Using Redirections in Routes

Routes do not have to select components; they can also be used as aliases that redirect the browser to a different URL. Redirections are defined using the `redirectTo` property in a route, as shown in Listing 26-10.

Listing 26-10. Using Route Redirection in the app.routing.ts File

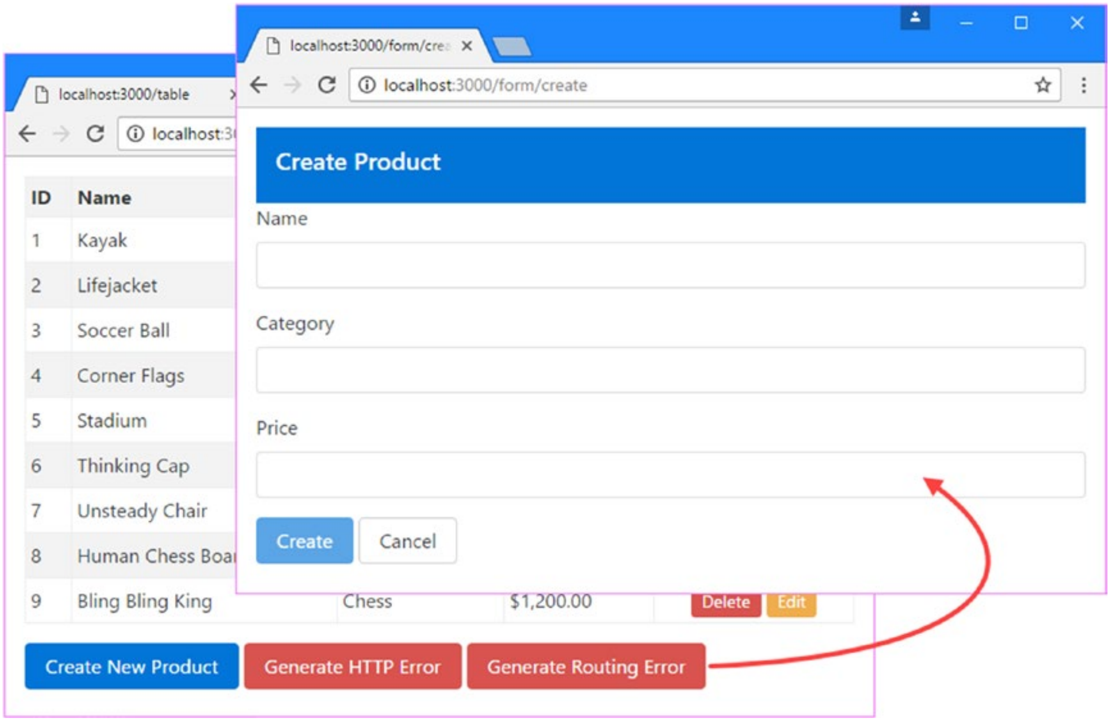
```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";

const routes: Routes = [
    { path: "form/:mode/:id", component: FormComponent },
    { path: "form/:mode", component: FormComponent },
    { path: "does", redirectTo: "/form/create", pathMatch: "prefix" },
    { path: "table", component: TableComponent },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

The `redirectTo` property is used to specify the URL that the browser will be redirected to. When defining redirections, the `pathMatch` property must also be specified, using one of the values described in Table 26-2.

Table 26-2. *The pathMatch Values*

Name	Description
`prefix`	This value configures the route so that it matches URLs that start with the specified path, ignoring any subsequent segments.
`full`	This value configures the route so that it matches only the URL specified by the `path` property.

The first route added in Listing 26-10 specifies a `pathMatch` value of `prefix` and a path of `does`, which means it will match any URL whose first segment is `does`, such as the `/does/not/exist` URL that is navigated to by the Generate Routing Error button. When the browser navigates to a URL that has this prefix, the routing system will redirect it to the `/form/create` URL, as shown in Figure 26-4.



ID	Name			
1	Kayak			
2	Lifejacket			
3	Soccer Ball			
4	Corner Flags			
5	Stadium			
6	Thinking Cap			
7	Unsteady Chair			
8	Human Chess Boa			
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Figure 26-4. *Performing a route redirection*

The other routes in Listing 26-10 redirect the empty path to the `/table` URL, which displays the table component. This is a common technique that makes the URL schema more obvious because it matches the default URL (`http://localhost:3000/`) and redirects it to something more meaningful and memorable to the user (`http://localhost:3000/table`). In this case, the `pathMatch` property value is `full`, although this has no effect since it has been applied to the empty path.

Navigating Within a Component

The navigation examples in the previous chapter all navigated between different components so that clicking a button in the table component navigates to the form component and vice versa.

This isn't the only kind of navigation that's possible: you can also navigate within a component. To demonstrate, Listing 26-11 adds buttons to the form component that allow the user to edit the previous or next data objects.

Listing 26-11. Adding Buttons to the form.component.html File

```
<div class="bg-primary p-a-1" [class.bg-warning]="editing">
    <h5>{{editing  ? "Edit" : "Create"}} Product</h5>
</div>
<div *ngIf="editing" class="p-t-1">
    <button class="btn btn-secondary"
        [routerLink]="['/form', 'edit', model.getPreviousProductid(product.id)]">
            Previous
    </button>
    <button class="btn btn-secondary"
        [routerLink]="['/form', 'edit', model.getNextProductId(product.id)]">
            Next
    </button>
</div>
<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)" (reset)="resetForm()" >
    <div class="form-group">
        <label>Name</label>
        <input class="form-control" name="name"
               [(ngModel)]="product.name" required />
    </div>

    <div class="form-group">
        <label>Category</label>
        <input class="form-control" name="category"
               [(ngModel)]="product.category" required />
    </div>

    <div class="form-group">
        <label>Price</label>
        <input class="form-control" name="price"
               [(ngModel)]="product.price"
               required pattern="^[0-9\.]+$" />
    </div>

    <button type="submit" class="btn btn-primary"
            [class.btn-warning]="editing" [disabled]="form.invalid">
        {{editing ? "Save" : "Create"}}
    </button>
    <button type="reset" class="btn btn-secondary" routerLink="/">Cancel</button>
</form>
```

These buttons have bindings for the `routerLink` directive with expressions that target the previous and next objects in the data model. This means that if you click the `Edit` button in the table for the Lifejacket product, for example, the Next button will navigate to the URL that edits the Soccer Ball and the Previous button will navigate to the URL for the Kayak.

Responding to Ongoing Routing Changes

Clicking the new buttons has no effect at the moment. Angular tries to be efficient during navigation, and it knows that the URLs that the Previous and Next buttons navigate to are handled by the same component that is currently displayed to the user. Rather than create a new instance of the component, it simply tells the component that the selected route has changed.

This is a problem because the form component isn't set up to receive change notifications. Its constructor receives the `ActivatedRoute` object that Angular uses to provide details of the current route, but only its `snapshot` property is used. The component's constructor has long been executed by the time that Angular updates the values in the `ActivatedRoute`, which means that it misses the notification. This worked when the configuration of the application meant that a new form component would be created each time the user wanted to create or edit a product, but it is no longer sufficient.

Fortunately, the `ActivatedRoute` class defines a set of properties that allow interested parties to receive notifications through Reactive Extensions `Observable` objects. These properties correspond to the ones provided by the `ActivatedRouteSnapshot` object returned by the snapshot property (described in Chapter 25) but send new events when there are any subsequent changes, as described in Table 26-3.

Table 26-3. *The Observable Properties of the ActivatedRoute Class*

Name	Description
`url`	This property returns an `Observable<UrlSegment[]>`, which provides the set of URL segments each time the route changes.
`params`	This property returns an `Observable<Params>`, which provides the URL parameters each time the route changes.
`queryParams`	This property returns an `Observable<Params>`, which provides the URL query parameters each time the route changes.
`fragment`	This property returns an `Observable<string>`, which provides the URL fragment each time the route changes.

These properties can be used by components that need to handle navigation changes that don't result in a different component being displayed to the user, as shown in Listing 26-12.

■ **Tip** If you need to combine different data elements from the route, such as using both segments and parameters, then subscribe to the `Observer` for one data element and use the `snapshot` property to get the rest of the data you require.

Listing 26-12. Observing Route Changes in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute, Router } from "@angular/router";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();

    constructor(private model: Model, activeRoute: ActivatedRoute,
        private router: Router) {

        activeRoute.params.subscribe(params => {
            this.editing = params["mode"] == "edit";
            let id = params["id"];
            if (id != null) {
                Object.assign(this.product, model.getProduct(id) || new Product());
            }
        })
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.router.navigateByUrl("/");
        }
    }

    resetForm() {
        this.product = new Product();
    }
}
```

The component subscribes to the `Observer<Params>` that sends a new `Params` object to subscribers each time the active route changes. The `Observer` objects returned by the `ActivatedRoute` properties send details of the most recent route change when the subscribe method is called, ensuring that the component's constructor doesn't miss the initial navigation that led to it being called.

The result is that the component can react to route changes that don't cause Angular to create a new component, meaning that clicking the Next or Previous button changes the product that has been selected for editing, as shown in Figure 26-5.

■ **Tip** The effect of navigation is obvious when the activated route changes the component that is displayed to the user. It may not be so obvious when just the data changes. To help emphasize changes, Angular can apply animations that can draw attention to the effects of navigation. See Chapter 28 for details.

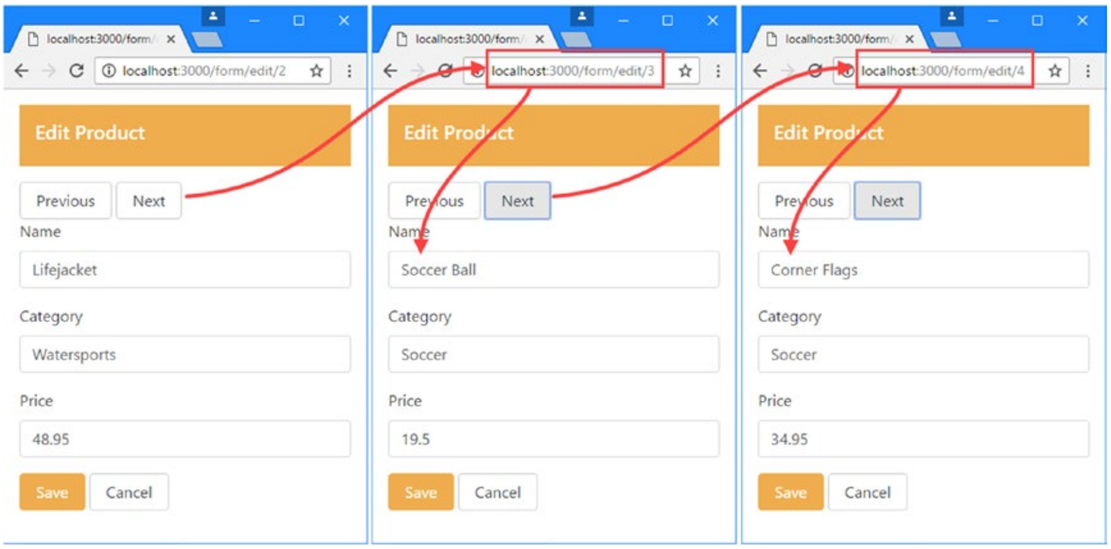


Figure 26-5. *Responding to route changes*

Styling Links for Active Routes

A common use for the routing system is to display multiple navigation elements alongside the content that they select. To demonstrate, Listing 26-13 adds a new route to the application that will allow the table component to be targeted with a URL that contains a category filter.

Listing 26-13. Defining a Route in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";

const routes: Routes = [
    { path: "form/:mode/:id", component: FormComponent },
    { path: "form/:mode", component: FormComponent },
    { path: "does", redirectTo: "/form/create", pathMatch: "prefix" },
    { path: "table/:category", component: TableComponent },
    { path: "table", component: TableComponent },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

Listing 26-14 updates the `TableComponent` class so that it uses the routing system to get details of the active route and assigns the value of the `category` route parameter to a `category` property that can be accessed in the template. The `category` property is used in the `getProducts` method to filter the objects in the data model.

Listing 26-14. Adding Category Filter Support in the table.component.ts File

```
import { Component, Inject } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute } from "@angular/router";

@Component({
    selector: "paTable",
    moduleId: module.id,
    templateUrl: "table.component.html"
})
export class TableComponent {
    category: string = null;

    constructor(private model: Model, activeRoute: ActivatedRoute) {
        activeRoute.params.subscribe(params => {
            this.category = params["category"] || null;
        })
    }

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts()
            .filter(p => this.category == null || p.category == this.category);
    }

    get categories(): string[] {
        return this.model.getProducts()
            .map(p => p.category)
            .filter((category, index, array) => array.indexOf(category) == index);
    }

    deleteProduct(key: number) {
        this.model.deleteProduct(key);
    }
}
```

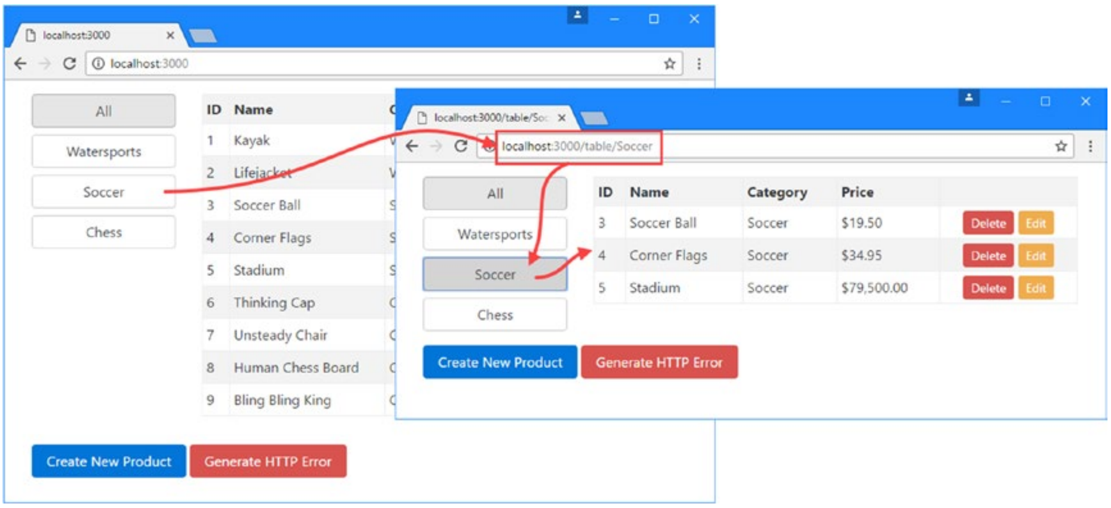
There is also a new categories property that will be used in the template to generate the set of categories for filtering. The final step is to add the HTML elements to the template that will allow the user to apply a filter, as shown in Listing 26-15.

Listing 26-15. Adding Filter Elements in the table.component.html File

```
<div class="col-xs-3">
    <button class="btn btn-secondary btn-block"
            routerLink="/" routerLinkActive="active">
        All
    </button>
    <button *ngFor="let category of categories" class="btn btn-secondary btn-block"
            [routerLink]="['/table', category]" routerLinkActive="active">
        {{category}}
    </button>
</div>
<div class="col-xs-9">
    <table class="table table-sm table-bordered table-striped">
        <tr>
            <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
        </tr>
        <tr *ngFor="let item of getProducts()">
            <td style="vertical-align:middle">{{item.id}}</td>
            <td style="vertical-align:middle">{{item.name}}</td>
            <td style="vertical-align:middle">{{item.category}}</td>
            <td style="vertical-align:middle">
                {{item.price | currency:"USD":true }}
            </td>
            <td class="text-xs-center">
                <button class="btn btn-danger btn-sm"
                        (click)="deleteProduct(item.id)">
                    Delete
                </button>
                <button class="btn btn-warning btn-sm"
                    [routerLink]="['/form', 'edit', item.id]">
                    Edit
                </button>
            </td>
        </tr>
    </table>
</div>
<div class="col-xs-12 p-t-1">
    <button class="btn btn-primary" routerLink="/form/create">
        Create New Product
    </button>
    <button class="btn btn-danger" (click)="deleteProduct(-1)">
        Generate HTTP Error
    </button>
    <button class="btn btn-danger" routerLink="/does/not/exist">
        Generate Routing Error
    </button>
</div>
```

The important part of this example is the use of the `routerLinkActive` attribute, which is used to specify a CSS class that the element will be assigned to when the URL specified by the `routerLink` attribute matches the active route.

The listing specifies a CSS class called `active`, which is the Bootstrap CSS framework's class for setting the active state for buttons. When combined with the functionality added to the component in Listing 26-14, the result is a set of buttons that allow the user to view products in a single category, as shown in Figure 26-6.



ID	Name
1	Kayak
2	Lifejacket
3	Soccer Ball
4	Corner Flags
5	Stadium
6	Thinking Cap
7	Unsteady Chair
8	Human Chess Board
9	Bling Bling King

ID	Name	Category	Price	
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit

Figure 26-6. *Filtering products*

If you click the Soccer button, the application will navigate to the `/table/Soccer` URL, and the table will display only those products in the `Soccer` category. The `Soccer` button will also be highlighted since the `routerLinkActive` attribute means that Angular will add the `button` element to the Bootstrap `active` class.

Fixing the All Button

The navigation buttons reveal a common problem, which is that the All button is always added to the `active` class, even when the user has filtered the table to show a specific category.

This happens because the `routerLinkActive` attribute performs partial matches on the active URL by default. In the case of the example, the / URL will always cause the All button to be activated because it is at the start of all URLs. This problem can be fixed by configuring the `routerLinkActive` directive, as shown in Listing 26-16.

Listing 26-16. Configuring the Directive in the table.component.html File

```
...
<div class="col-xs-3">
    <button class="btn btn-secondary btn-block"
            routerLink="/table" routerLinkActive="active"
            [routerLinkActiveOptions]="{exact: true}">
        All
    </button>
    <button *ngFor="let category of categories" class="btn btn-secondary btn-block"
            [routerLink]="['/table', category]" routerLinkActive="active">
        {{category}}
    </button>
</div>
...
```

The configuration is performed using a binding on the `routerLinkActiveOptions` attribute, which accepts a literal object. The `exact` property is the only available configuration setting and is used to control matching the active route URL. Setting this property `true` will add the element to the class specified by the `routerLinkActive` attribute only when there is an exact match with the active route's URL. With this change, the All button will be highlighted only when all of the products are shown, as illustrated by Figure 26-7.

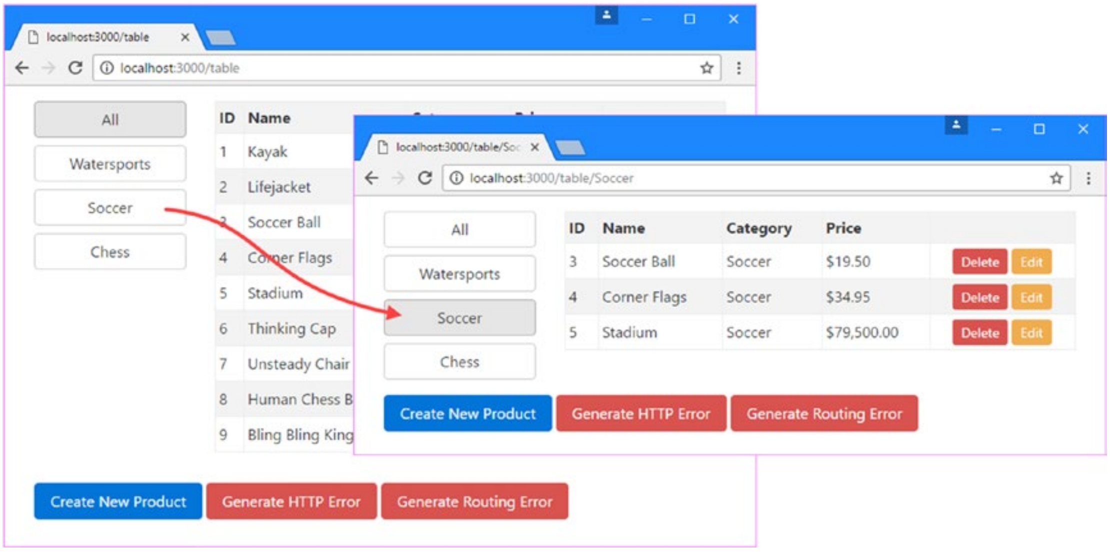


Figure 26-7. *Fixing the All button problem*

Creating Child Routes

Child routes allow components to respond to part of the URL by embedding `router-outlet` elements in their templates, creating more complex arrangements of content. I am going to use the simple components I created at the start of the chapter to demonstrate how child routes work. These components will be displayed above the product table, and the component that is shown will be specified in the URLs shown in Table 26-4.

Table 26-4. *The URLs and the Components They Will Select*

URL	Component
`/table/products`	The `ProductCountComponent` will be displayed.
`/table/categories`	The `CategoryCountComponent` will be displayed.
`/table`	Neither component will be displayed.

Listing 26-17 shows the changes to the application's routing configuration to implement the routing strategy in the table.

Listing 26-17. Configuring Routes in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";

const routes: Routes = [
    { path: "form/:mode/:id", component: FormComponent },
    { path: "form/:mode", component: FormComponent },
    { path: "does", redirectTo: "/form/create", pathMatch: "prefix" },
    {
        path: "table",
        component: TableComponent,
        children: [
            { path: "products", component: ProductCountComponent },
            { path: "categories", component: CategoryCountComponent },
            { path: "" }
        ]
    },
    { path: "table/:category", component: TableComponent },
    //{ path: "table", component: TableComponent },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

Child routes are defined using the `children` property, which is set to an array of routes defined in the same way as the top-level routes.

When Angular uses the entire URL to match a route that has children, there will be a match only if the URL to which the browser navigates contains segments that match both the top-level segment and the segments specified by one of the child routes.

The first two child routes use the `path` and `component` properties to define routes that will match the segment of the URL and select one of the new components. The third child route does something different. This is a *componentless route*, which means it uses the `path` property to match a URL segment, but it doesn't select a component to be displayed. This is a useful way to allow routes to match more widely, since without the componentless route, I would have to create a separate route to match the `/table` URL.

■ **Tip** Notice that I have added the new route before the one whose path is `table/:category`. Angular tries to match routes in the order in which they are defined. The `table/:category` path would match both the `/table/products` and `/table/categories` URLs and lead the table component to filter the products for nonexistent categories. By placing the more specific route first, the `/table/products` and `/table/categories` URLs will be matched before the `table/:category` path is considered.

Creating the Child Route Outlet

The components selected by child routes are displayed in a `router-outlet` element defined in the template of the component selected by the parent route. In the case of the example, this means that the child routes will target an element in the table component's template, as shown in Listing 26-18, which also adds elements that will navigate to the new routes.

Listing 26-18. Adding an Outlet and Navigation in the table.component.html File

```
<div class="col-xs-3">
    <button class="btn btn-secondary btn-block"
            routerLink="/" routerLinkActive="active"
            [routerLinkActiveOptions]="{exact: true}">
        All
    </button>
    <button *ngFor="let category of categories" class="btn btn-secondary btn-block"
            [routerLink]="['/table', category]" routerLinkActive="active">
        {{category}}
    </button>
</div>
<div class="col-xs-9">
    <div class="m-b-1">
        <button class="btn btn-info" routerLink="/table/products">
            Count Products
        </button>
        <button class="btn btn-primary" routerLink="/table/categories">
            Count Categories
        </button>
        <button class="btn btn-secondary" routerLink="/table">
            Count Neither
        </button>
        <div class="m-t-1">
            <router-outlet></router-outlet>
        </div>
    </div>
    <table class="table table-sm table-bordered table-striped">
        <tr>
            <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
        </tr>
        <tr *ngFor="let item of getProducts()">
            <td style="vertical-align:middle">{{item.id}}</td>
            <td style="vertical-align:middle">{{item.name}}</td>
            <td style="vertical-align:middle">{{item.category}}</td>
            <td style="vertical-align:middle">
                {{item.price | currency:"USD":true }}
            </td>
            <td class="text-xs-center">
                <button class="btn btn-danger btn-sm"
                        (click)="deleteProduct(item.id)">
                    Delete
                </button>
                <button class="btn btn-warning btn-sm"
```

```
                    [routerLink]="['/form', 'edit', item.id]">
                    Edit
                </button>
            </td>
        </tr>
    </table>
</div>
<div class="col-xs-12 p-t-1">
    <button class="btn btn-primary" routerLink="/form/create">
        Create New Product
    </button>
    <button class="btn btn-danger" (click)="deleteProduct(-1)">
        Generate HTTP Error
    </button>
    <button class="btn btn-danger" routerLink="/does/not/exist">
        Generate Routing Error
    </button>
</div>
```

The button elements have routerLink attributes that specify the URLs listed in Table 26-4, and there is also a router-outlet element, which will be used to display the selected component, as shown in Figure 26-8, or no component if the browser navigates to the /table URL.

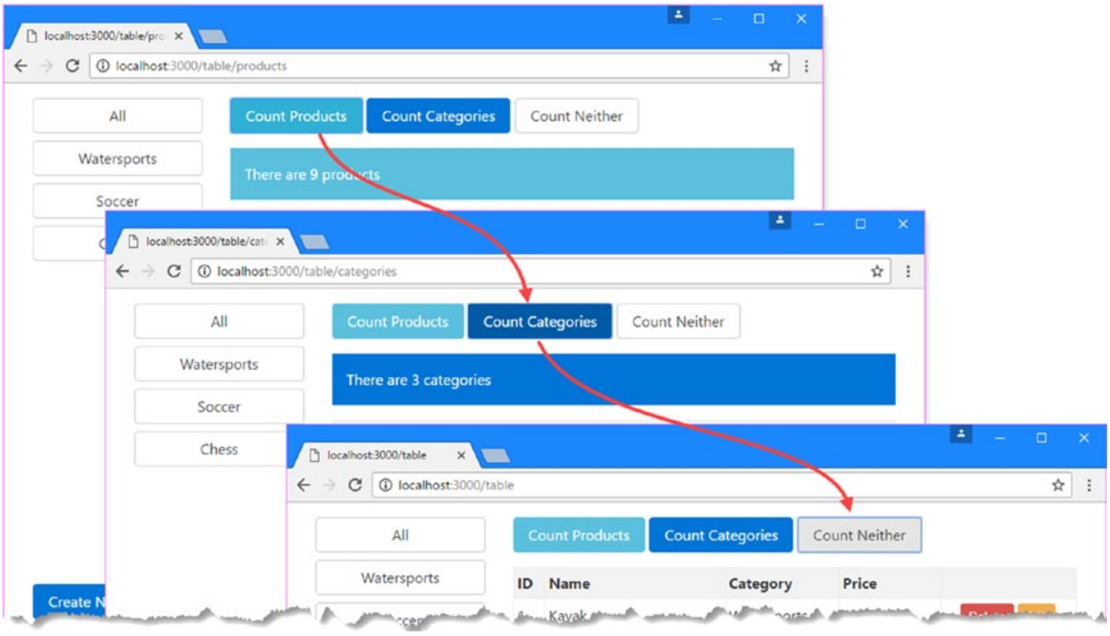


Figure 26-8. *Using child routes*

Accessing Parameters from Child Routes

Child routes can use all the features available to the top-level routes, including defining route parameters and even having their own child routes. Route parameters are worth special attention in child routes because of the way that Angular isolates children from their parents. For this section, I am going to add support for the URLs described in Table 26-5.

Table 26-5. *The New URLs Supported by the Example Application*

Name	Description
`/table/:category/products`	This route will filter the contents of the table and select the `ProductCountComponent`.
`/table/:category/categories`	This route will filter the contents of the table and select the `CategoryCountComponent`.

Listing 26-19 defines the routes that support the URLs shown in the table.

Listing 26-19. Adding Routes in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";

const childRoutes: Routes = [
    { path: "products", component: ProductCountComponent },
    { path: "categories", component: CategoryCountComponent },
    { path: "", component: ProductCountComponent }
];

const routes: Routes = [
    { path: "form/:mode/:id", component: FormComponent },
    { path: "form/:mode", component: FormComponent },
    { path: "does", redirectTo: "/form/create", pathMatch: "prefix" },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

The type of the `children` property is a `Routes` object, which makes it easy to minimize duplication in the route configuration when you need to apply the same set of child routes in different parts of the URL schema. In the listing, I have defined the child routes in a `Routes` object called `childRoutes` and used it as the value for the `children` property in two different top-level routes.

■ **Tip** Notice that I changed the empty path child route in Listing 26-19 so that the `ProductCountComponent` is selected. As I write this, there is a bug in Angular that causes an error if navigation doesn't select a component for an outlet once it has been used to display a component. For simplicity I selected the `ProductCountComponent`, but if you really don't want to display any content to the user, then create a component with an empty template and select that instead.

To make it possible to target these new routes, Listing 26-20 changes the targets of the buttons that appear above the table so they navigate relative to the current URL. I have removed the Count Neither button, since the `ProductCountComponent` will be shown when the empty path child route matches the URL.

Listing 26-20. Using Relative URLs in the table.component.html File

```
...
<div class="m-b-1">
    <button class="btn btn-info" routerLink="products">Count Products</button>
    <button class="btn btn-primary" routerLink="categories">Count Categories</button>
    <div class="m-t-1">
        <router-outlet></router-outlet>
    </div>
</div>
...
```

When Angular matches routes, the information it provides to the components that are selected through the `ActivatedRoute` object is segregated, so that each component only receives details of the part of the route that selected it.

In the case of the routes added in Listing 26-20, this means the `ProductCountComponent` and `CategoryCountComponent` receive an `ActivatedRoute` object that only describes the child route that selected them, with the single segment of `/products` or `/categories`. Equally, the `TableComponent` component receives an `ActivatedRoute` object that doesn't contain the segment that was used to match the child route.

Fortunately, the `ActivatedRoute` class provides some properties that provide access to the rest of the route, allowing parents and children to access the rest of the routing information, as described in Table 26-6.

Table 26-6. *The ActivatedRoute Properties for Child/Parent Route Information*

Name	Description
`pathFromRoot`	This property returns an array of `ActivatedRoute` objects representing all the routes used to match the current URL.
`parent`	This property returns an `ActivatedRoute` representing the parent of the route that selected the component.
`firstChild`	This property returns an `ActivatedRoute` representing the first child route used to match the current URL.
`children`	This property returns an array of `ActivatedRoute` objects representing all the children routes used to match the current URL.

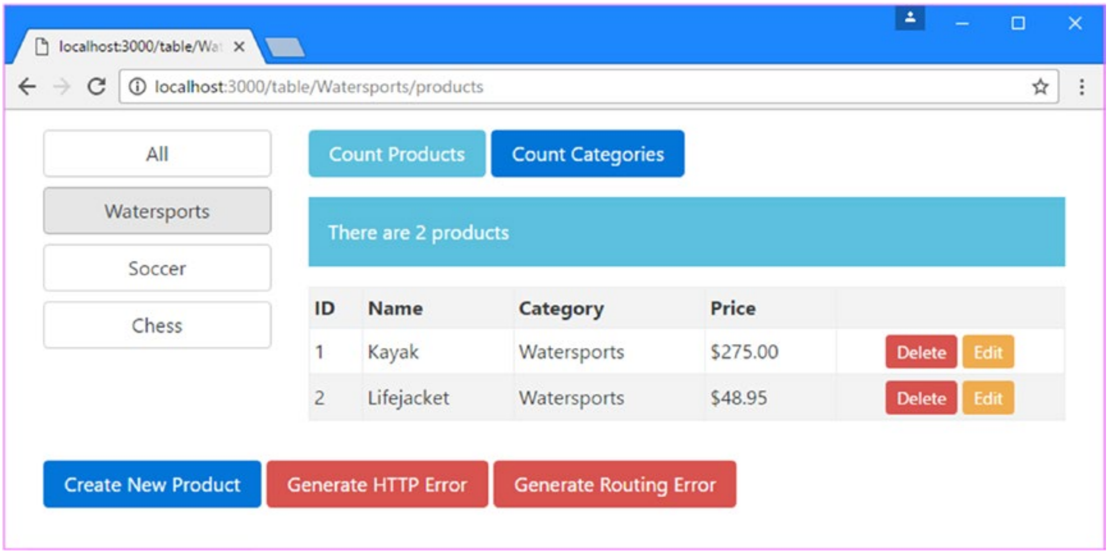
Listing 26-21 shows how the `ProductCountComponent` component can access the wider set of routes used to match the current URL to get a value for the category route parameter and adapt its output when the contents of the table are filtered for a single category.

Listing 26-21. Accessing Ancestor Routes in the productCount.component.ts File

```
import {
    Component, KeyValueDiffer,
    KeyValueDiffers, ChangeDetectorRef
} from "@angular/core";
import { Model } from "../model/repository.model";
import { ActivatedRoute } from "@angular/router";

@Component({
    selector: "paProductCount",
    template: `<div class="bg-info p-a-1">There are {{count}} products</div>`
})
export class ProductCountComponent {
    private differ: KeyValueDiffer;
    count: number = 0;
    private category: string;

    constructor(private model: Model,
            private keyValueDiffers: KeyValueDiffers,
            private changeDetector: ChangeDetectorRef,
            activeRoute: ActivatedRoute) {

        activeRoute.pathFromRoot.forEach(route => route.params.subscribe(params => {
            if (params["category"] != null) {
                this.category = params["category"];
                this.updateCount();
            }
        }))
    }

    ngOnInit() {
        this.differ = this.keyValueDiffers
            .find(this.model.getProducts())
            .create(this.changeDetector);
    }

    ngDoCheck() {
        if (this.differ.diff(this.model.getProducts()) != null) {
            this.updateCount();
        }
    }

    private updateCount() {
        this.count = this.model.getProducts()
            .filter(p => this.category == null || p.category == this.category)
            .length;
    }
}
```

The pathFromRoot property is especially useful because it allows a component to inspect all the routes that have been used to match the URL. Angular minimizes the routing updates required to handle navigation, which means that a component that has been selected by a child route won't receive a change notification through its ActivatedRoute object if only its parent has changed. It is for this reason that I have subscribed to updates from all the ActivatedRoute objects returned by the pathFromRoot property, ensuring that the component will always detect changes in the value of the category route parameter.

To see the result, save the changes, click the Watersports button to filter the contents of the table, and then click the Count Products button, which selects the ProductCountComponent. This number of products reported by the component will correspond to the number of rows in the table, as shown in Figure 26-9.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit

Figure 26-9. *Accessing the other routes used to match a URL*

Summary

In this chapter, I continued to describe the features provided by the Angular URL routing system, going beyond the basic features described in the previous chapter. I explained how to create wildcard and redirection routes, how to create routes that navigate relative to the current URL, and how to create child routes to display nested components. In the next chapter, I finish describing the URL routing system, focusing on the most advanced features.

CHAPTER 27

Routing and Navigation: Part 3

In this chapter, I continue to describe the Angular URL routing system, focusing on the most advanced features. I explain how to control route activation, how to load feature modules dynamically, and how to use multiple outlet elements in a template. Table 27-1 summarizes the chapter.

Table 27-1. *Chapter Summary*

Problem	Solution	Listing
Delay navigation until a task is complete	Use a route resolver	1–7
Prevent route activation	Use an activation guard	8–14
Prevent the user form navigating away from the current content	Use a deactivation guard	15–19
Defer loading a feature module until it is required	Create a dynamically loaded module	20–25
Control when a dynamically loaded module is used	Use a loading guard	26–28
Use routing to manage multiple router outlets	Use named outlets in the same template	29–34

Preparing the Example Project

For this chapter, I will continue using the `exampleApp` that was created in Chapter 22 and has been modified in each subsequent chapter. To prepare for this chapter, I have simplified the routing configuration, as shown in Listing 27-1.

Tip The examples in this chapter rely on the Reactive Extensions package created in Chapter 22. If you don't want to create the project yourself, you can get the example application, including the Reactive Extensions module, as part of the free source code download that accompanies this book from `apress.com`.

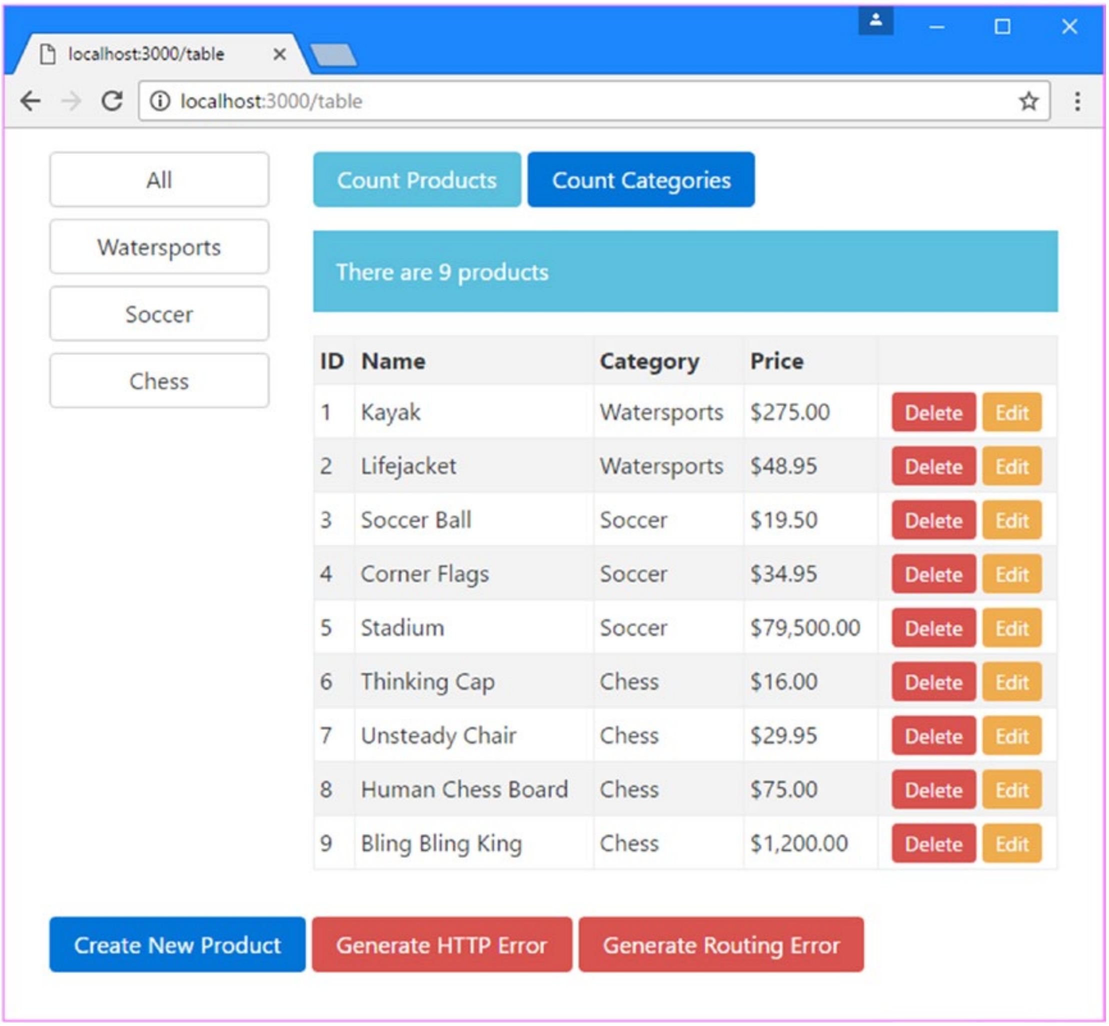
Listing 27-1. Simplifying the Routes in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";

const childRoutes: Routes = [
    { path: "products", component: ProductCountComponent },
    { path: "categories", component: CategoryCountComponent },
    { path: "", component: ProductCountComponent }
];

const routes: Routes = [
    { path: "form/:mode/:id", component: FormComponent },
    { path: "form/:mode", component: FormComponent },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

Save the changes and run the following command in the `exampleApp` folder to start the TypeScript compiler, the development HTTP server, and the RESTful web service:

```
npm start
```

A new browser tab or window will open, and you will see the content shown in Figure 27-1.



There are 9 products

ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Figure 27-1. *Running the example application*

Guarding Routes

At the moment, the user can navigate to anywhere in the application at any time. This isn't always a good idea, either because some parts of the application may not always be ready or because some parts of the application are restricted until specific actions are performed. To control the use of navigation, Angular supports *guards*, which are specified as part of the route configuration using the properties defined by the `Routes` class, described in Table 27-2.

Table 27-2. *The Routes Properties for Guards*

Name	Description
`resolve`	This property is used to specify guards that will delay route activation until some operation has been completed, such as loading data from a server.
`canActivate`	This property is used to specify the guards that will be used to determine whether a route can be activated.
`canActivateChild`	This property is used to specify the guards that will be used to determine whether a child route can be activated.
`canDeactivate`	This property is used to specify the guards that will be used to determine whether a route can be deactivated.
`canLoad`	This property is used to guard routes that load feature modules dynamically, as described in the "Loading Features Modules Dynamically" section.

Delaying Navigation with a Resolver

A common reason for guarding routes is to ensure that the application has received the data that it requires before a route is activated. The example application loads data from the RESTful web service asynchronously, which means there can be a delay between the moment at which the browser is asked to send the HTTP request and the moment at which the response is received and the data is processed. You may not have noticed this delay as you have followed the examples because the browser and the web service are running on the same machine. In a deployed application, there is a much greater prospect of there being a delay, caused by network congestion, high server load, and a dozen other factors.

To simulate network congestion, Listing 27-2 modifies the RESTful data source class to introduce a delay after the response is received from the web service.

Listing 27-2. Adding a Delay in the rest.datasource.ts File

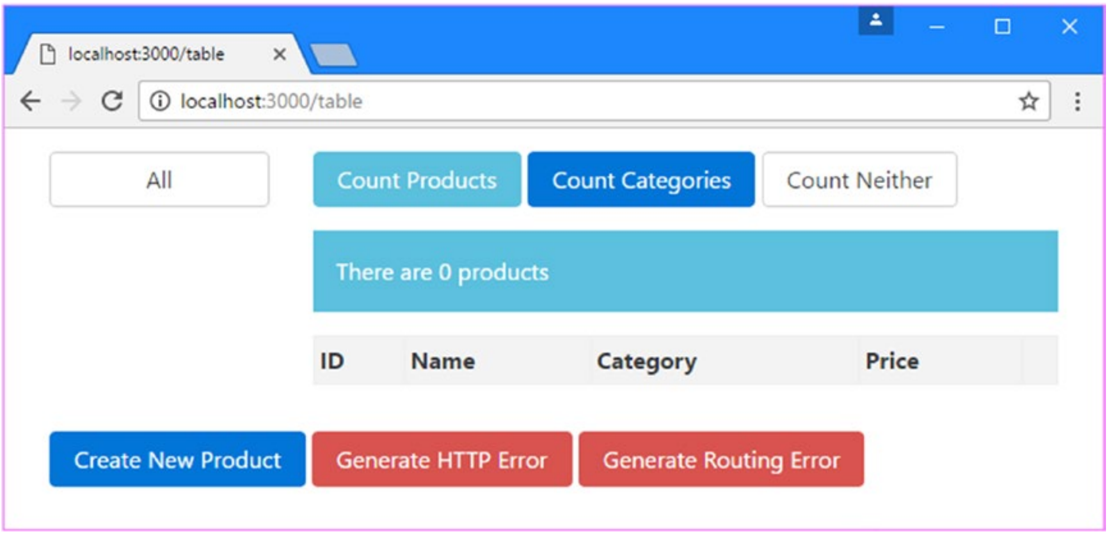
```
import { Injectable, Inject, OpaqueToken } from "@angular/core";
import { Http, Request, RequestMethod, Headers, Response } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import "rxjs/add/operator/map";
import "rxjs/add/operator/catch";
import "rxjs/add/observable/throw";
import "rxjs/add/operator/delay";

export const REST_URL = new OpaqueToken("rest_url");

@Injectable()
export class RestDataSource {

    constructor(private http: Http,
        @Inject(REST_URL) private url: string) { }

    // ...other methods omitted for brevity...

    private sendRequest(verb: RequestMethod,
        url: string, body?: Product): Observable<Product> {
```

```
        let headers = new Headers();
        headers.set("Access-Key", "<secret>");
        headers.set("Application-Names", ["exampleApp", "proAngular"]);

        return this.http.request(new Request({
            method: verb,
            url: url,
            body: body,
            headers: headers
        })).delay(5000)
           .map(response => response.json())
           .catch((error: Response) => Observable.throw(
               `Network Error: ${error.statusText} (${error.status})`));

    }
}
```

The delay is added using the Reactive Extensions delay method and is applied to create a five-second delay, which is long enough to create a noticeable pause without being too painful to wait for every time the application is reloaded. To change the delay, increase or decrease the argument for the delay method, which is expressed in milliseconds.

The effect of the delay is that the user is presented with an incomplete and confusing layout while the application is waiting for the data to load, as shown in Figure 27-2.

■ **Note** The delay is applied to all HTTP requests, which means that if you create, edit, or delete a product, the change you have made will not be reflected in the product table for five seconds.



There are 0 products

ID	Name	Category	Price

Figure 27-2. *Waiting for data*

Creating a Resolver Service

A *resolver* is used to ensure that a task is performed before a route can be activated. To create a resolver, I added a file called `model.resolver.ts` in the `exampleApp/app/model` folder and defined the class shown in Listing 27-3.

Listing 27-3. The Contents of the model.resolver.ts File in the exampleApp/app/model Folder

```
import { Injectable } from "@angular/core";
import { ActivatedRouteSnapshot, RouterStateSnapshot } from "@angular/router";
import { Observable } from "rxjs/Observable";
import { Model } from "./repository.model"
import { RestDataSource } from "./rest.datasource";
import { Product } from "./product.model";

@Injectable()
export class ModelResolver {

    constructor(
        private model: Model,
        private dataSource: RestDataSource) { }

    resolve(route: ActivatedRouteSnapshot,
            state: RouterStateSnapshot): Observable<Product[]> {

        return this.model.getProducts().length == 0
            ? this.dataSource.getData() : null;
    }
}
```

Resolvers are classes that define a `resolve` method that accepts two arguments. The first argument is an `ActivatedRouteSnapshot` object, which describes the route that is being navigated to using the properties described in Chapter 25. The second argument is a `RouterStateSnapshot` object, which describes the current route through a single property called `url`. These arguments can be used to adapt the resolver to the navigation that is about to be performed, although neither is required by the resolver in the listing, which uses the same behavior regardless of the routes that are being navigated to and from.

■ **Note** All of the guards described in this chapter can implement interfaces defined in the `@angular/router` module. For example, resolvers can implement an interface called `Resolve`. These interfaces are optional, and I have not used them in this chapter.

The `resolve` method can return three different types of result, as described in Table 27-3.

Table 27-3. *The Result Types Allowed by the resolve Method*

Result Type	Description
`Observable<any>`	The browser will activate the new route when the `Observer` emits an event.
`Promise<any>`	The browser will activate the new route when the `Promise` resolves.
Any other result	The browser will activate the new route as soon as the method produces a result.

The `Observable` and `Promise` results are useful when dealing with asynchronous operations, such as requesting data using an HTTP request. Angular waits until the asynchronous operation is complete before activating the new route. Any other result is interpreted as the result from a synchronous operation, and Angular will activate the new route immediately.

The resolver in Listing 27-3 uses its constructor to receive `Model` and `RestDataSource` objects via dependency injection. When the `resolve` method is called, it checks the number of objects in the data model to determine whether the HTTP request to the RESTful web service has completed. If there are no objects in the data model, the `resolve` method returns the `Observable` from the `RestDataSource.getData` method, which will emit an event when the HTTP request completes. Angular will subscribe to the `Observable` and delay activating the new route until it emits an event. The `resolve` method returns `null` if there are objects in the model and, since this is neither an `Observable` nor a `Promise`, Angular will activate the new route immediately.

■ **Tip** Combining asynchronous and synchronous results means that the resolver will delay navigation only until the HTTP request completed and the data model has been populated. This is important because the resolve method will be called every time that the application tries to navigate to a route to which the resolver has been applied.

Registering the Resolver Service

The next step is to register the resolver as a service in its feature module, as shown in Listing 27-4.

Listing 27-4. Registering the Resolver as a Service in the model.module.ts File

```
import { NgModule } from "@angular/core";
import { HttpModule, JsonpModule } from "@angular/http"
import { Model } from "./repository.model";
import { RestDataSource, REST_URL } from "./rest.datasource";
import { ModelResolver } from "./model.resolver";

@NgModule({
    imports: [HttpModule, JsonpModule],
    providers: [Model, RestDataSource, ModelResolver,
        { provide: REST_URL, useValue: "http://localhost:3500/products" }]

})
export class ModelModule { }
```

Applying the Resolver

The resolver is applied to routes using the `resolve` property, as shown in Listing 27-5.

Listing 27-5. Applying a Resolver in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";

const childRoutes: Routes = [
    {   path: "",
        children: [{ path: "products", component: ProductCountComponent },
                   { path: "categories", component: CategoryCountComponent },
                   { path: "", component: ProductCountComponent }],
        resolve: { model: ModelResolver }
    }
];

const routes: Routes = [
    { path: "form/:mode/:id", component: FormComponent },
    { path: "form/:mode", component: FormComponent },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

The `resolve` property accepts a map object whose property values are the resolver classes that will be applied to the route. (The property names do not matter.) I want to apply the resolver to all the views that display the product table, and so to avoid duplication, I created a componentless route with the `resolve` property and used it as the parent for the existing child routes.

Displaying Placeholder Content

Angular uses the resolver before activating any of the routes to which it has been applied, which prevents the user from seeing the product table until the model has been populated with the data from the RESTful web service. Sadly, that just means the user sees an empty window while the browser is waiting for the server to respond. To address this, Listing 27-6 enhances the resolver to use the message service to tell the user what is happening when the data is being loaded.

Listing 27-6. Displaying a Message in the model.resolver.ts File

```
import { Injectable } from "@angular/core";
import { ActivatedRouteSnapshot, RouterStateSnapshot } from "@angular/router";
import { Observable } from "rxjs/Observable";
import { Model } from "./repository.model"
import { RestDataSource } from "./rest.datasource";
import { Product } from "./product.model";
import { MessageService } from "../messages/message.service";
import { Message } from "../messages/message.model";

@Injectable()
export class ModelResolver {

    constructor(
        private model: Model,
        private dataSource: RestDataSource,
        private messages: MessageService) { }

    resolve(route: ActivatedRouteSnapshot,
        state: RouterStateSnapshot): Observable<Product[]> {

        if (this.model.getProducts().length == 0) {
            this.messages.reportMessage(new Message("Loading data..."));
            return this.dataSource.getData();
        }
    }
}
```

The component that displays the messages from the service clears its contents when it receives the `NavigationEnd` event, which means that the placeholder will be removed when the data has been loaded, as shown in Figure 27-3.

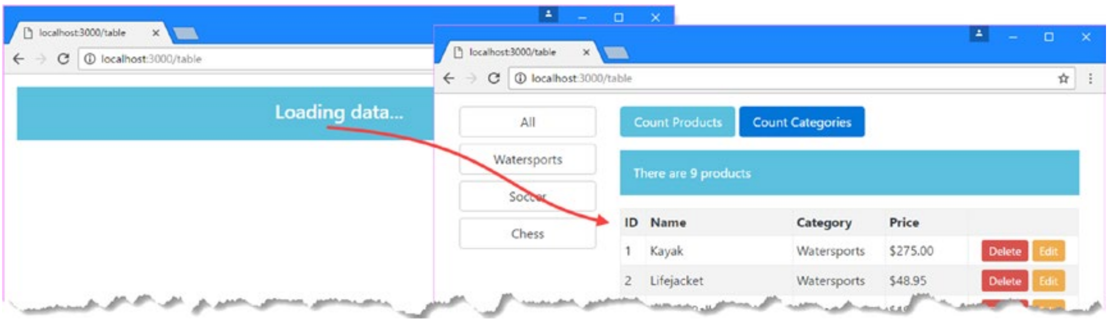


Figure 27-3. *Using a resolver to ensure data is loaded*

Using a Resolver to Prevent URL Entry Problems

As I explained in Chapter 25, the development HTTP server will return the contents of the `index.html` file when it receives a request for a URL for which there is no corresponding file. Combined with the automatic browser reload functionality, it is easy to make a change in the project and have the browser reload a URL that causes the application to jump to a specific URL without going through the navigation steps that the application expects and that sets up the required state data.

To see an example of the problem, click one of the Edit buttons in the product table and then reload the browser page. The browser will request a URL like `http://localhost:3000/form/edit/1`, but this doesn't have the expected effect because the component for the activated route attempts to retrieve an object from the model before the HTTP response from the RESTful server has been received. As a consequence, the form is just empty, as shown in Figure 27-4.

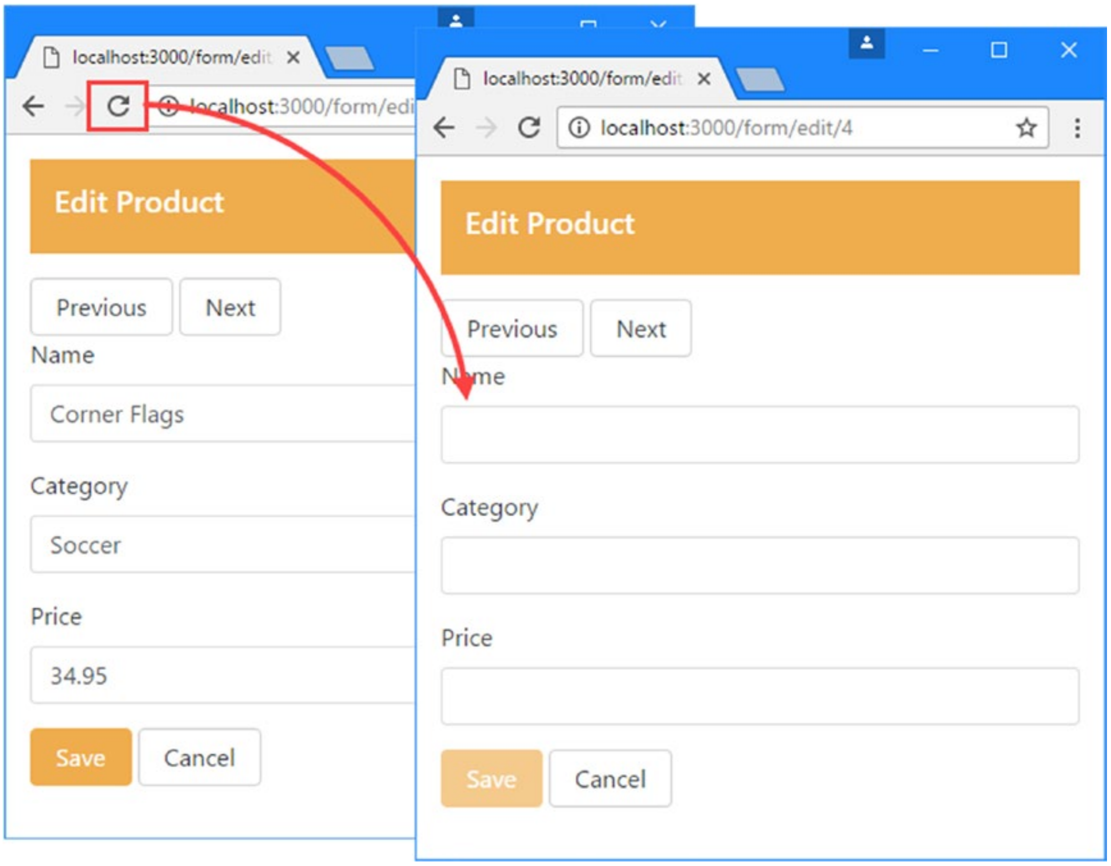


Figure 27-4. *The effect of reloading an arbitrary URL*

To avoid this problem, the resolver can be applied more broadly so that it protects other routes, as shown in Listing 27-7.

Listing 27-7. Applying the Resolver to Other Routes in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";
```

```
const childRoutes: Routes = [
    {
        path: "",
        children: [{ path: "products", component: ProductCountComponent },
                   { path: "categories", component: CategoryCountComponent },
                   { path: "", component: ProductCountComponent }],
        resolve: { model: ModelResolver }
    }
];

const routes: Routes = [
    {
        path: "form/:mode/:id", component: FormComponent,
        resolve: { model: ModelResolver }
    },
    {
        path: "form/:mode", component: FormComponent,
        resolve: { model: ModelResolver }
    },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

Applying the `ModelResolver` class to the routes that target `FormComponent` prevents the problem shown in Figure 27-4. There are other ways to solve this problem, including the approach that I used in Chapter 8 for the SportsStore application, which uses the route guard feature described in the “Preventing Route Activation” section of this chapter.

Preventing Navigation with Guards

Resolvers are used to delay navigation while the application performs some prerequisite work, such as loading data. The other guards that Angular provides are used to control whether navigation can occur at all, which can be useful when you want to alert the user to prevent potentially unwanted operations (such as abandoning data edits) or limit access to parts of the application unless the application is in a specific state (such as when a user has been authenticated).

Many uses for route guards introduce an additional interaction with the user, either to gain explicit approval to perform an operation or to obtain additional data, such as authentication credentials. For this chapter, I am going to handle this kind of interaction by extending the message service so that messages can require user input. In Listing 27-8, I have added an optional `responses` constructor argument/property to the `Message` model class, which will allow messages to contain prompts to the user and callbacks that will be invoked when they are selected. The `responses` property is an array of TypeScript tuples, where the first value is the name of the response, which will be presented to the user, and the second value is the callback function, which will be passed the name as its argument.

Listing 27-8. Adding Responses in the message.model.ts File

```
export class Message {

    constructor(private text: string,
        private error: boolean = false,
        private responses?: [[string, (string) => void]]) { }
}
```

The only other change required to implement this feature is to present the response options to the user. Listing 27-9 adds `button` elements below the message text for each `response`. Clicking the buttons will invoke the callback function.

Listing 27-9. Presenting Responses in the message.component.html File

```
<div *ngIf="lastMessage"
     class="bg-info p-a-1 text-xs-center"
     [class.bg-danger]="lastMessage.error">
        <h4>{{lastMessage.text}}</h4>
</div>
<div class="text-xs-center m-b-1">
    <button *ngFor="let resp of lastMessage?.responses; let i = index"
            (click)="resp[1](resp[0])"
            class="btn btn-primary m-a-1" [class.btn-secondary]="i > 0">
        {{resp[0]}}
    </button>
</div>
```

Preventing Route Activation

Guards can be used to prevent a route from being activated, helping to protect the application from entering an unwanted state or warning the user about the impact of performing an operation. To demonstrate, I am going to guard the `/form/create` URL to prevent the user from starting the process of creating a new product unless the user agrees to the application's terms and conditions.

Guards for route activation are classes that define a method called `canActivate`, which receives the same `ActivatedRouteSnapshot` and `RouterStateSnapshot` arguments as resolvers. The `canActivate` method can be implemented to return three different result types, as described in Table 27-4.

Table 27-4. *The Result Types Allowed by the canActivate Method*

Result Type	Description
`boolean`	This type of result is useful when performing synchronous checks to see whether the route can be activated. A `true` result will activate the route, and a result of `false` will not, effectively ignoring the navigation request.
`Observable<boolean>`	This type of result is useful when performing asynchronous checks to see whether the route can be activated. Angular will wait until the `Observable` emits a value, which will be used to determine whether the route is activated. When using this kind of result, it is important to terminate the `Observable` by calling the `complete` method; otherwise, Angular will just keep waiting.
`Promise<boolean>`	This type of result is useful when performing asynchronous checks to see whether the route can be activated. Angular will wait until the `Promise` is resolved and activate the route if it yields `true`. If the `Promise` yields `false`, then the route will not be activated, effectively ignoring the navigation request.

To get started, I added a file called `terms.guard.ts` to the `exampleApp/app` folder and defined the class shown in Listing 27-10.

Listing 27-10. The Contents of the terms.guard.ts File in the exampleApp/app Folder

```
import { Injectable } from "@angular/core";
import {
    ActivatedRouteSnapshot, RouterStateSnapshot,
    Router
} from "@angular/router";
import { MessageService } from "./messages/message.service";
import { Message } from "./messages/message.model";

@Injectable()
export class TermsGuard {

    constructor(private messages: MessageService,
                private router: Router) { }

    canActivate(route: ActivatedRouteSnapshot, state: RouterStateSnapshot):
        Promise<boolean> | boolean {

        if (route.params["mode"] == "create") {

            return new Promise<boolean>((resolve, reject) => {
                let responses: [[string, (string) => void]] = [
                    ["Yes", () => { resolve(true) }],
                    ["No", () => {
                        this.router.navigateByUrl(this.router.url);
                        resolve(false);
                    }]
                ];
                this.messages.reportMessage(
                    new Message("Do you accept the terms & conditions?",
                        false, responses));
            });
        } else {
            return true;
        }
    }
}
```

The canActivate method can return two different types of result. The first type is a boolean, which allows the guard to respond immediately for routes that it doesn't need to protect, which in this case is any that lacks a parameter called mode whose value is create. If the URL matched by the route doesn't contain this parameter, the canActivate method returns true, which tells Angular to activate the route. This is important because the edit and create features both rely on the same routes, and the guard should not interfere with edit operations.

The other type of result is a Promise<boolean>, which I have used instead of Observable<true> for variety. The Promise uses the modifications to the message service to solicit a response from the user, confirming they accept the (unspecified) terms and conditions. There are two possible responses from the user. If the user clicks the Yes button, then the Promise will resolve and yield true, which tells Angular to activate the route, displaying the form that is used to create a new product. The Promise will resolve and yield false if the user clicks the No button, which tells Angular to ignore the navigation request.

UNDERSTANDING THE ROUTE ACTIVATION WORKAROUND

There is one statement in Listing 27-10 that requires additional attention. It is this statement, which is highlighted in the block of code invoked when the user selects the No response:

```
...
["No", () => {
    this.router.navigateByUrl(this.router.url);
    resolve(false);
}]
...
```

When the activation of a route is cancelled, Angular doesn't allow the route to be activated again. This is a behavior change that appeared in a recent release, made at the time of writing. It means that once the user has selected No, clicking the Create New Product button again has no effect. To work around this, the highlighted statement navigates to the current URL, which has no effect other than ensuring that the route activation that was previously canceled can be attempted again. This behavior may have changed again by the time you read this chapter, in which case you may not require this statement in your own projects.

Listing 27-11 registers the TermsGuard as a service so that it can be used in the application's routing configuration.

Listing 27-11. Registering the Guard as a Service in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ModelModule } from "./model/model.module";
import { CoreModule } from "./core/core.module";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { MessageModule } from "./messages/message.module";
import { MessageComponent } from "./messages/message.component";
import { routing } from "./app.routing";
import { AppComponent } from "./app.component";
import { TermsGuard } from "./terms.guard"

@NgModule({
    imports: [BrowserModule, CoreModule, MessageModule, routing],
    declarations: [AppComponent],
    providers: [TermsGuard],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

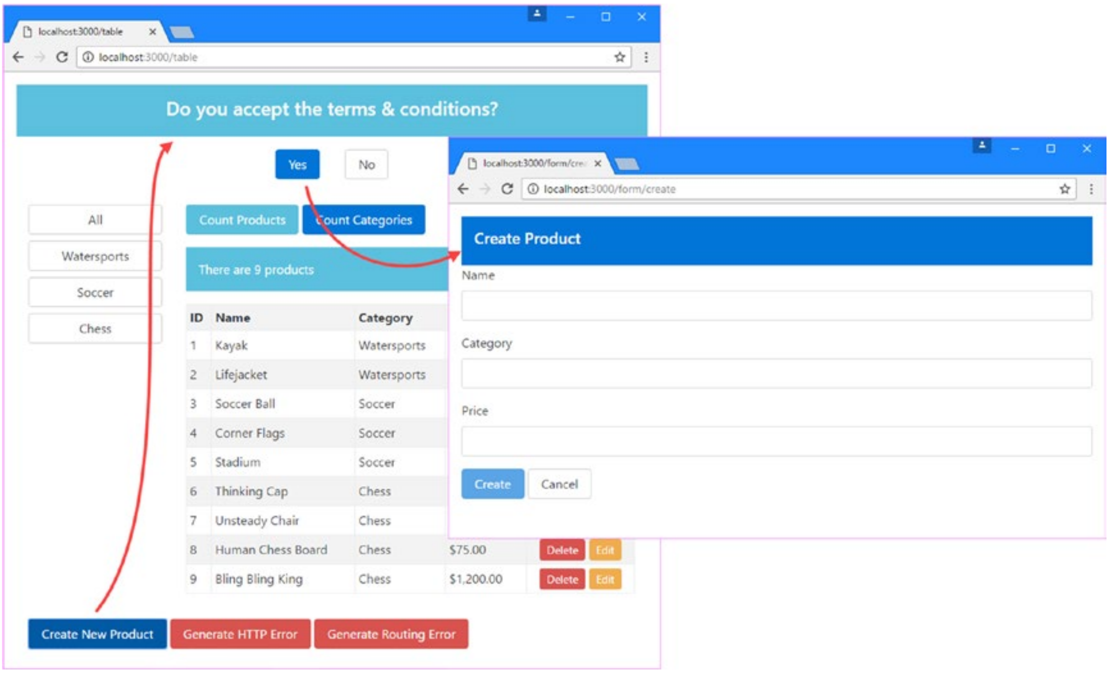
Finally, Listing 27-12 applies the guard to the routing configuration. Activation guards are applied to a route using the canActivate property, which is assigned an array of guard services. The canActivate method of all the guards must return true (or return an Observable or Promise that eventually yields true) before Angular will activate the route.

Listing 27-12. Applying the Guard to a Route in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";
import { TermsGuard } from "./terms.guard";

const childRoutes: Routes = [
    {
        path: "",
        children: [{ path: "products", component: ProductCountComponent },
                   { path: "categories", component: CategoryCountComponent },
                   { path: "", component: ProductCountComponent }],
        resolve: { model: ModelResolver }
    }
];
```

```
const routes: Routes = [
    {
        path: "form/:mode/:id", component: FormComponent,
        resolve: { model: ModelResolver }
    },
    {
        path: "form/:mode", component: FormComponent,
        resolve: { model: ModelResolver },
        canActivate: [TermsGuard]
    },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

The effect of creating and applying the activation guard is that the user is prompted when clicking the Create New Product button, as shown in Figure 27-5. If they respond by clicking the Yes button, then the navigation request will be completed, and Angular will activate the route that selects the form component, which will allow a new product to be created. If the user clicks the No button, then the navigation request will be canceled. In both cases, the routing system emits an event that is received by the component that displays the messages to the user, which clears its display and ensures that the user doesn't see stale messages.



ID	Name	Category			
1	Kayak	Watersports			
2	Lifejacket	Watersports			
3	Soccer Ball	Soccer			
4	Corner Flags	Soccer			
5	Stadium	Soccer			
6	Thinking Cap	Chess			
7	Unsteady Chair	Chess			
8	Human Chess Board	Chess	$75.00	Delete	Edit
9	Bling Bling King	Chess	$1,200.00	Delete	Edit

Figure 27-5. *Guarding route activation*

Consolidating Child Route Guards

If you have a set of child routes, you can guard against their activation using a child route guard, which is a class that defines a method called canActivateChild. The guard is applied to the parent route in the application's configuration, and the canActivateChild method is called whenever any of the child routes are about to be activated. The method receives the same ActivatedRouteSnapshot and RouterStateSnapshot objects as the other guards and can return the set of result types described in Table 27-4.

This guard in this example is more readily dealt with by changing the configuration before implementing the canActivateChild method, as shown in Listing 27-13.

Listing 27-13. Guarding Child Routes in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";
import { TermsGuard } from "./terms.guard";

const childRoutes: Routes = [
    {
        path: "",
        canActivateChild: [TermsGuard],
        children: [{ path: "products", component: ProductCountComponent },
                   { path: "categories", component: CategoryCountComponent },
                   { path: "", component: ProductCountComponent }],
        resolve: { model: ModelResolver }
    }
];

const routes: Routes = [
    {
        path: "form/:mode/:id", component: FormComponent,
        resolve: { model: ModelResolver }
    },
    {
        path: "form/:mode", component: FormComponent,
        resolve: { model: ModelResolver },
        canActivate: [TermsGuard]
    },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

Child route guards are applied to a route using the canActivateChild property, which is set to an array of service types that implement the canActivateChild method. This method will be called before Angular activates any of the route's children. Listing 27-14 adds the canActivateChild method to the guard class from the previous section.

Listing 27-14. Implementing Child Route Guards in the terms.guard.ts File

```
import { Injectable } from "@angular/core";
import {
    ActivatedRouteSnapshot, RouterStateSnapshot,
    Router
} from "@angular/router";
import { MessageService } from "./messages/message.service";
import { Message } from "./messages/message.model";

@Injectable()
export class TermsGuard {

    constructor(private messages: MessageService,
                private router: Router) { }

    canActivate(route: ActivatedRouteSnapshot, state: RouterStateSnapshot):
        Promise<boolean> | boolean {

        if (route.params["mode"] == "create") {

            return new Promise<boolean>((resolve, reject) => {
                let responses: [[string, (string) => void]] = [
                    ["Yes", () => { resolve(true) }],
                    ["No", () => {
                        this.router.navigateByUrl(this.router.url);
                        resolve(false);
                    }]
                ];
                this.messages.reportMessage(
                    new Message("Do you accept the terms & conditions?",
                        false, responses));
            });
        } else {
            return true;
        }
    }
    canActivateChild(route: ActivatedRouteSnapshot, state: RouterStateSnapshot):
        Promise<boolean> | boolean {

        if (route.url.length > 0
            && route.url[route.url.length - 1].path == "categories") {

            return new Promise<boolean>((resolve, reject) => {
                let responses: [[string, (string) => void]] = [
                    ["Yes", () => { resolve(true) }],
                    ["No ", () => {
                        this.router.navigateByUrl(state.url.replace("categories",
                            "products"));
                        resolve(false);
                    }]
                ];

                this.messages.reportMessage(
                    new Message("Do you want to see the categories component?",
                        false, responses));
            });
        } else {
            return true;
        }
    }
}
```

The guard only protects the `categories` child route and will return `true` immediately for any other route. The guard prompts the user using the message service but does something different if the user clicks the No button. In addition to rejecting the active route, the guard navigates to a different URL using the `Router` service, which is received as a constructor argument. This is a common pattern for authentication, when the user is redirected to a component that will solicit security credentials if a restricted operation is attempted. The example is simpler in this case, and the guard navigates to a sibling route that shows a different component. (You can see an example of using route guards for navigation in the SportsStore application in Chapter 9.)

To see the effect of the guard, click the Count Categories button, as shown in Figure 27-6. Responding to the prompt by clicking the Yes button will show the `CategoryCountComponent`, which displays the number of categories in the table. Clicking No will reject the active route and navigate to a route that displays the `ProductCountComponent` instead.

■ **Note** Guards are applied only when the active route changes. So, for example, if you click the Count Categories button when the `/table` URL is active, then you will see the prompt, and clicking Yes will change the activate route. But nothing will happen if you click the Count Categories button again because Angular doesn't trigger a route change when the target route and the active route are the same.

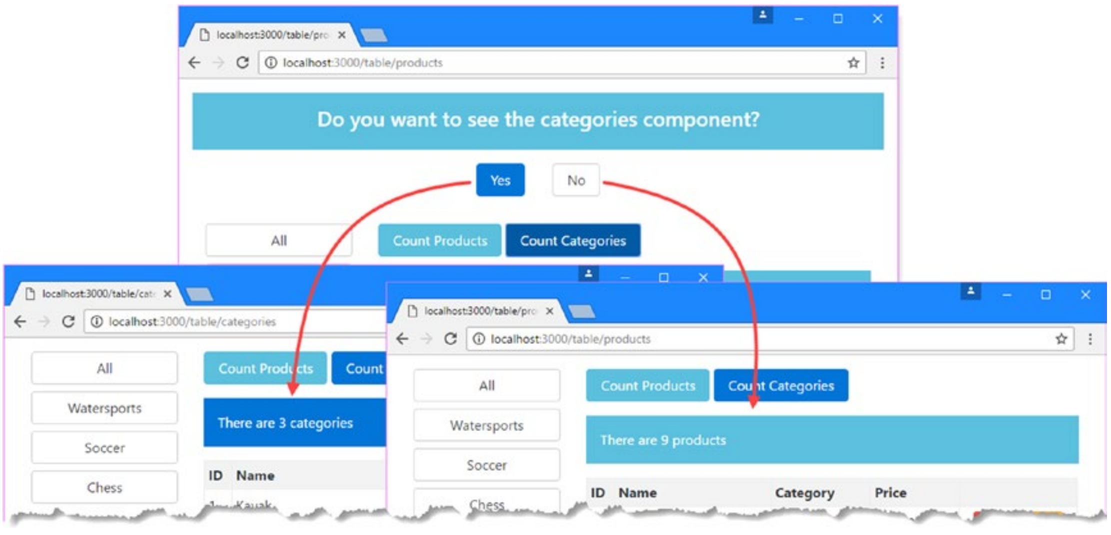


Figure 27-6. *Guarding child routes*

Preventing Route Deactivation

When you start working with routes, you will tend to focus on the way that routes are activated to respond to navigation and present new content to the user. But equally important is route *deactivation*, which occurs when the application navigates away from a route.

The most common use for deactivation guards is to prevent the user from navigating when there are unsaved edits to data. In this section, I will create a guard that warns the user when they are about to abandon unsaved changes when editing a product. In preparation for this, Listing 27-15 changes the FormComponent class to simplify the work of the guard.

Listing 27-15. Preparing for the Guard in the form.component.ts File

```
import { Component, Inject } from "@angular/core";
import { NgForm } from "@angular/forms";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute, Router } from "@angular/router";

@Component({
    selector: "paForm",
    moduleId: module.id,
    templateUrl: "form.component.html",
    styleUrls: ["form.component.css"]
})
export class FormComponent {
    product: Product = new Product();
    originalProduct = new Product();

    constructor(private model: Model, activeRoute: ActivatedRoute,
        private router: Router) {
```

```
        activeRoute.params.subscribe(params => {
            this.editing = params["mode"] == "edit";
            let id = params["id"];
            if (id != null) {
                Object.assign(this.product, model.getProduct(id) || new Product());
                Object.assign(this.originalProduct, this.product);
            }
        })
    }

    editing: boolean = false;

    submitForm(form: NgForm) {
        if (form.valid) {
            this.model.saveProduct(this.product);
            this.originalProduct = this.product;
            this.router.navigateByUrl("/");
        }
    }

    //resetForm() {
    //    this.product = new Product();
    //}
}
```

When the component begins editing, it creates a copy of the Product object that it gets from the data model and assigns it to the originalProduct property. This property will be used by the deactivation guard to see whether there are unsaved edits. To prevent the guard interrupting save operations, the originalProduct property is set to the editing product object in the submitForm method before the navigation request.

A corresponding change is required in the template so that the Cancel button doesn't invoke the form's reset event handler, as shown in Listing 27-16.

Listing 27-16. Disabling Form Reset in the form.component.html File

```
<div class="bg-primary p-a-1" [class.bg-warning]="editing">
    <h5>{{editing  ? "Edit" : "Create"}} Product</h5>
</div>
<div *ngIf="editing" class="p-t-1">
    <button class="btn btn-secondary"
        [routerLink]="['/form', 'edit', model.getPreviousProductid(product.id)]">
            Previous
    </button>
    <button class="btn btn-secondary"
        [routerLink]="['/form', 'edit', model.getNextProductId(product.id)]">
            Next
    </button>
</div>
<!--<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)" (reset)="resetForm()" >-->
<form novalidate #form="ngForm" (ngSubmit)="submitForm(form)" >
    <div class="form-group">
        <label>Name</label>
        <input class="form-control" name="name"
               [(ngModel)]="product.name" required />
    </div>

    <div class="form-group">
        <label>Category</label>
        <input class="form-control" name="category"
               [(ngModel)]="product.category" required />
    </div>

    <div class="form-group">
        <label>Price</label>
        <input class="form-control" name="price"
               [(ngModel)]="product.price"
               required pattern="^[0-9\.]+$" />
    </div>

    <button type="submit" class="btn btn-primary"
            [class.btn-warning]="editing" [disabled]="form.invalid">
        {{editing ? "Save" : "Create"}}
    </button>
    <button type="button" class="btn btn-secondary" routerLink="/">Cancel</button>
</form>
```

To create the guard, I added a file called unsaved.guard.ts in the exampleApp/core/app folder and defined the class shown in Listing 27-17.

Listing 27-17. The Contents of the unsaved.guard.ts File in the exampleApp/app/core Folder

```
import { Injectable } from "@angular/core";
import {
    ActivatedRouteSnapshot, RouterStateSnapshot,
    Router
} from "@angular/router";
import { Observable } from "rxjs/Observable";
import { Subject } from "rxjs/Subject";
import { MessageService } from "../messages/message.service";
import { Message } from "../messages/message.model";
import { FormComponent } from "./form.component";

@Injectable()
export class UnsavedGuard {

    constructor(private messages: MessageService,
                private router: Router) { }

    canDeactivate(component: FormComponent, route: ActivatedRouteSnapshot,
        state: RouterStateSnapshot): Observable<boolean> | boolean {

        if (component.editing) {
            if (["name", "category", "price"]
                .some(prop => component.product[prop]
                    != component.originalProduct[prop])) {
                let subject = new Subject<boolean>();

                let responses: [[string, (string) => void]] = [
                    ["Yes", () => {
                        subject.next(true);
                        subject.complete();
                    }],
                    ["No", () => {
                        this.router.navigateByUrl(this.router.url);
                        subject.next(false);
                        subject.complete();
                    }]
                ];
                this.messages.reportMessage(new Message("Discard Changes?",
                    true, responses));
                return subject;
            }
        }
        return true;
    }
}
```

Deactivation guards define a class called `canDeactivate` that receives three arguments: the component that is about to be deactivated and the `ActivatedRouteSnapshot` and `RouteStateSnapshot` objects. This guard checks to see whether there are unsaved edits in the component and prompts the user if there are. For variety, this guard uses an `Observable<true>`, implemented as a `Subject<true>`, instead of a `Promise<true>` to tell Angular whether it should activate the route, based on the response selected by the user.

■ **Tip** Notice that I call the `complete` method on the `Subject` after calling the `next` method. Angular will wait indefinitely for the `complete` method is called, effectively freezing the application.

The next step is to register the guard as a service in the module that contains it, as shown in Listing 27-18.

Listing 27-18. Registering the Guard as a Service in the core.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { FormsModule } from "@angular/forms";
import { ModelModule } from "../model/model.module";
import { TableComponent } from "./table.component";
import { FormComponent } from "./form.component";
import { Subject } from "rxjs/Subject";
import { StatePipe } from "./state.pipe";
import { MessageModule } from "../messages/message.module";
import { MessageService } from "../messages/message.service";
import { Message } from "../messages/message.model";
import { Model } from "../model/repository.model";
import { RouterModule } from "@angular/router";
import { ProductCountComponent } from "./productCount.component";
import { CategoryCountComponent } from "./categoryCount.component";
import { NotFoundComponent } from "./notFound.component";
import { UnsavedGuard } from "./unsaved.guard";

@NgModule({
    imports: [BrowserModule, FormsModule, ModelModule, MessageModule, RouterModule],
    declarations: [TableComponent, FormComponent, StatePipe,
        ProductCountComponent, CategoryCountComponent, NotFoundComponent],
    providers: [UnsavedGuard],
    exports: [ModelModule, TableComponent, FormComponent]
})
export class CoreModule { }
```

Finally, Listing 27-19 applies the guard to the application's routing configuration. Deactivation guards are applied to routes using the canDeactivate property, which is set to an array of guard services.

Listing 27-19. Applying the Guard in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";
import { TermsGuard } from "./terms.guard";
import { UnsavedGuard } from "./core/unsaved.guard";

const childRoutes: Routes = [
    {
        path: "",
        canActivateChild: [TermsGuard],
        children: [{ path: "products", component: ProductCountComponent },
                   { path: "categories", component: CategoryCountComponent },
                   { path: "", component: ProductCountComponent }],
        resolve: { model: ModelResolver }
    }
];

const routes: Routes = [
    {
        path: "form/:mode/:id", component: FormComponent,
        resolve: { model: ModelResolver },
        canDeactivate: [UnsavedGuard]
    },
    {
        path: "form/:mode", component: FormComponent,
        resolve: { model: ModelResolver },
        canActivate: [TermsGuard]
    },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

To see the effect of the guard, click one of the Edit buttons in the table; edit the data in one of the text fields; and then click the Cancel, Next, or Previous button. The guard will prompt you before allowing Angular to activate the route you selected, as shown in Figure 27-7.

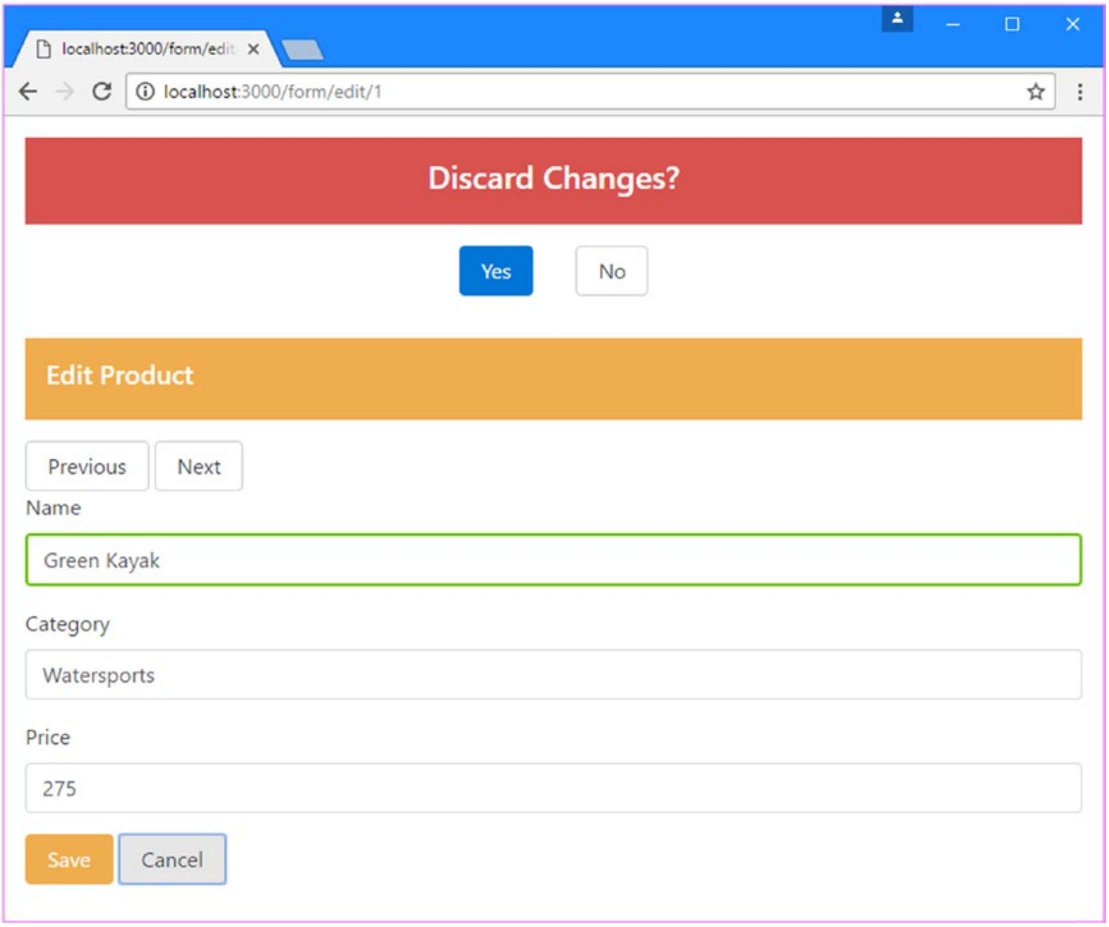


Figure 27-7. *Guarding route deactivation*

Loading Feature Modules Dynamically

Angular supports loading feature modules only when they are required, known as *dynamic loading* or *lazy loading*. This can be useful for functionality that is unlikely to be required by all users. In the sections that follow, I create a simple feature module and demonstrate how to configure the application so that Angular will load the module only when the application navigates to a specific URL.

■ **Note** Loading modules dynamically is a trade-off. The application will be smaller and faster to download for most users, improving their overall experience. But users who require the dynamically loaded features will have wait while Angular gets the module and its dependencies. The effect can be jarring because the user has no idea that some features have been loaded and others have not. When you create dynamically loaded modules, you are balancing improving the experience for some users against making it worse for others. Consider about how your users fall into these groups, and be careful not to degrade the experience of your most valuable and important customers.

Creating a Simple Feature Module

Dynamically loaded modules must contain only functionality that not all users will require. I can't use the existing modules because they provide the core functionality for the application, which means that I need a new module for this part of the chapter. I started by creating a folder called `ondemand` in the `exampleApp/app` folder. To give the new module a component, I added a file called `first.component.ts` in the `example/app/ondemand` folder and added the code shown in Listing 27-20.

■ **Caution** It is important not to create dependencies between other parts of the application and the classes in the dynamically loaded module so that the JavaScript module loader doesn't try to load the module before it is required.

Listing 27-20. The Contents of the ondemand.component.ts File in the exampleApp/app/ondemand Folder

```
import { Component } from "@angular/core";

@Component({
    selector: "ondemand",
    moduleId: module.id,
    templateUrl: "ondemand.component.html"
})
export class OndemandComponent { }
```

To provide the component with a template, I added a file called `ondemand.component.html` and added the markup shown in Listing 27-21.

Listing 27-21. The ondemand.component.html File in the exampleApp/app/ondemand Folder

```
<div class="bg-primary p-a-1">This is the ondemand component</div>
<button class="btn btn-primary m-t-1" routerLink="/" >Back</button>
```

The template contains a message that will make it obvious when the component is selected and that contains a `button` element that will navigate back to the application's root URL when clicked.

To define the module, I added a file called `ondemand.module.ts` and added the code shown in Listing 27-22.

Listing 27-22. The Contents of the ondemand.module.ts File in the exampleApp/app/ondemand Folder

```
import { NgModule } from "@angular/core";
import { CommonModule } from "@angular/common";
import { OndemandComponent } from "./ondemand.component";

@NgModule({
    imports: [CommonModule],
    declarations: [OndemandComponent],
    exports: [OndemandComponent]
})
export class OndemandModule { }
```

The module imports the `CommonModule` functionality, which is used instead of the browser-specific `BrowserModule` to access the built-in directives in feature modules that are loaded on-demand.

Loading the Module Dynamically

There are two steps to setting up dynamic loading a module. The first is to set up a routing configuration inside the feature module to provide the rules that will allow Angular to select a component when the module is loaded. Listing 27-23 adds a single route to the feature module.

Listing 27-23. Defining a Routing Configuration in the ondemand.module.ts File

```
import { NgModule } from "@angular/core";
import { CommonModule } from "@angular/common";
import { OndemandComponent } from "./ondemand.component";
import { RouterModule } from "@angular/router";

let routing = RouterModule.forChild([
    { path: "", component: OndemandComponent }
]);

@NgModule({
    imports: [CommonModule, routing],
    declarations: [OndemandComponent],
    exports: [OndemandComponent]
})
export class OndemandModule { }
```

Routes in dynamically loaded modules are defined using the same properties as in the main part of the application and can use all the same features, including child components, guards, and redirections. The route defined in the listing matches the empty path and selects the `OndemandComponent` for display.

One important different is the method used to generate the module that contains the routing information, as follows:

```
...
let routing = RouterModule.forChild([
    { path: "", component: OndemandComponent }
]);
...
```

When I created the application-wide routing configuration, I used the `RouterModule.forRoot` method. This is the method that is used to set up the routes in the root module of the application. When creating dynamically loaded modules, the `RouterModule.forChild` method must be used; this method creates a routing configuration that is merged into the overall routing system when the module is loaded.

Creating a Route to Dynamically Load a Module

The second step to set up a dynamically loaded module is to create a route in the main part of the application that provides Angular with the module's location, as shown in Listing 27-24.

Listing 27-24. Creating an On-Demand Route in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";
import { TermsGuard } from "./terms.guard";
import { UnsavedGuard } from "./core/unsaved.guard";

const childRoutes: Routes = [
    {
        path: "",
        canActivateChild: [TermsGuard],
        children: [{ path: "products", component: ProductCountComponent },
                   { path: "categories", component: CategoryCountComponent },
                   { path: "", component: ProductCountComponent }],
        resolve: { model: ModelResolver }
    }
];

const routes: Routes = [
    {
        path: "ondemand",
        loadChildren: "app/ondemand/ondemand.module#OndemandModule"
    },
    {
        path: "form/:mode/:id", component: FormComponent,
        resolve: { model: ModelResolver },
        canDeactivate: [UnsavedGuard]
    },
    {
        path: "form/:mode", component: FormComponent,
        resolve: { model: ModelResolver },
        canActivate: [TermsGuard]
    },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

The `loadChildren` property is used to provide Angular with details of how the module should be loaded. The value for the property is the path to the JavaScript file that contains the module (omitting the file extension), followed by a # character, followed by the name of the `module` class. The value in the listing tells Angular to load the `OndemandModule` class from the `app/ondemand/ondemand.module.js` file.

Using a Dynamically Loaded Module

All that remains is to add support for navigating to the URL that will activate the route for the on-demand module, as shown in Listing 27-25, which adds a button to the template for the table component.

Listing 27-25. Adding Navigation in the table.component.html File

```
<div class="col-xs-3">
    <button class="btn btn-secondary btn-block"
            routerLink="/" routerLinkActive="active"
            [routerLinkActiveOptions]="{exact: true}">
        All
    </button>
    <button *ngFor="let category of categories" class="btn btn-secondary btn-block"
            [routerLink]="['/table', category]" routerLinkActive="active">
        {{category}}
    </button>
</div>
<div class="col-xs-9">

    < !-- ...elements omitted for brevity... -->

</div>
<div class="col-xs-12 p-t-1">
    <button class="btn btn-primary" routerLink="/form/create">
        Create New Product
    </button>
    <button class="btn btn-danger" (click)="deleteProduct(-1)">
        Generate HTTP Error
    </button>
    <button class="btn btn-danger" routerLink="/does/not/exist">
        Generate Routing Error
    </button>
    <button class="btn btn-danger" routerLink="/ondemand">
        Load Module
    </button>
</div>
```

No special measures are required to target a route that loads a module, and the `Load Module` button in the listing uses the standard `routerLink` attribute to navigate to the URL specified by the route added in Listing 27-24.

To see how dynamic module loading works, use the browser's developer tools to see the list of files that are loaded as the application starts. You won't see HTTP requests for any of the files in the on-demand module until you click the `Load Module` button. When the button is clicked, Angular uses the routing configuration to load the module, inspect its routing configuration, and select the component that will be displayed to the user, as shown in Figure 27-8.

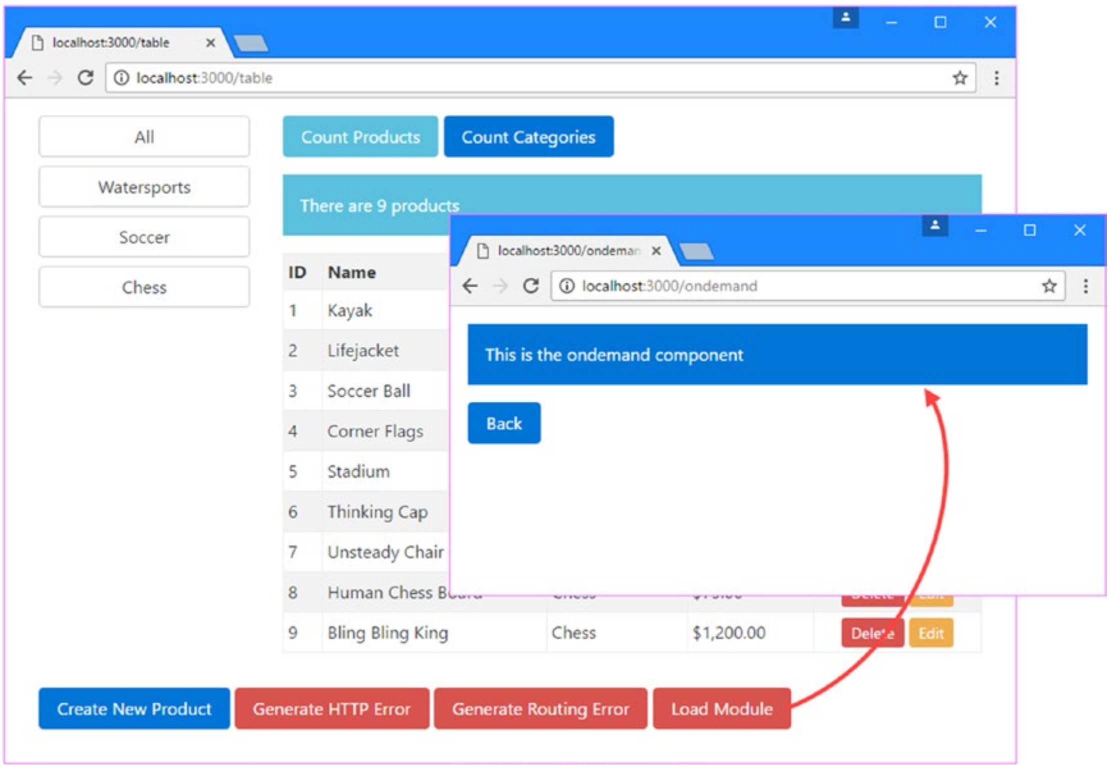


Figure 27-8. *Loading a module dynamically*

Guarding Dynamic Modules

You can guard against dynamically loading modules to ensure that they are loaded only when the application is in a specific state or when the user has explicitly agreed to wait while Angular does the loading (this latter option is typically used only for administration functions, where the user can be expected to have some understanding of how the application is structured).

The guard for the module must be defined in the main part of the application, so I added a file called `load.guard.ts` in the `exampleApp/app` folder and defined the class shown in Listing 27-26.

Listing 27-26. The Contents of the load.guard.ts File in the exampleApp/app Folder

```
import { Injectable } from "@angular/core";
import { Route, Router } from "@angular/router";
import { MessageService } from "./messages/message.service";
import { Message } from "./messages/message.model";
```

```
@Injectable()
export class LoadGuard {
    private loaded: boolean = false;

    constructor(private messages: MessageService,
                private router: Router) { }

    canLoad(route: Route): Promise<boolean> | boolean {

        return this.loaded || new Promise<boolean>((resolve, reject) => {
            let responses: [[string, (string) => void]] = [
                ["Yes", () => {
                    this.loaded = true;
                    resolve(true);
                }],
                ["No", () => {
                    this.router.navigateByUrl(this.router.url);
                    resolve(false);
                }]
            ];

            this.messages.reportMessage(
                new Message("Do you want to load the module?",
                    false, responses));
        });
    }
}
```

Dynamic loading guards are classes that implement a method called `canLoad`, which is invoked when Angular needs to activate the route it is applied to and which is provided with a `Route` object that describes the route.

The guard is required only when the URL that loads the module is first activated, so it defines a `loaded` property that is set to `true` when the module has been loaded so that subsequent requests are immediately approved. Otherwise, this guard follows the same pattern as earlier examples and returns a `Promise` that will be resolved when the user clicks one of the buttons displayed by the message service.

Listing 27-27 registers the guard as a service in the root module.

Listing 27-27. Registering the Guard as a Service in the app.module.ts File

```
import { NgModule } from "@angular/core";
import { BrowserModule } from "@angular/platform-browser";
import { ModelModule } from "./model/model.module";
import { CoreModule } from "./core/core.module";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { MessageModule } from "./messages/message.module";
import { MessageComponent } from "./messages/message.component";
import { routing } from "./app.routing";
import { AppComponent } from "./app.component";
import { TermsGuard } from "./terms.guard"
import { LoadGuard } from "./load.guard";
```

```
@NgModule({
    imports: [BrowserModule, CoreModule, MessageModule, routing],
    declarations: [AppComponent],
    providers: [TermsGuard, LoadGuard],
    bootstrap: [AppComponent]
})
export class AppModule { }
```

Applying a Dynamic Loading Guard

Guards for dynamic loading are applied to routes using the canLoad property, which accepts an array of guard types. Listing 27-28 applies the LoadGuard class, which was defined in Listing 27-26, to the route that dynamically loads the module.

Listing 27-28. Guarding the Route in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";
import { TermsGuard } from "./terms.guard";
import { UnsavedGuard } from "./core/unsaved.guard";
import { LoadGuard } from "./load.guard";

const childRoutes: Routes = [
    {
        path: "",
        canActivateChild: [TermsGuard],
        children: [{ path: "products", component: ProductCountComponent },
                   { path: "categories", component: CategoryCountComponent },
                   { path: "", component: ProductCountComponent }],
        resolve: { model: ModelResolver }
    }
];

const routes: Routes = [
    {
        path: "ondemand",
        loadChildren: "app/ondemand/ondemand.module#OndemandModule",
        canLoad: [LoadGuard]
    },
    {
        path: "form/:mode/:id", component: FormComponent,
        resolve: { model: ModelResolver },
        canDeactivate: [UnsavedGuard]
    },
    {
        path: "form/:mode", component: FormComponent,
        resolve: { model: ModelResolver },
        canActivate: [TermsGuard]
    },
    { path: "table", component: TableComponent, children: childRoutes },
    { path: "table/:category", component: TableComponent, children: childRoutes },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

The result is that the user is prompted to determine whether they want to load the module the first time that Angular tries to activate the route, as shown in Figure 27-9.

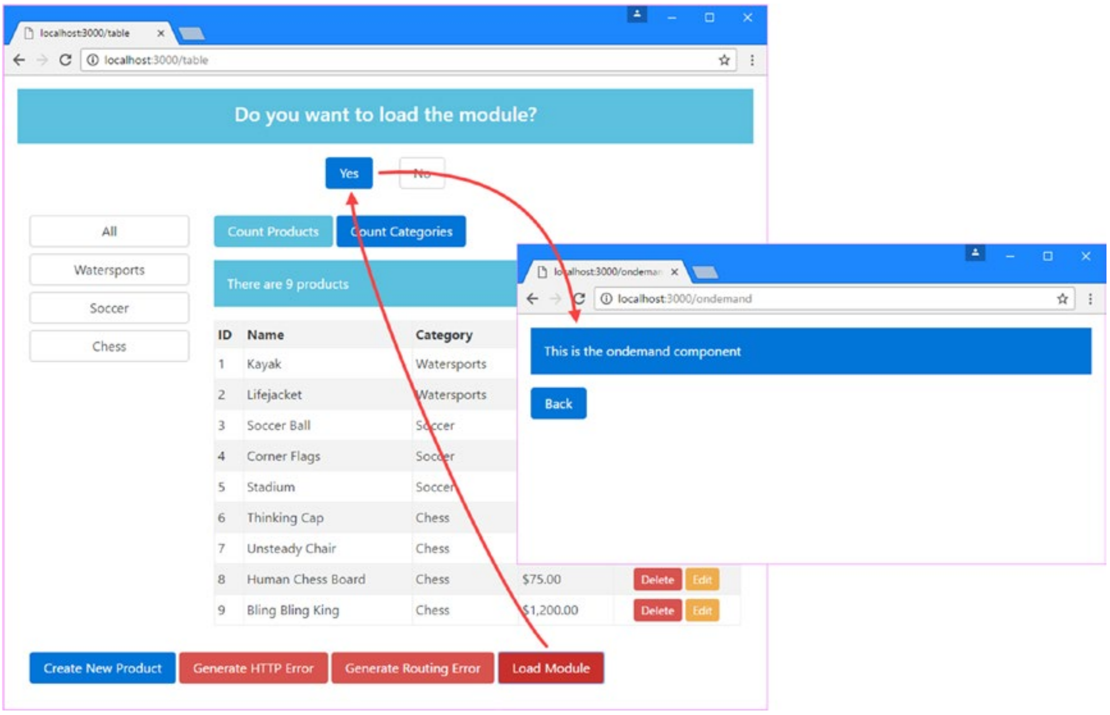


Figure 27-9. *Guarding dynamic loading*

Targeting Named Outlets

A template can contain more than one `router-outlet` element, which allows a single URL to select multiple components to be displayed to the user.

To demonstrate this feature, I need to add two new components to the `ondemand` module. I started by creating a file called `first.component.ts` in the `exampleApp/app/ondemand` folder and using it to define the component shown in Listing 27-29.

Listing 27-29. The first.component.ts File in the exampleApp/app/ondemand Folder

```
import { Component } from "@angular/core";

@Component({
    selector: "first",
    template: `<div class="bg-primary p-a-1">First Component</div>`
})
export class FirstComponent { }
```

This component uses an inline template to display a message whose purpose is simply to make it clear which component has been selected by the routing system. Next, I created a file called `second.component.ts` in the `exampleApp/app/ondemand` folder and created the component shown in Listing 27-30.

Listing 27-30. The second.component.ts File in the exampleApp/app/ondemand Folder

```
import { Component } from "@angular/core";

@Component({
    selector: "second",
    template: `<div class="bg-info p-a-1">Second Component</div>`
})
export class SecondComponent { }
```

This component is almost identical to the one in Listing 27-29, differing only in the message that it displays through its inline template.

Creating Additional Outlet Elements

When you are using multiple outlet elements in the same template, Angular needs some way to tell them apart. This is done using the `name` attribute, which allows an outlet to be uniquely identified, as shown in Listing 27-31.

Listing 27-31. Adding Named Outlet Elements in the ondemand.component.html File

```
<div class="bg-primary p-a-1">This is the ondemand component</div>
<div class="col-xs-12 m-t-1">
    <router-outlet></router-outlet>
</div>
<div class="col-xs-6">
    <router-outlet name="left"></router-outlet>
</div>
<div class="col-xs-6">
    <router-outlet name="right"></router-outlet>
</div>
<button class="btn btn-primary m-t-1" routerLink="/" >Back</button>
```

The new elements create three new outlets. There can be at most one `router-outlet` element without a name element, which is known as the *primary outlet*. This is because omitting the `name` attribute has the same effect as applying it with a value of `primary`. All the routing examples so far in this book have relied on the primary outlet to display components to the user.

All other `router-outlet` elements must have a `name` element with a unique name. The names I have used in the listing are `left` and `right` because the classes applied to the `div` elements that contain the outlets use CSS to position these two outlets side by side.

The next step is to create a route that includes details of which component should be displayed in each outlet element, as shown in Listing 27-32. If Angular can't find a route that matches a specific outlet, then no content will be shown in that element.

Listing 27-32. Targeting Named Outlets in the ondemand.module.ts File

```
import { NgModule } from "@angular/core";
import { CommonModule } from "@angular/common";
import { OndemandComponent } from "./ondemand.component";
import { RouterModule } from "@angular/router";
import { FirstComponent } from "./first.component";
import { SecondComponent } from "./second.component";

let routing = RouterModule.forChild([
    {
        path: "",
        component: OndemandComponent,
        children: [
            { path: "",
              children: [
                   { outlet: "primary", path: "", component: FirstComponent, },
                   { outlet: "left", path: "", component: SecondComponent, },
                   { outlet: "right", path: "", component: SecondComponent, },
              ]},
        ]
    },
]);

@NgModule({
    imports: [CommonModule, routing],
    declarations: [OndemandComponent, FirstComponent, SecondComponent],
    exports: [OndemandComponent]
})
export class OndemandModule { }
```

The `outlet` property is used to specify the outlet element that the route applies to. The routing configuration in the listing matches the empty path for all three outlets and selects the newly created components for them: the primary outlet will display `FirstComponent`, and the `left` and `right` outlets will display `SecondComponent`, as shown in Figure 27-10. To see the effect yourself, click the `Load Module` button and click the `Yes` button when prompted.

■ **Tip** If you omit the outlet property, then Angular assumes that the route targets the primary outlet. I tend to include the `outlet` property on all routes to emphasize which routes match an outlet element.

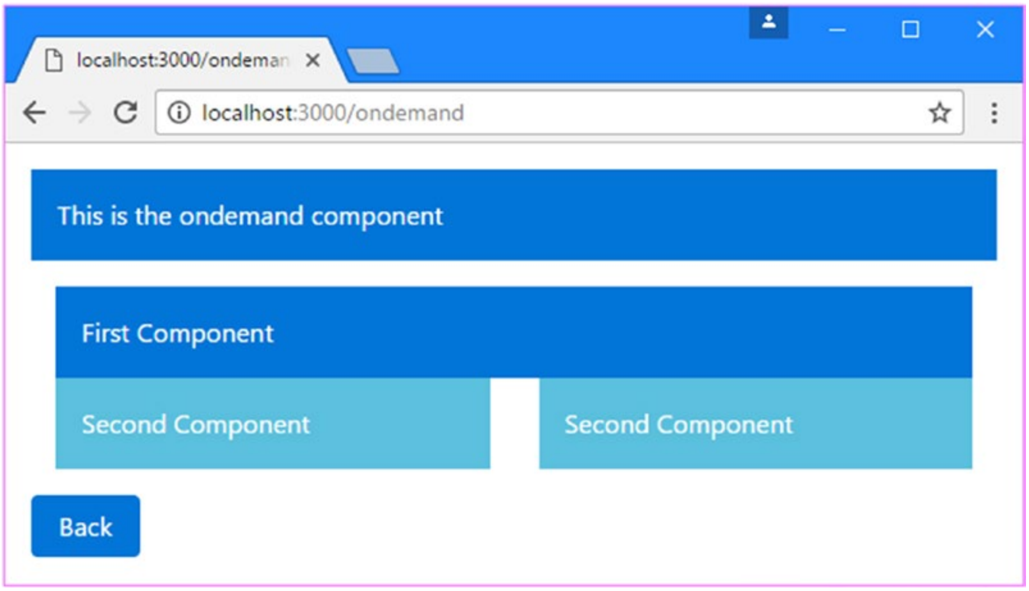


Figure 27-10. *Using multiple router outlets*

When Angular activates the route, it looks for matches for each outlet. All three of the new outlets have routes that match the empty path, which allows Angular to present the components shown in the figure.

Navigating When Using Multiple Outlets

Changing the components that are displayed by each outlet means creating a new set of routes and then navigating to the URL that contains them. Listing 27-33 sets up a route that will match the path `/ondemand/swap` and that switches the components displayed by the three outlets.

SIMPLIFYING NAMED OUTLETS

The way that I set up the routes and navigate around the application in this section isn't the only approach, but it works reliably and can be used in dynamically loaded modules.

The alternative approach is to navigate to URLs that contain paths for all the outlets that are being targeted, such as this one:

```
http://localhost:3000/ondemand/primarypath(left:leftpath//right:rightpath)
```

The main part of the URL targets the primary URL, and the sections in the brackets target the `left` and `right` outlets. The problem is that Angular doesn't look for the routes that target the named outlets consistently, and it is easy to create a routing configuration that doesn't work as expected or doesn't work at all.

The approach I have used in this chapter is something of a cheat because I target componentless routes that have children that take care of the named outlets. This makes the routing configuration more complicated and requires that you create sets of routes for each combination of components and outlets you require. But, on the other hand, it is an approach that is easier to understand and can be relied on to behave, even when using dynamically loaded modules.

Listing 27-33. Setting Up Routes for Named Outlets in the ondemand.module.ts File

```
import { NgModule } from "@angular/core";
import { CommonModule } from "@angular/common";
import { OndemandComponent } from "./ondemand.component";
import { RouterModule } from "@angular/router";
import { FirstComponent } from "./first.component";
import { SecondComponent } from "./second.component";

let routing = RouterModule.forChild([
    {
        path: "",
        component: OndemandComponent,
        children: [
            {
                path: "",
                children: [
                    { outlet: "primary", path: "", component: FirstComponent, },
                    { outlet: "left", path: "", component: SecondComponent, },
                    { outlet: "right", path: "", component: SecondComponent, },
                ]
            },
            {
                path: "swap",
                children: [
                    { outlet: "primary", path: "", component: SecondComponent, },
                    { outlet: "left", path: "", component: FirstComponent, },
                    { outlet: "right", path: "", component: FirstComponent, },
                ]
            },
        ]
    },
]);

@NgModule({
    imports: [CommonModule, routing],
    declarations: [OndemandComponent, FirstComponent, SecondComponent],
    exports: [OndemandComponent]
})
export class OndemandModule { }
```

Listing 27-34 adds `button` elements to the component's template that will navigate to the two sets of routes in Listing 27-33, alternating the set of components displayed to the user.

Listing 27-34. Navigating to Multiple Outlets in the ondemand.component.html File

```
<div class="bg-primary p-a-1">This is the ondemand component</div>
<div class="col-xs-12 m-t-1">
    <router-outlet></router-outlet>
</div>
<div class="col-xs-6">
    <router-outlet name="left"></router-outlet>
</div>
<div class="col-xs-6">
    <router-outlet name="right"></router-outlet>
</div>
<button class="btn btn-secondary m-t-1" routerLink="/ondemand">Normal</button>
<button class="btn btn-secondary m-t-1" routerLink="/ondemand/swap">Swap</button>
<button class="btn btn-primary m-t-1" routerLink="/">Back</button>
```

The result is that clicking the Swap and Normal button will navigate to routes whose children tell Angular which components should be displayed by each of the outlet elements, as illustrated by Figure 27-11.

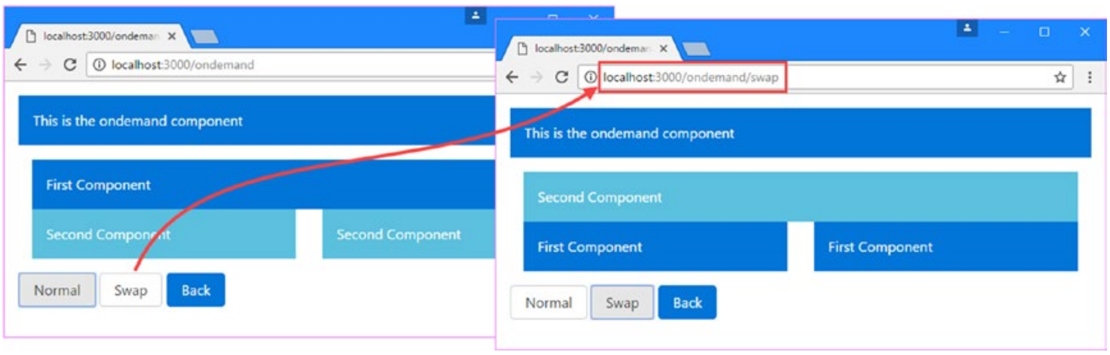


Figure 27-11. *Using navigation to target multiple outlet elements*

Summary

In this chapter, I finished describing the Angular URL routing features, explaining how to guard routes to control when a route is activated, how to load modules only when they are needed, and how to use multiple outlet elements to display components to the user. In the next chapter, I show you how to apply animations to Angular applications.

CHAPTER 28

Using Animation

In this chapter, I describe the Angular animation system, which uses data bindings to animate HTML elements to reflect changes in the state of the application. In broad terms, animations have two roles in an Angular application: to emphasize changes in content or to smooth them out.

Emphasizing changes is important when the content changes in a way that may not be obvious to the user. In the example application, using the Previous and Next buttons when editing a product changes the data fields but doesn't create any other visual change, which results in a transition that the user may not notice. Animations can be used to draw the eye to this kind of change, helping the user notice the results of an action.

Smoothing out changes can make an application more pleasant to use. When the user clicks the Edit button to start editing a product, the content displayed by the example application switches in a way that can be jarring. Using animations to slow down the transition can help provide a sense of context for the content change and make it less abrupt. In this chapter, I explain how the animation system works and how it can be used to draw the user's eye or take the edge off of sudden transitions.

ANIMATION BROWSER SUPPORT

The Angular animation features depend on the Web Animations API, which is reliably implemented only in Chrome and Mozilla. Other browsers either don't implement the API at all or don't implement all features. I use a polyfill library to add basic support for older browsers, but some features still won't work.

This situation may improve with time, but you should test carefully to make sure that the browsers you target with your project are able to handle the animation features you use.

You should use Chrome if you want to follow the examples in this chapter to make sure you get the expected results.

A. Freeman, *Pro Angular*, DOI 10.1007/978-1-4842-2307-9_28

Table 28-1 puts Angular animations in context.

Table 28-1. *Putting Angular Animations in Context*

Question	Answer
What is it?	The animations system can change the appearance of HTML elements to reflect changes in the application state.
Why is it useful?	Used judiciously, animations can make applications more pleasant to use.
How is it used?	Animations are defined using functions defined in the `@angular/core` module, registered using the animations property in the `@Component` decorator and applied using a data binding.
Are there any pitfalls or limitations?	The main limitation is that it is fully supported on few browsers and, as a consequence, cannot be relied on to work properly on all the browsers that Angular supports for its other features.
Are there any alternatives?	The only alternative is not to animate the application.

Table 28-2 summarizes the chapter.

Table 28-2. *Chapter Summary*

Problem	Solution	Listing
Draw the user's attention to a transition in the state of an element	Apply an animation	1–9
Animate the change from one element state to another	Use an element transition	10–15
Perform animations in parallel	Use animation groups	16
Use the same styles in multiple animations	Use common styles	17
Animate the position or size of elements	Use element transformations	18
Use animations to apply CSS framework styles	Use the DOM and CSS APIs	19, 20
Receive notifications about animations	Receive animation events	21, 22

Preparing the Example Project

In this chapter, I continue using the `exampleApp` that was first created in Chapter 22 and has been the focus of every chapter since. The changes in the following sections prepare the example application for the features described in this chapter.

Adding the Animations Polyfill

The Angular animations feature relies on a JavaScript API that is supported only by recent browsers, and a polyfill is required to allow older browsers to work. Listing 28-1 adds the polyfill to the set of packages for the example application.

Listing 28-1. Adding the Animation Polyfill in the package.json File

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/forms": "2.2.0",
    "@angular/http": "2.2.0",
    "@angular/router": "3.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4",
    "intl": "1.2.4",
    "html5-history-api": "4.2.7",
    "web-animations-js": "2.2.2"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.2",
    "typings": "1.3.2",
    "concurrently": "2.2.0",
    "systemjs-builder": "0.15.32",
    "json-server": "0.8.21"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" \"npm run json\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "json": "json-server --p 3500 restData.js",
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

The `web-animations-js` package is recommended by the Angular team for providing animation support for older browsers. Run the following command in the `exampleApp` folder to download the polyfill package:

```
npm install
```

Listing 28-2 adds a `script` element to the `index.html` file for the polyfill JavaScript file.

Listing 28-2. Adding the Animations Polyfill in the index.html File

```
<!DOCTYPE html>
<html>
<head>
    <base href="/">
    <title></title>
    <meta charset="utf-8" />
    <script src="node_modules/html5-history-api/history.min.js"></script>
    <script src="node_modules/classlist.js/classList.min.js"></script>
    <script src="node_modules/web-animations-js/web-animations.min.js"></script>
    <script src="node_modules/core-js/client/shim.min.js"></script>
    <script src="node_modules/intl/dist/Intl.complete.js"></script>
    <script src="node_modules/zone.js/dist/zone.min.js"></script>
    <script src="node_modules/reflect-metadata/Reflect.js"></script>
    <script src="node_modules/systemjs/dist/system.src.js"></script>
    <script src="rxjs.module.min.js"></script>
    <script src="systemjs.config.js"></script>
    <script>
      System.import("app/main").catch(function(err){ console.error(err); });
    </script>
    <link href="node_modules/bootstrap/dist/css/bootstrap.min.css"
        rel="stylesheet" />
</head>
<body class="m-a-1">
    <app></app>
</body>
</html>
```

Disabling the HTTP Delay

The next preparatory step for this chapter is to disable the delay added to asynchronous HTTP requests, as shown in Listing 28-3.

■ **Tip** You can download complete projects for every chapter as part of the free source code download that accompanies this book at `apress.com`.

Listing 28-3. Disabling the Delay in the rest.datasource.ts File

```
import { Injectable, Inject, OpaqueToken } from "@angular/core";
import { Http, Request, RequestMethod, Headers, Response } from "@angular/http";
import { Observable } from "rxjs/Observable";
import { Product } from "./product.model";
import "rxjs/add/operator/map";
import "rxjs/add/operator/catch";
import "rxjs/add/observable/throw";
import "rxjs/add/operator/delay";
```

```
export const REST_URL = new OpaqueToken("rest_url");

@Injectable()
export class RestDataSource {

    constructor(private http: Http,
        @Inject(REST_URL) private url: string) { }

    // ...other methods omitted for brevity...

    private sendRequest(verb: RequestMethod,
        url: string, body?: Product): Observable<Product> {

        let headers = new Headers();
        headers.set("Access-Key", "<secret>");
        headers.set("Application-Names", ["exampleApp", "proAngular"]);

        return this.http.request(new Request({
            method: verb,
            url: url,
            body: body,
            headers: headers
        }))
            //.delay(5000)
            .map(response => response.json())
            .catch((error: Response) => Observable.throw(
                `Network Error: ${error.statusText} (${error.status})`));
    }
}
```

Simplifying the Table Template and Routing Configuration

Many of the examples in this chapter are applied to the elements in the table of products. The final preparation for this chapter is to simplify the template for the table component so that I can focus on a smaller amount of content in the listings.

Listing 28-4 shows the simplified template, which removes the buttons that generated HTTP and routing errors and the button and outlet element that counted the categories or products. The listing also removes the buttons that allow the table to be filtered by category.

Listing 28-4. Simplifying the Template in the table.component.html File

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm"
                    (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm"
                [routerLink]="['/form', 'edit', item.id]">
                Edit
            </button>
        </td>
    </tr>
</table>

<div class="col-xs-12 p-t-1">
    <button class="btn btn-primary" routerLink="/form/create">
        Create New Product
    </button>
</div>
```

Listing 28-5 updates the URL routing configuration for the application so that the routes don't target the outlet element that has been removed from the table component's template.

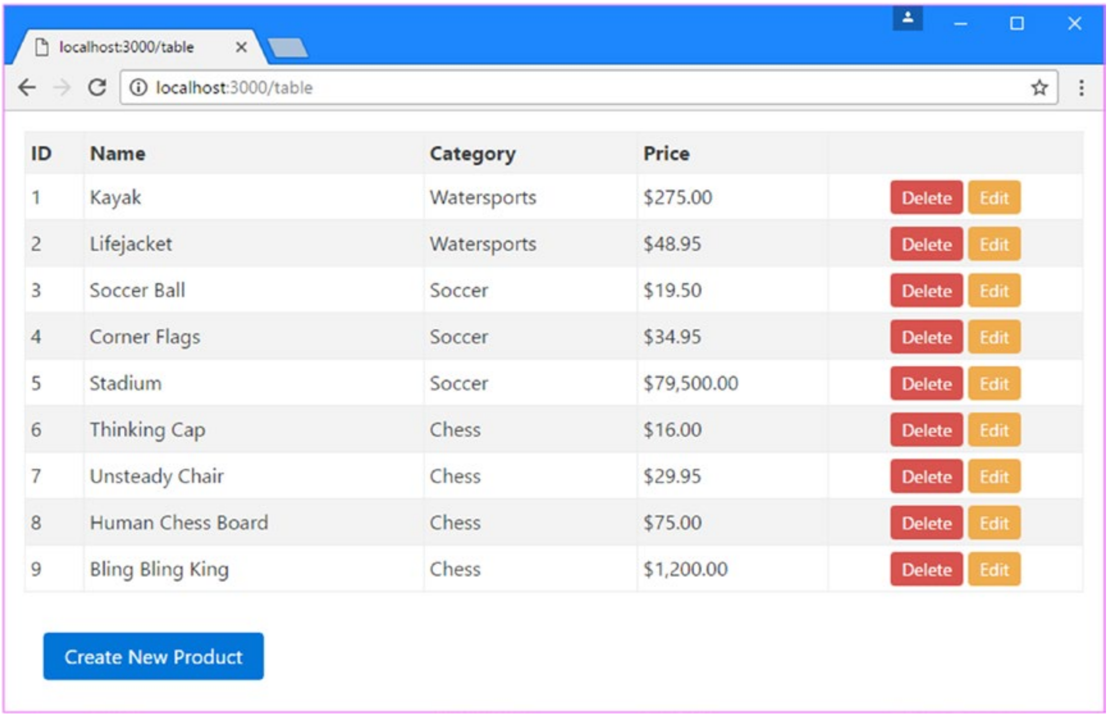
Listing 28-5. Updating the Routing Configuration in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";
import { TermsGuard } from "./terms.guard";
import { UnsavedGuard } from "./core/unsaved.guard";
import { LoadGuard } from "./load.guard";

const routes: Routes = [
    {
        path: "form/:mode/:id", component: FormComponent,
        canDeactivate: [UnsavedGuard]
    },
    { path: "form/:mode", component: FormComponent, canActivate: [TermsGuard] },
    { path: "table", component: TableComponent },
    { path: "table/:category", component: TableComponent },
    { path: "", redirectTo: "/table", pathMatch: "full" },
    { path: "**", component: NotFoundComponent }
]

export const routing = RouterModule.forRoot(routes);
```

Run the following command in the exampleApp folder to start the RESTful web service, the TypeScript compiler, and the development HTTP server:

```
npm start
```

A new browser tab or window will open and display the content shown in Figure 28-1.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Figure 28-1. *Running the example application*

Getting Started with Angular Animation

As with most Angular features, the best place to start is with an example, which will let me introduce how animation works and how it fits in to the rest of the Angular functionality. In the sections that follow, I create a basic animation that will affect the rows in the table of products. Once you have seen how the basic features work, I will dive into the detail for each of the different configuration option and explain how they work in depth.

But to get started, I am going to add a select element to the application that allows the user to select a category. When a category is selected, the table rows for products in that category will be shown in one of two styles, as described in Table 28-3.

Table 28-3. *The Styles for the Animation Example*

Description	Styles
The product is in the selected category.	The table row will have a green background and larger text.
The product is not in the selected category.	The table row will have a red background and smaller text.

Creating the Animation

To get started, I created a file called `table.animations.ts` in the `example/app/core` folder and added the code shown in Listing 28-6.

Listing 28-6. The Contents of the table.animations.ts File in the exampleApp/app/core Folder

```
import { trigger, style, state, transition, animate } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    transition("selected => notselected", animate("200 ms")),
    transition("notselected => selected", animate("400 ms"))
]);
```

The syntax used to define animations can be dense and relies on a set of functions defined in the `@angular/core` module. In the following sections, I start at the top and work my way down through the detail to explain each of the animation building blocks used in the listing.

■ **Tip** Don't worry if all the building blocks described in the following sections don't make immediate sense. This is an area of functionality that starts to make more sense only when you see how all the parts fit together.

Defining Style Groups

The heart of the animation system is the style group, which is a set of CSS style properties and values that will be applied to an HTML element. Style groups are defined using the `style` function, which accepts a JavaScript object literal that provides a map between property names and values, like this:

```
...
style({
    backgroundColor: "lightgreen",
    fontSize: "20px"
})
...
```

This style group tells Angular to set the background color to `lightgreen` and to set the font size to 20 pixels.

CSS PROPERTY NAME CONVENTIONS

There are two ways to specify CSS properties when using the `style` function. You can use the JavaScript property naming convention, such that the property to set the background color of an element is specified as `backgroundColor` (all one word, no hyphens, and subsequent words capitalized). This is the convention I used in Listing 28-6:

```
...
style({
    backgroundColor: "lightgreen",
    fontSize: "20px"
})),
...
```

Alternatively, you can use the CSS convention, where the same property is expressed as `background-color` (all lowercase with hyphens between words). If you use the CSS format, then you must enclose the property names in quotes to stop JavaScript from trying to interpret the hyphens as arithmetic operators, like this:

```
...
state("green", style({
    "background-color": "lightgreen",
    "font-size": "20px"
})),
...
```

It doesn't matter which name convention you use, just as long as you are consistent. At the time of writing, Angular does not correctly apply styles if you mix and match property name conventions. To get consistent results, pick a naming convention and use it for all the style properties you set throughout your application.

Defining Element States

Angular needs to know when it needs to apply a set of styles to an element. This is done by defining an element state, which provides a name by which the set of styles can be referred to. Element states are created using the `state` function, which accepts the name and the style set that should be associated with it. This is one of the two element states that are defined in Listing 28-6:

```
...
state("selected", style({
    backgroundColor: "lightgreen",
    fontSize: "20px"
})),
...
```

There are two states in the listing, called `selected` and `notselected`, which will correspond to whether the product described by a table row is in the category selected by the user.

Defining State Transitions

When an HTML element is in one of the states created using the `state` function, Angular will apply the CSS properties in the state's style group. The `transition` function is used to tell Angular how the new CSS properties should be applied. There are two transitions in Listing 28-6.

```
...
transition("selected => notselected", animate("200 ms")),
transition("notselected => selected", animate("400 ms"))
...
```

The first argument passed to the `transition` function tells Angular which states this instruction applies to. The argument is a string that specifies two states and an arrow that expresses the relationship between them. Two kinds of arrow are available, as described in Table 28-4.

Table 28-4. *The Animation Transition Arrow Types*

Arrow	Example	Description
`=>`	`selected => notselected`	This arrow specifies a one-way transition between two states, such as when the element moves from the `selected` to the `notselected` state.
`<=>`	`selected <=> notselected`	This array specifies a two-way transition between two states, such as when the element moves from the `selected` to the `notselected` state and from the `notselected` to the `selected` state.

The transitions defined in Listing 28-6 use one-way arrows to tell Angular how it should respond when an element moves from the `selected` to the `notselected` state and from the `notselected` to the `selected` state.

The second argument to the `transition` function tells Angular what action it should take when the state change occurs. The `animate` function tells Angular to gradually transition between the properties defined in the CSS style set defined by two element states. The arguments passed to the `animate` function in Listing 28-6 specify the period of time that this gradual transition should take, either 200 milliseconds or 400 milliseconds.

GUIDANCE FOR APPLYING ANIMATIONS

Developers often get carried away when applying animations, and the result is applications that users find frustrating. Animations should be applied sparingly, they should be simple, and they should be quick. Use animations to help the user make sense of your application and not as a vehicle to demonstrate your artistic skills. Users, especially for corporate line-of-business applications, have to perform the same task repeatedly, and excessive and long animations just get in the way.

I suffer from this tendency, and, unchecked, my applications behave like Las Vegas slot machines. I have two rules that I follow to keep the problem under control. The first is that I perform the major tasks or workflows in the application 20 times in a row. In the case of the example application, that might mean creating 20 products and then editing 20 products. I remove or shorten any animation that I find myself having to wait to complete before I can move on to the next step in the process.

The second rule is that I don't disable animations during development. It can be tempting to comment out an animation when I am working on a feature because I will be performing a series of quick tests as I write the code. But any animation that gets in my way will also get in the user's way, so I leave the animations in place and adjust them—generally reducing their duration—until they become less obtrusive and annoying.

You don't have to follow my rules, of course, but it is important to make sure that the animations are helpful to the user and not a barrier to working quickly or a distracting annoyance.

Defining the Trigger

The final piece of plumbing is the animation trigger, which packages up the element states and transitions and assigns a name that can be used to apply the animation in a component. Triggers are created using the `trigger` function, like this:

```
...
export const HighlightTrigger = trigger("rowHighlight", [...])
...
```

The first argument is the name by which the trigger will be known, which is `rowHighlight` in this example, and the second argument is the array of states and transitions that will be available when the trigger is applied.

Applying the Animation

Once you have defined an animation, you can apply it to one or more components by using the `animations` property of the `@Component` decorator. Listing 28-7 applies the animation defined in Listing 28-6 to the table component and adds some additional features that are needed to support the animation.

Listing 28-7. Applying an Animation in the table.component.ts File

```
import { Component, Inject } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute } from "@angular/router";
import { HighlightTrigger } from "./table.animations";

@Component({
    selector: "paTable",
    moduleId: module.id,
    templateUrl: "table.component.html",
    animations: [HighlightTrigger]
})
export class TableComponent {
    category: string = null;

    constructor(private model: Model, activeRoute: ActivatedRoute) {
        activeRoute.params.subscribe(params => {
            this.category = params["category"] || null;
        })
    }
    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts()
            .filter(p => this.category == null || p.category == this.category);
    }

    get categories(): string[] {
        return this.model.getProducts()
            .map(p => p.category)
            .filter((category, index, array) => array.indexOf(category) == index);
    }

    deleteProduct(key: number) {
        this.model.deleteProduct(key);
    }

    highlightCategory: string = "";

    getRowState(category: string): string {
        return this.highlightCategory == "" ? "" :
            this.highlightCategory == category ? "selected" : "notselected";
    }
}
```

The animations property is set to an array of triggers. You can define animations inline, but they can quickly become complex and make the entire component hard to read, which is why I used a separate file and exported a constant value from it, which I then assign to the animations property.

The other changes are to provide a mapping between the category selected by the user and the animation state that will be assigned to elements. The value of the highlightCategory property will be set using a select element and is used in the getRowState method to tell Angular which of the animation states defined in Listing 28-7 should be assigned based on a product category. If a product is in the selected category, then the method returns selected; otherwise, it returns notselected. If the user has not selected a category, then the empty string is returned.

The final step is to apply the animation to the component's template, telling Angular which elements are going to animated, as shown in Listing 28-8. This listing also adds a select element that sets the value of the component's highlightCategory property using the ngModel binding.

Listing 28-8. Applying an Animation in the table.component.html File

```
<div class="form-group bg-info p-a-1">
    <label>Category</label>
    <select [(ngModel)]="highlightCategory" class="form-control">
        <option value="">None</option>
        <option *ngFor="let category of categories">
            {{category}}
        </option>
    </select>
</div>
```

```
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()"
            [@rowHighlight]="getRowState(item.category)">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm"
                    (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm"
                [routerLink]="['/form', 'edit', item.id]">
                Edit
            </button>
        </td>
    </tr>
</table>
<div class="col-xs-12 p-t-1">
    <button class="btn btn-primary" routerLink="/form/create">
        Create New Product
    </button>
</div>
```

Animations are applied to templates using special data bindings, which associate an animation trigger with an HTML element. The binding's target tells Angular which animation trigger to apply, and the binding's expression tells Angular how to work out which state an element should be assigned to, like this:

```
...
<tr *ngFor="let item of getProducts()" [@rowHighlight]="getRowState(item.category)">
...
```

The target of the binding is the name of the animation trigger, prefixed with the `@` character, which denotes an animation binding. This binding tells Angular that it should apply the `rowHighlight` trigger to the `tr` element. The expression tells Angular that it should invoke the component's `getRowState` method to work out which state the element should be assigned to, using the `item.category` value as an argument. Figure 28-2 illustrates the anatomy of an animation data binding for quick reference.

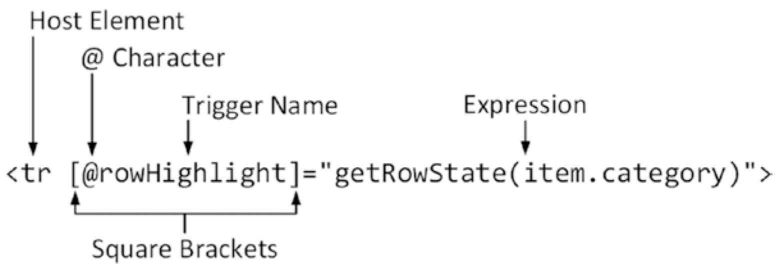
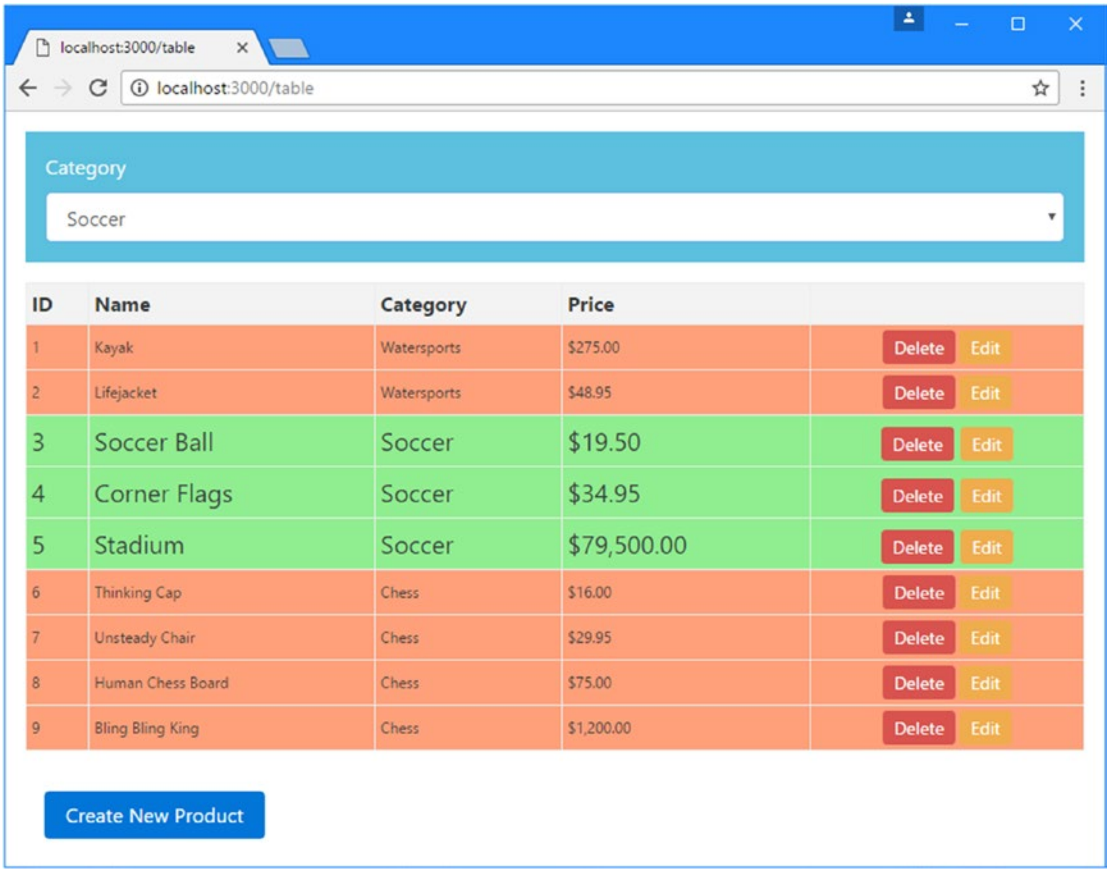


Figure 28-2. *The anatomy of an animation data binding*

Testing the Animation Effect

The changes in the previous section add a `select` element above the product table. To see the effect of the animation, select `Soccer` from the list, and Angular will use the trigger to figure out which of the animation states each element should be applied to. Table rows for products in the `Soccer` category will be assigned to the `selected` state, while the other rows will be assigned to the `notselected` state, creating the effect shown in Figure 28-3.

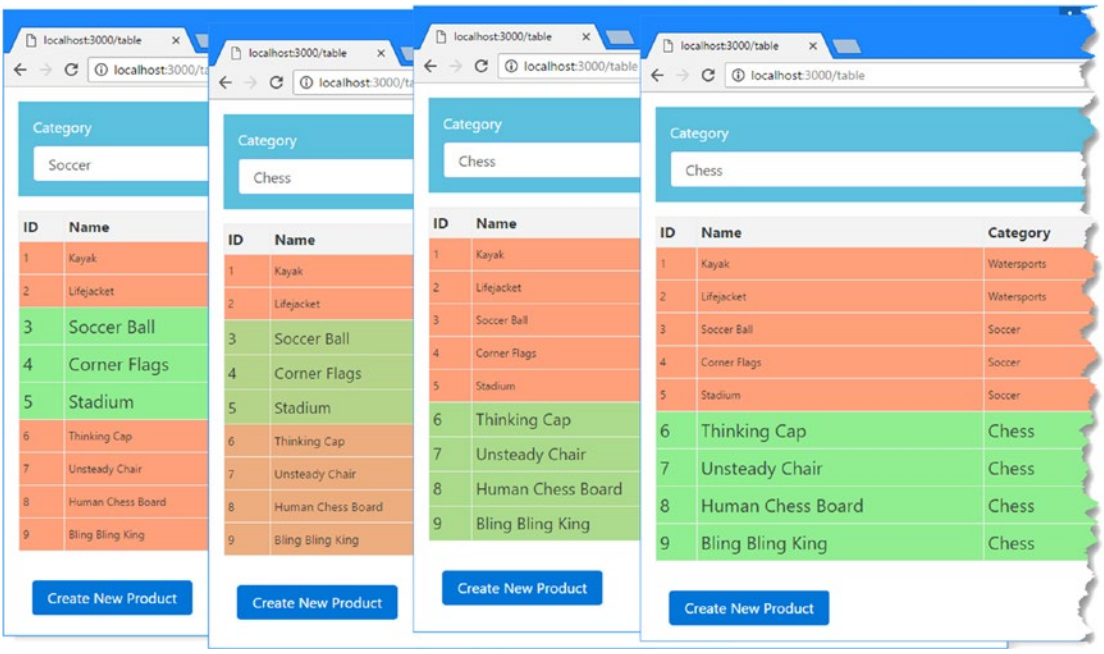


ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Figure 28-3. *Selecting a product category*

The new styles are applied suddenly. To see a smoother transition, select one the `Chess` category from the list, and you will see a gradual animation as the `Chess` rows are assigned to the `selected` state and the other rows are assigned to the `notselected` state. This happens because the animation trigger contains transitions between these states that tell Angular to animate the change in CSS styles, as illustrated in Figure 28-4. There is no transition for the earlier change, so Angular defaults to applying the new styles immediately.

■ **Tip** It is impossible to capture the effect of animations in a series of screenshots, and the best I can do is present some of the intermediate states. This is a feature that requires first-hand experimentation to understand. I encourage you to download the project for this chapter from `apress.com` and create your own animations.



ID	Name
1	Kayak
2	Lifejacket
3	Soccer Ball
4	Corner Flags
5	Stadium
6	Thinking Cap
7	Unsteady Chair
8	Human Chess Board
9	Bling Bling King

ID	Name	Category
1	Kayak	Watersports
2	Lifejacket	Watersports
3	Soccer Ball	Soccer
4	Corner Flags	Soccer
5	Stadium	Soccer
6	Thinking Cap	Chess
7	Unsteady Chair	Chess
8	Human Chess Board	Chess
9	Bling Bling King	Chess

***Figure 28-4.** A gradual transition between animation states*

To understand the Angular animation system, you need to understand the relationship between the different building blocks used to define and apply an animation, which can be described like this:

1. Evaluating the data binding expression tells Angular which animation state the host element is assigned to.
2. The data binding target tells Angular which animation target defines CSS styles for the element's state.
3. The state tells Angular which CSS styles should be applied to the element.
4. The transition tells Angular how it should apply CSS styles when evaluating the data binding expression results in a change to the element's state.

Keep these four points in mind as you read through the rest of the chapter, and you will find the animation system easier to understand.

Understanding the Built-in Animation States

Animation states are used to define the end result of an animation, grouping together the styles that should be applied to an element with a name that can be selected by an animation trigger. There are two built-in states that Angular provides that make it easier to manage the appearance of elements, as described in Table 28-5.

Table 28-5. *The Built-in Animation States*

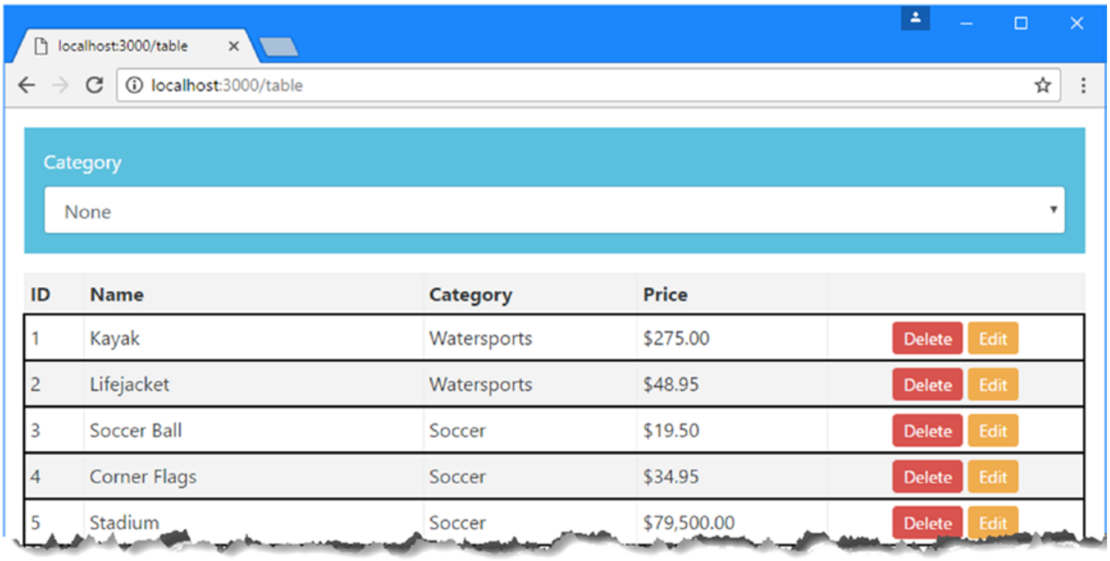
State	Description
`*`	This is a fallback state that will be applied if the element isn't in any of the other states defined by the animation trigger.
`void`	Elements are in the void state when they are not part of the template. When the expression for an `ngIf` directive evaluates as `false`, for example, the host element is in the `void` state. This state is used to animate the addition and removal of elements, as described in the next section.

An asterisk (the * character) is used to denote a special state that Angular should apply to elements that are not in any of the other states defined by an animation trigger. Listing 28-9 adds the fallback state to the animations in the example application.

Listing 28-9. Using the Fallback State in the table.animations.ts File

```
import { trigger, style, state, transition, animate } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    state("*", style({
        border: "solid black 2px"
    })),
    transition("selected => notselected", animate("200 ms")),
    transition("notselected => selected", animate("400 ms"))
]);
```

In the example application, elements are assigned only to the `selected` or `notselected` state once the user has picked a value with the `select` element. The fallback state defines a style group that will be applied to elements until they are entered into one of the other states, as shown in Figure 28-5.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit

Figure 28-5. *Using the fallback state*

Understanding Element Transitions

The transitions are the real power of the animation system; they tell Angular how it should manage the change from one state to another. In the sections that follow, I describe different ways in which transitions can be created and used.

Creating Transitions for Built-in States

The built-in states described in Table 28-5 can be used in transitions. The fallback state can be used to simplify the animation configuration by representing any state, as shown in Listing 28-10.

Listing 28-10. Using the Fallback State in a Transition in the table.animations.ts File

```
import { trigger, style, state, transition, animate } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    state("*", style({
        border: "solid black 2px"
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected", animate("400 ms"))
]);
```

The transitions in the listing tell Angular how to deal with the change from any state into the `notselected` and `selected` states. The effect is that Angular will animate the transition when the user first picks a category using the `select` element and also if the `None` category is subsequently selected.

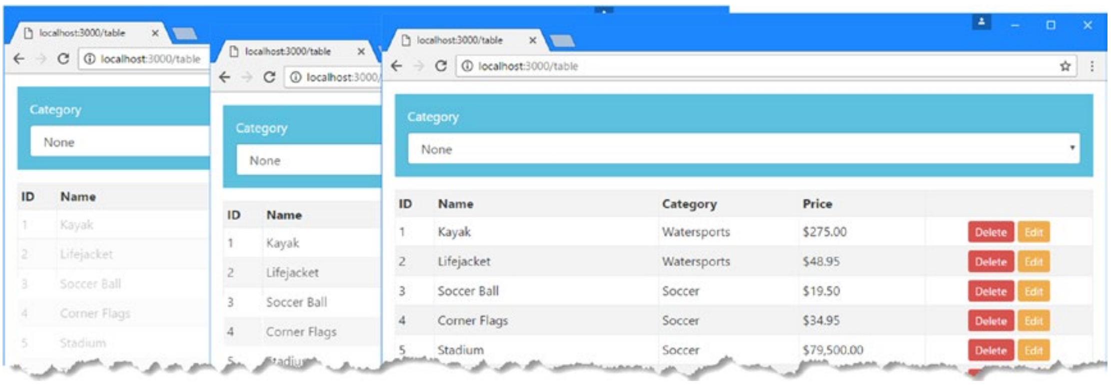
Animating Element Addition and Removal

The `void` state is used to define transitions for when an element is added to or removed from the template, as shown in Listing 28-11.

Listing 28-11. Using the Void State in the table.animations.ts File

```
import { trigger, style, state, transition, animate } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    state("void", style({
        opacity: 0
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected", animate("400 ms")),
    transition("void => *", animate("500 ms"))
]);
```

This listing includes a definition for the `void` state that sets the `opacity` property to zero, which makes the element transparent and, as a consequence, invisible. There is also a transition that tells Angular to animate the change from the `void` state to any other state. The effect is that the rows in the table fade into view as the browser gradually increases the opacity value until the fill opacity is reached, as shown in Figure 28-6.



ID	Name	Category	Price
1	Kayak	Watersports	$275.00
2	Lifejacket	Watersports	$48.95
3	Soccer Ball	Soccer	$19.50
4	Corner Flags	Soccer	$34.95
5	Stadium	Soccer	$79,500.00

Figure 28-6. *Animating element addition*

■ **Tip** Angular provides aliases that can be used for transitions for the built-in state. The `:enter` alias can be used instead of `void => *`, and the `:leave` alias can be used instead of `* => void`.

Controlling Transition Animations

All the examples so far in this chapter have used to `animate` function in its simplest form, which is to specify how long a transition between two states should take, like this:

```
...
transition("void => *", animate("500 ms"))
...
```

The `string` argument passes to the `animate` method can be used to exercise finer-grain control over the way that transitions are animated by providing an initial delay and specifying how intermediate values for the style properties are calculated.

EXPRESSING ANIMATION DURATIONS

Durations for animations are expressed using CSS time values, which are string values containing one or more numbers followed by either `s` for seconds or `ms` for milliseconds. This value, for example, specifies a duration of 500 milliseconds:

```
...
transition("void => *", animate("500 ms"))
...
```

Durations are expressed flexibly, and the same value could be expressed as a fraction of a second, like this:

```
...
transition("void => *", animate("0.5 s"))
...
```

My advice is to stick to one set of units throughout a project to avoid confusion, although it doesn't matter which one you use.

Specifying a Timing Function

The timing function is responsible for calculating the intermediate values for CSS properties during the transition. The timing functions, which are defined as part of the Web Animations specification, are described in Table 28-6.

Table 28-6. *The Animation Timing Functions*

Name	Description
`linear`	This function changes the value in equal amounts. This is the default.
`ease-in`	This function starts with small changes that increase over time, resulting in an animation that that starts slowly and speeds up.
`ease-out`	This function starts with large changes that decrease over time, resulting in an animation that starts quickly and then slows down.
`ease-in-out`	This function starts with large changes that become smaller until the midway point, after which they become larger again. The result is an animation that starts quickly, slows down in the middle, and then speeds up again at the end.
`cubic-bezier`	This function is used to create intermediate values using a Bezier curve. See `http://w3c.github.io/web-animations/#time-transformations` for details.

Listing 28-12 applies a timing function to one of the transitions in the example application. The timing function is specified after the duration in the argument to the `animate` function.

Listing 28-12. Applying a Timing Function in the table.animations.ts File

```
import { trigger, style, state, transition, animate } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    state("void", style({
        opacity: 0
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected", animate("400 ms ease-in")),
    transition("void => *", animate("500 ms"))
]);
```

Specifying an Initial Delay

An initial delay can be provided to the `animate` method, which can be used to stagger animations when there are multiple transitions being performed simultaneously. The delay is specified as the second value in the argument passed to the `animate` function, as shown in Listing 28-13.

Listing 28-13. Adding an Initial Delay in the table.animations.ts File

```
import { trigger, style, state, transition, animate } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    state("void", style({
        opacity: 0
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected", animate("400 ms 200 ms ease-in")),
    transition("void => *", animate("500 ms"))
]);
```

The 200-millisecond delay in this example corresponds to the duration of the animation used when an element transitions into the notselected state. The effect is that changing the selected category will show elements returning to the notselected state before the selected elements are changed.

Using Additional Styles During Transition

The animate function can accept a style group as its second argument, as shown in Listing 28-14. These styles are applied to the host element gradually, over the duration of the animation.

Listing 28-14. Defining Transition Styles in the table.animations.ts File

```
import { trigger, style, state, transition, animate } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    state("void", style({
        opacity: 0
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected",
        animate("400 ms 200 ms ease-in",
            style({
                backgroundColor: "lightblue",
                fontSize: "25px"
            }))
    ),
    transition("void => *", animate("500 ms"))
]);
```

The effect of this change is that when an element is transitioning into the `selected` state, its appearance will be animated so that the background color will be `lightblue` and its font size will be 25 pixels. At the end of the animation, the styles defined by the `selected` state will be applied all at once, creating a snap effect.

The sudden change in appearance at the end of the animation can be jarring. An alternative approach is to change the second argument to the `transition` function to an array of animations. This defines multiple animations that will be applied to the element in sequence, and, as long as it doesn't define a style group, the final animation will be used to transition to the styles defined by the state. Listing 28-15 uses this feature to add two additional animations to the transition, the last of which will apply the styles defined by the `selected` state.

Listing 28-15. Using Multiple Animations in a Transition in the table.animations.ts File

```
import { trigger, style, state, transition, animate } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    state("void", style({
        opacity: 0
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected",
        [animate("400 ms 200 ms ease-in",
            style({
                backgroundColor: "lightblue",
                fontSize: "25px"
            })),
            animate("250 ms", style({
                backgroundColor: "lightcoral",
                fontSize: "30px"
            })),
            animate("200 ms")]
    ),
    transition("void => *", animate("500 ms"))
]);
```

There are three animations in this transition, and the last one will apply the styles defined by the `selected` state. Table 28-7 describes the sequence of animations.

Table 28-7. *The Sequence of Animations in the Transition to the selected State*

Duration	Style Properties and Values
`400 milliseconds`	`backgroundColor: lightblue; fontSize: 25px`
`250 milliseconds`	`backgroundColor: lightcoral; fontSize: 30px`
`200 milliseconds`	`backgroundColor: lightgreen; fontSize: 20px`

Pick a category using the `select` element to see the sequence of animations. Figure 28-7 shows one frame from each animation.

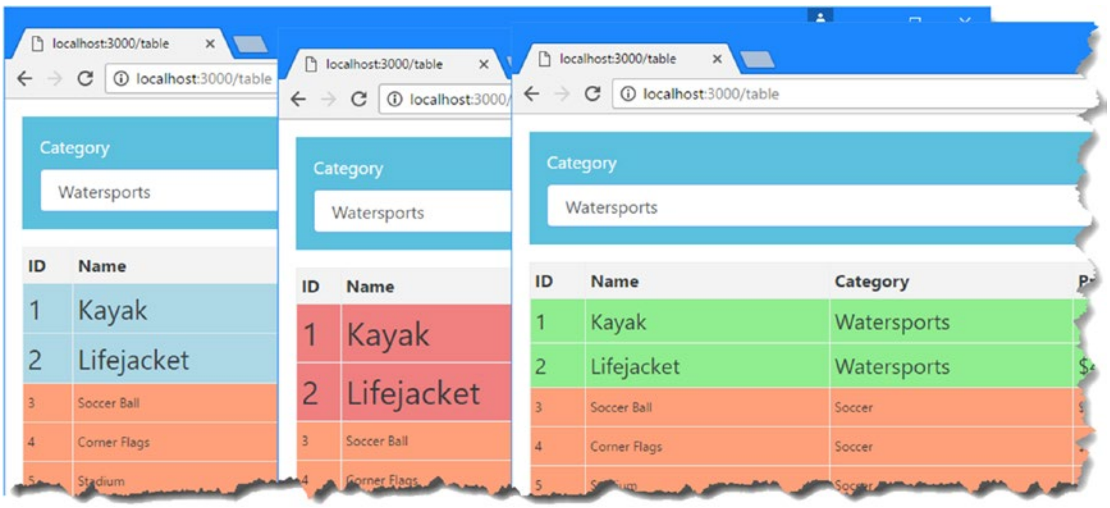


Figure 28-7. *Using multiple animations in a transition*

Performing Parallel Animations

Angular is able to perform animations at the same time, which means you can have different CSS properties change over different time periods. Parallel animations are passed to the `group` function, as shown in Listing 28-16.

Listing 28-16. Performing Parallel Animations in the table.animations.ts File

```
import { trigger, style, state, transition, animate, group } from "@angular/core";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style({
        backgroundColor: "lightgreen",
        fontSize: "20px"
    })),
    state("notselected", style({
        backgroundColor: "lightsalmon",
        fontSize: "12px"
    })),
    state("void", style({
        opacity: 0
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected",
        [animate("400 ms 200 ms ease-in",
            style({
                backgroundColor: "lightblue",
                fontSize: "25px"
            })),
            group([
                animate("250 ms", style({
                    backgroundColor: "lightcoral",
                })),
                animate("450 ms", style({
                    fontSize: "30px"
                })),
            ]),
            animate("200 ms")]
    ),
    transition("void => *", animate("500 ms"))
]);
```

The listing replaces one of the animations in sequence with a pair of parallel animations. The animations for the backgroundColor and fontSize properties will be started at the same time but last for differing durations. When both of the animations in the group have completed, Angular will move on to the final animation, which will target the styles defined in the state.

Understanding Animation Style Groups

The outcome of an Angular animation is that an element is put into a new state and styled using the properties and values in the associated style group. In this section, I explain some different ways in which style groups can be used.

■ **Tip** Not all CSS properties can be animated, and of those that can be animated, some are handled better by the browser than others. As a rule of thumb, the best results are achieved with properties whose values can be easily interpolated, which allows the browser to provide a smooth transition between element states. This means you will usually get good results using properties whose values are colors or numerical values, such as background, text and font colors, opacity, element sizes, and borders. See `https://www.w3.org/TR/css3-transitions/#animatable-properties` for a complete list of properties that can be used with the animation system.

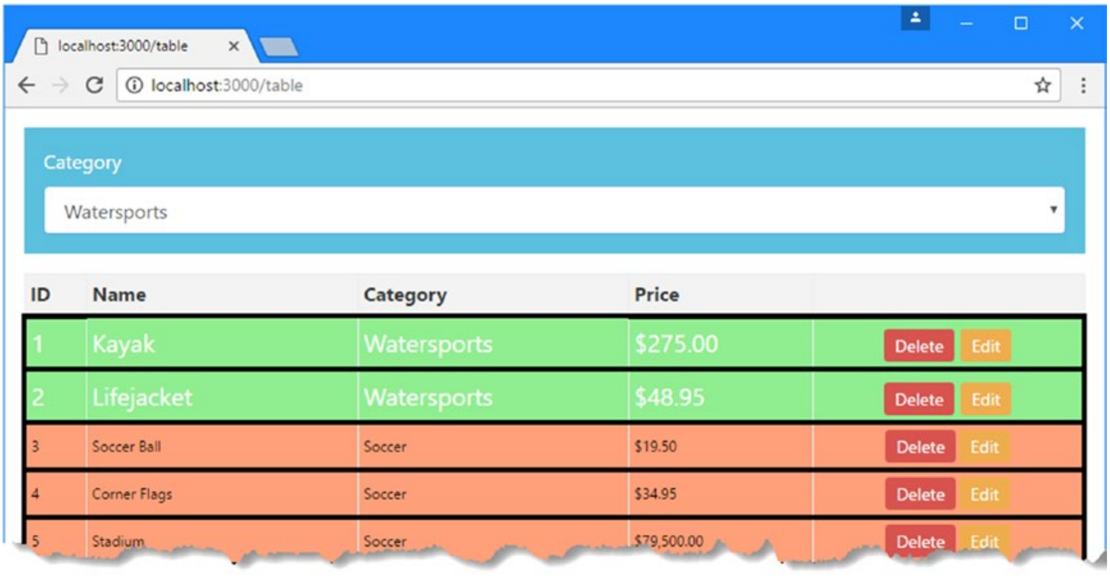
Defining Common Styles in Reusable Groups

As you create more complex animations and apply them throughout your application, you will inevitably find that you need to apply some common CSS property values in multiple places. The `style` function can accept an array of objects, all of which are combined to create the overall set of styles in the group. This means you can reduce duplication by defining objects that contain common styles and use them in multiple style groups, as shown in Listing 28-17. (To keep the example simple, I have also removed the sequence of styles defined in the previous section.)

Listing 28-17. Defining Common Styles in the table.animations.ts File

```
import { trigger, style, state, transition, animate, group } from "@angular/core";

const commonStyles = {
    border: "black solid 4px",
    color: "white"
};

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style([commonStyles, {
        backgroundColor: "lightgreen",
        fontSize: "20px"
    }])),
    state("notselected", style([commonStyles, {
        backgroundColor: "lightsalmon",
        fontSize: "12px",
        color: "black"
    }])),
    state("void", style({
        opacity: 0
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected", animate("400 ms 200 ms ease-in")),
    transition("void => *", animate("500 ms"))
]);
```

The `commonStyles` object defines values for the `border` and `color` properties and is passed to the `style` function in an array along with the regular style objects. Angular processes the style objects in order, which means you can override a style value by redefining it in a later object. As an example, the second style object for the `notselected` state overrides the common value for the `color` property with a custom value. The result is that both the styles for both animation states incorporate the common value for the `border` property, and the styles for the `selected` state also use the common value for the `color` property, as shown in Figure 28-8.



ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit

Figure 28-8. *Defining common properties*

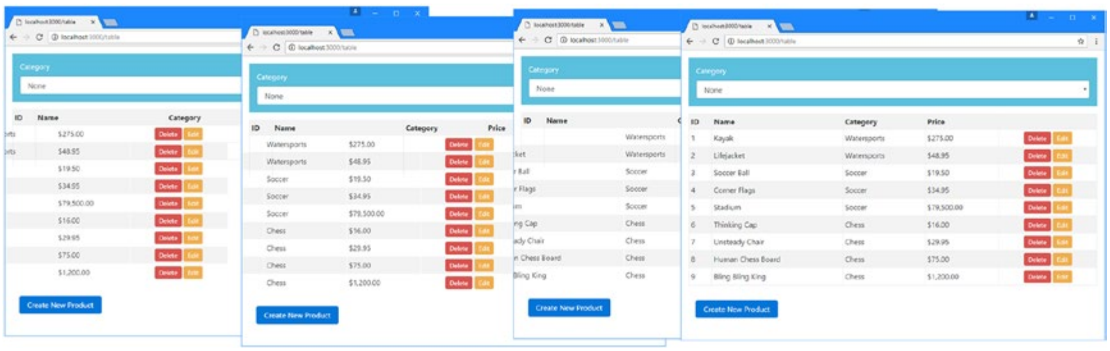
Using Element Transformations

All the examples so far in this chapter have animated properties that have affected an aspect of an element's appearance, such as background color, font size, or opacity. Animations can also be used to apply CSS element transformation effects, which are used to move, resize, rotate, or skew an element. These effects are applied by defining a `transform` property in a style group, as shown in Listing 28-18.

Listing 28-18. Using an Element Transformation in the table.animations.ts File

```
import { trigger, style, state, transition, animate, group } from "@angular/core";

const commonStyles = {
    border: "black solid 4px",
    color: "white"
};

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style([commonStyles, {
        backgroundColor: "lightgreen",
        fontSize: "20px"
    }])),
    state("notselected", style([commonStyles, {
        backgroundColor: "lightsalmon",
        fontSize: "12px",
        color: "black"
    }])),
    state("void", style({
        transform: "translateX(-50%)"
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected", animate("400 ms 200 ms ease-in")),
    transition("void => *",  animate("500 ms"))
]);
```

The value of the `transform` property is `translateX(50%)`, which tells Angular to move the element 50 percent of its length along the x-axis. The `transform` property has been applied to the `void` state, which means that it will be used on elements as they are being added to the template. The animation contains a transition from the `void` state to any other state and tells Angular to animate the changes over 500 milliseconds. The result is that new elements will be shifted to the left initially and then slid back into their default position over a period of half a second, as illustrated in Figure 28-9.



ID	Name	Category	Price
1	Kayak	Watersports	$275.00
2	Lifejacket	Watersports	$48.95
3	Soccer Ball	Soccer	$19.50
4	Corner Flags	Soccer	$34.95
5	Stadium	Soccer	$79,500.00
6	Thinking Cap	Chess	$16.00
7	Unsteady Chair	Chess	$29.95
8	Human Chess Board	Chess	$75.00
9	Bling Bling King	Chess	$1,200.00

Figure 28-9. *Transforming an element*

Table 28-8 describes the set of transformations that can be applied to elements.

■ **Tip** Multiple transformations can be applied in a single `transform` property by separating them with spaces, like this: `transform: "scale(1.1, 1.1) rotate(10 deg)"`.

Table 28-8. *The CSS Transformation Functions*

Function	Description
`translateX(offset)`	This function moves the element along the x-axis. The amount of movement can be specified as a percentage or as a length (expressed in pixels or one of the other CSS length units). Positive values translate the element to the right, negative values to the left.
`translateY(offset)`	This function moves the element along the y-axis.
`translate(xOffset, yOffset)`	This function moves the element along both axes.
`scaleX(amount)`	The function scales the element along the x-axis. The scaling size is expressed as a fraction of the element's regular size, such that `0.5` reduces the element to 50 percent of the original width and 2.0 will double the width.
`scaleY(amount)`	This function scales the element along the y-axis.
`scale(xAmount, yAmount)`	This function scales the element along both axes.
`rotate(angle)`	This function rotates the element clockwise. The amount of rotation is expressed as an angle, such as `90 deg` or `3.14 rad`.
`skewX(angle)`	This function skews the element along the x-axis by a specified angle, expressed in the same way as for the `rotate` function.
`skewY(angle)`	This function skews the element along the y-axis by a specified angle, expressed in the same way as for the `rotate` function.
`skew(xAngle, yAngle)`	This function skews the element along both axes.

Applying CSS Framework Styles

If you are using a CSS framework like Bootstrap, you may want to apply classes to elements, rather than having to define groups of properties. There is no built-in support for working directly with CSS classes, but the Document Object Model (DOM) and the CSS Object Model (CSSOM) provides API access to inspect the CSS stylesheets that have been loaded and to see whether they apply to an HTML element. To get the set of styles defined by classes, I created a file called `animationUtils.ts` to the `exampleApp/app/core` folder and added the code shown in Listing 28-19.

■ **Caution** This technique can require substantial processing in an application that uses a lot of complex stylesheets, and you may need to adjust the code to work with different browsers and different CSS frameworks.

Listing 28-19. The Contents of the animationUtils.ts File in the exampleApp/app/core Folder

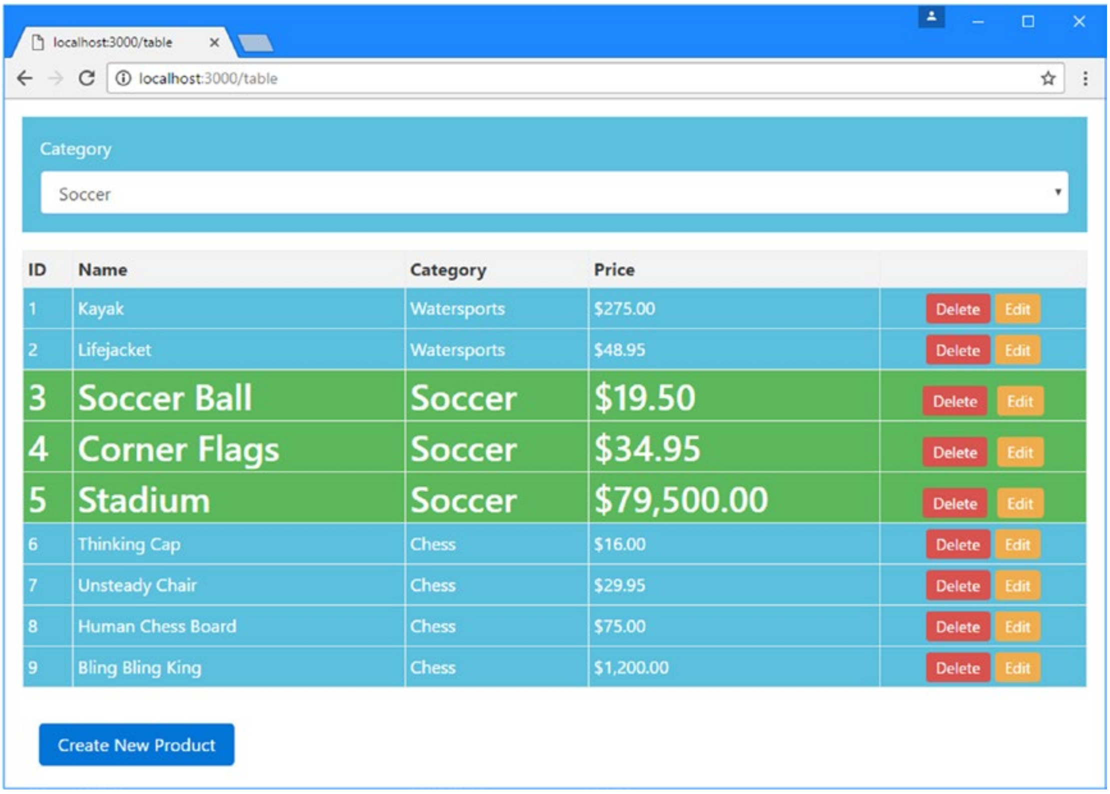
```
export function getStylesFromClasses(names: string | string[],
        elementType: string = "div") : { [key: string]: string | number } {

    let elem = document.createElement(elementType);
    (typeof names == "string" ? [names] : names).forEach(c => elem.classList.add(c));

    let result = {};
    for (let i = 0; i < document.styleSheets.length; i++) {
        let sheet = document.styleSheets[i] as CSSStyleSheet;
        let rules = sheet.rules || sheet.cssRules;
        for (let j = 0; j < rules.length; j++) {
            if (rules[j].type == CSSRule.STYLE_RULE) {
                let styleRule = rules[j] as CSSStyleRule;
                if (elem.matches(styleRule.selectorText)) {
                    for (let k = 0; k < styleRule.style.length; k++) {
                        result[styleRule.style[k]] =
                            styleRule.style[styleRule.style[k]];
                    }
                }
            }
        }
    }
    return result;
}
```

The `getStylesFromClass` method accepts a single class name or an array of class names and the element type to which they should be applied, which defaults to a `div` element. An element is created and assigned to the classes and then inspected to see which of the CSS rules defined in the CSS stylesheets apply to it. The style properties for each matching style are added to an object that can be used to create Angular animation style groups, as shown in Listing 28-20.

Listing 28-20. Using Bootstrap Classes in the table.animations.ts File

```
import { trigger, style, state, transition, animate, group } from "@angular/core";
import { getStylesFromClasses } from "./animationUtils";

export const HighlightTrigger = trigger("rowHighlight", [
    state("selected", style(getStylesFromClasses(["bg-success", "h2"]))),
    state("notselected", style(getStylesFromClasses("bg-info"))),
    state("void", style({
        transform: "translateX(-50%)"
    })),
    transition("* => notselected", animate("200 ms")),
    transition("* => selected", animate("400 ms 200 ms ease-in")),
    transition("void => *", animate("500 ms"))
]);
```

The `selected` state uses the styles defined in the Bootstrap `bg-success` and `h2` classes, and the `notselected` state uses the styles defined by the Bootstrap `bg-info` class, producing the results shown in Figure 28-10.



Category

Soccer

ID	Name	Category	Price	
1	Kayak	Watersports	$275.00	Delete Edit
2	Lifejacket	Watersports	$48.95	Delete Edit
3	Soccer Ball	Soccer	$19.50	Delete Edit
4	Corner Flags	Soccer	$34.95	Delete Edit
5	Stadium	Soccer	$79,500.00	Delete Edit
6	Thinking Cap	Chess	$16.00	Delete Edit
7	Unsteady Chair	Chess	$29.95	Delete Edit
8	Human Chess Board	Chess	$75.00	Delete Edit
9	Bling Bling King	Chess	$1,200.00	Delete Edit

Create New Product

Figure 28-10. *Using CSS framework styles in Angular animations*

Understanding Animation Trigger Events

By comparison to the other animation building blocks, triggers are relatively simple. They provide a wrapper around a set of states and transitions and provide the connection between the elements that animations are applied to, meaning the data model and the animation configuration.

There is one feature that I have yet to describe, however, which is that the directive that applies triggers to elements emits events about the animations it performs. The events are expressed using the `AnimationTransitionEvent` class, which defines the properties described in Table 28-9.

Table 28-9. *The AnimationTransitionEvent Properties*

Name	Description
`fromState`	This property returns the state that the element is exiting.
`toState`	This property returns the state that the element is entering.
`totalTime`	This property returns the duration of the animation.

The animation directive provides `start` and `done` properties that can be used in event bindings, as shown in Listing 28-21.

Listing 28-21. Binding to Animation Events in the table.component.html File

```
<div class="form-group bg-info p-a-1">
    <label>Category</label>
    <select [(ngModel)]="highlightCategory" class="form-control">
        <option value="">None</option>
        <option *ngFor="let category of categories">
            {{category}}
        </option>
    </select>
</div>
<table class="table table-sm table-bordered table-striped">
    <tr>
        <th>ID</th><th>Name</th><th>Category</th><th>Price</th><th></th>
    </tr>
    <tr *ngFor="let item of getProducts()"
            [@rowHighlight]="getRowState(item.category)"
            (@rowHighlight.start)="writeAnimationEvent($event, item.name, true)"
            (@rowHighlight.done)="writeAnimationEvent($event, item.name, false)">
        <td style="vertical-align:middle">{{item.id}}</td>
        <td style="vertical-align:middle">{{item.name}}</td>
        <td style="vertical-align:middle">{{item.category}}</td>
        <td style="vertical-align:middle">
            {{item.price | currency:"USD":true }}
        </td>
        <td class="text-xs-center">
            <button class="btn btn-danger btn-sm"
                    (click)="deleteProduct(item.id)">
                Delete
            </button>
            <button class="btn btn-warning btn-sm"
                [routerLink]="['/form', 'edit', item.id]">
                Edit
            </button>
        </td>
    </tr>
</table>
<div class="col-xs-12 p-t-1">
    <button class="btn btn-primary" routerLink="/form/create">
        Create New Product
    </button>
</div>
```

These bindings target a component method called `writeAnimationEvent`, which is given the event, the name of the product that the `tr` element displays, and whether or not this is the start event. Listing 28-22 shows the implementation of this method in the component, which simply writes out the details to the browser's JavaScript console.

Listing 28-22. Handling Animation Events in the table.component.ts File

```
import { Component, Inject } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { ActivatedRoute } from "@angular/router";
import { HighlightTrigger } from "./table.animations";
import { AnimationTransitionEvent } from "@angular/core";

@Component({
    selector: "paTable",
    moduleId: module.id,
    templateUrl: "table.component.html",
    animations: [HighlightTrigger]
})
export class TableComponent {
    category: string = null;

    constructor(private model: Model, activeRoute: ActivatedRoute) {
        activeRoute.params.subscribe(params => {
            this.category = params["category"] || null;
        })
    }

    getProduct(key: number): Product {
        return this.model.getProduct(key);
    }

    getProducts(): Product[] {
        return this.model.getProducts()
            .filter(p => this.category == null || p.category == this.category);
    }

    get categories(): string[] {
        return this.model.getProducts()
            .map(p => p.category)
            .filter((category, index, array) => array.indexOf(category) == index);
    }

    deleteProduct(key: number) {
        this.model.deleteProduct(key);
    }

    highlightCategory: string = "";

    getRowState(category: string): string {
        return this.highlightCategory == "" ? "" :
            this.highlightCategory == category ? "selected" : "notselected";
    }
    writeAnimationEvent(event: AnimationTransitionEvent,
        name: string, start: boolean) {
        console.log("Animation " + name + " " + (start ? 'Start' : 'Done')
            + " from: " + event.fromState + " to: " + event.toState + " time: "
            + event.totalTime);
    }
}
```

When you pick a category, you will see details of the animations for each table row displayed in the browser's JavaScript console, like this:

```
Animation Lifejacket Start from: notselected to: selected time: 600
Animation Soccer Ball Start from: selected to: notselected time: 200
Animation Corner Flags Start from: selected to: notselected time: 200
Animation Stadium Start from: selected to: notselected time: 200
Animation Soccer Ball Done from: selected to: notselected time: 200
Animation Corner Flags Done from: selected to: notselected time: 200
Animation Stadium Done from: selected to: notselected time: 200
Animation Kayak Done from: notselected to: selected time: 600
Animation Lifejacket Done from: notselected to: selected time: 600
```

Summary

I described the Angular animation system in this chapter and explained how it uses data bindings to animate changes in the application's state. In the next chapter, I describe the features that Angular provides to support unit testing.

CHAPTER 29

Angular Unit Testing

In this chapter, I describe the tools that Angular provides for unit testing components and directives. Some Angular building blocks, such as pipes and services, can be readily tested in isolation using the basic testing tools that I set up at the start of the chapter. Components (and, to a lesser extent, directives) have complex interactions with their host elements and with their template content and require special features. Table 29-1 puts Angular unit testing in context.

Table 29-1. *Putting Angular Unit Testing Context*

Question	Answer
What is it?	Angular components and directives require special support for testing so that their interactions with other parts of the application infrastructure can be isolated and inspected.
Why is it useful?	Isolated unit tests are able to assess the basic logic provided by the class that implements a component or directive but do not capture the interactions with host elements, services, templates, and other important Angular features.
How is it used?	Angular provides a test bed that allows a realistic application environment to be created and then used to perform unit tests.
Are there any pitfalls or limitations?	Like much of Angular, the unit testing tools are complex. It can take some time and effort to get to the point where unit tests are easily written and run and you are sure that you have isolated the correct part of the application for testing.
Are there any alternatives?	As noted, you don't have to unit test your projects. But if you do want to unit testing, then you will need to use the Angular features described in this chapter.

A. Freeman, *Pro Angular*, DOI 10.1007/978-1-4842-2307-9_29

Table 29-2 summarizes the chapter.

Table 29-2. *Chapter Summary*

Problem	Solution	Listing
Prepare for unit testing	Add the Karma and Jasmine packages to the project and configure them.	1–8
Perform a basic test on a component	Initialize a test module and create an instance of the component. If the component has an external template, an additional compilation step must be performed.	9–12, 14–16
Test a component's data bindings	Use the `DebugElement` class to query the component's template.	13
Test a component's response to events	Trigger the events using the debug element.	14–19
Test a component's output properties	Subscribe to the `EventEmitter` created by the component.	20, 21
Test a component's input properties	Create a test component whose template applies the component under test.	22, 23
Perform a test that relies on an asynchronous operation	Use the `whenStable` method to defer the test until the effect of the operation has been processed.	24, 25
Test a directive	Create a test component whose template applies the directive under test.	26, 27

DECIDING WHETHER TO UNIT TEST

Unit testing is a contentious topic. This chapter assumes you do want to do unit testing and shows you how to set up the tools and apply them to Angular components and directives. It isn't an introduction to unit testing, and I make no effort to persuade skeptical readers that unit testing is worthwhile. If would like an introduction to unit testing, then there is a good article here: `https://en.wikipedia.org/wiki/Unit_testing`.

I like unit testing, and I use it in my own projects—but not all of them and not as consistently as you might expect. I tend to focus on writing unit tests for features and functions that I know will be hard to write and that are likely to be the source of bugs in deployment. In these situations, unit testing helps structure my thoughts about how to best implement what I need. I find that just thinking about what I need to test helps produce ideas about potential problems, and that's before I start dealing with actual bugs and defects.

That said, unit testing is a tool and not a religion, and only you know how much testing you require. If you don't find unit testing useful or if you have a different methodology that suits you better, then don't feel you need to unit test just because it is fashionable. (However, if you don't have a better methodology and you are not testing at all, then you are probably letting users find your bugs, which is rarely ideal.)

Preparing the Example Project

I continue to use the exampleApp project from earlier chapters. I need a simple target to focus on for unit testing, so Listing 29-1 changes the routing configuration so that the ondemand feature module is loaded by default.

Listing 29-1. Changing the Routing Configuration in the app.routing.ts File

```
import { Routes, RouterModule } from "@angular/router";
import { TableComponent } from "./core/table.component";
import { FormComponent } from "./core/form.component";
import { NotFoundComponent } from "./core/notFound.component";
import { ProductCountComponent } from "./core/productCount.component";
import { CategoryCountComponent } from "./core/categoryCount.component";
import { ModelResolver } from "./model/model.resolver";
import { TermsGuard } from "./terms.guard";
import { UnsavedGuard } from "./core/unsaved.guard";
import { LoadGuard } from "./load.guard";

const routes: Routes = [
    {
        path: "ondemand",
        loadChildren: "app/ondemand/ondemand.module#OndemandModule"
    },
    { path: "", redirectTo: "/ondemand", pathMatch: "full" }
]

export const routing = RouterModule.forRoot(routes);
```

This module contains some simple components that I will use to demonstrate different unit testing features. To keep the content shown by the application simple, Listing 29-2 tidies up the template displayed by the top-level component in the feature module.

Listing 29-2. Simplifying the Template in the ondemand.component.html File

```
<div class="col-xs-12 p-a-1">
    <router-outlet></router-outlet>
</div>
<div class="col-xs-6">
    <router-outlet name="left"></router-outlet>
</div>
<div class="col-xs-6">
    <router-outlet name="right"></router-outlet>
</div>
<div class="p-a-1">
    <button class="btn btn-secondary m-t-1" routerLink="/ondemand">Normal</button>
    <button class="btn btn-secondary m-t-1" routerLink="/ondemand/swap">Swap</button>
</div>
```

Adding the Testing Packages

To set up and perform unit tests, I added a number of packages to the project, as shown in Listing 29-3.

■ **Caution** You can use any modern browser for running Angular applications, but the examples in this chapter assume you are using Google Chrome to run the unit tests. You will need to install Chrome if you want to follow the examples.

Listing 29-3. Adding Unit Testing Packages in the package.json File

```
{
  "dependencies": {
    "@angular/common": "2.2.0",
    "@angular/compiler": "2.2.0",
    "@angular/core": "2.2.0",
    "@angular/platform-browser": "2.2.0",
    "@angular/platform-browser-dynamic": "2.2.0",
    "@angular/upgrade": "2.2.0",
    "@angular/forms": "2.2.0",
    "@angular/http": "2.2.0",
    "@angular/router": "3.2.0",
    "reflect-metadata": "0.1.8",
    "rxjs": "5.0.0-beta.12",
    "zone.js": "0.6.26",
    "core-js": "2.4.1",
    "classlist.js": "1.1.20150312",
    "systemjs": "0.19.40",
    "bootstrap": "4.0.0-alpha.4",
    "intl": "1.2.4",
    "html5-history-api": "4.2.7",
    "web-animations-js": "2.2.2"
  },

  "devDependencies": {
    "lite-server": "2.2.2",
    "typescript": "2.0.2",
    "typings": "1.3.2",
    "concurrently": "2.2.0",
    "systemjs-builder": "0.15.32",
    "json-server": "0.8.21",
    "jasmine-core": "2.5.2",
    "karma": "1.3.0",
    "karma-jasmine": "1.0.2",
    "karma-chrome-launcher": "2.0.0"
  },

  "scripts": {
    "start": "concurrently \"npm run tscwatch\" \"npm run lite\" \"npm run json\" ",
    "tsc": "tsc",
    "tscwatch": "tsc -w",
    "lite": "lite-server",
    "json": "json-server --p 3500 restData.js",
    "karma": "karma start karma.conf.js",
    "tests": "npm run karma"
    "typings": "typings",
    "postinstall": "typings install"
  }
}
```

I use two different tools to perform unit testing in this chapter. Jasmin is a popular unit testing framework that allows test to be defined and evaluated. The code that is contained in the unit test files is written using the Jasmine API, which I describe in the "Working with Jasmine" section.

Karma is a test runner, which means it monitors the files in a project and runs the tests that have been defined using Jasmine when it detects a change. Together, these tools make it easy to define and run unit tests in JavaScript projects. There are some wrinkles introduced by Angular, however, which means that the process for configuring Karma and writing unit tests for Angular applications requires some measures that are not required for unit testing other kinds of JavaScript code.

Save the changes to the `package.json` file and run the following command in the `exampleApp` folder to download and install the new packages:

```
npm install
```

Configuring Karma

The most difficult part of setting up unit testing is getting the correct configuration, which can require some trial and error. The problem is that testing Angular applications requires using the JavaScript module loader to handle the dependencies in the application so that the unit test can access Angular functionality, which in turn requires the JavaScript packages that Angular relies on. The first step is to create a Karma configuration file, which I did by adding a file called `karma.conf.js` to the `exampleApp` folder and adding the configuration code shown in Listing 29-4.

Listing 29-4. The Contents of the karma.conf.js File in the exampleApp Folder

```
module.exports = (config) => { config.set({
frameworks: ["jasmine"],
plugins: [require("karma-jasmine"), require("karma-chrome-launcher")],

files: [
    "node_modules/reflect-metadata/Reflect.js",
    "node_modules/systemjs/dist/system.src.js",
    "node_modules/zone.js/dist/zone.js",
    "node_modules/zone.js/dist/proxy.js",
    "node_modules/zone.js/dist/sync-test.js",
    "node_modules/zone.js/dist/jasmine-patch.js",
    "node_modules/zone.js/dist/async-test.js",
    "node_modules/zone.js/dist/fake-async-test.js",
    { pattern: "node_modules/rxjs/**/*.js", included: false, watched: false },
    { pattern: "node_modules/@angular/**/*.js", included: false, watched: false },
    { pattern: "app/**/*.js", included: false, watched: true },
    { pattern: "app/**/*.html", included: false, watched: true },
    { pattern: "app/**/*.css", included: false, watched: true },
    { pattern: "tests/**/*.js", included: false, watched: true },

    { pattern: "karma-test-shim.js", included: true, watched: true },
],
reporters: ["progress"],
port: 9876,
colors: true,
logLevel: config.LOG_INFO,
autoWatch: true,
browsers: ["Chrome"],
singleRun: false
})}
```

The most important part of the configuration is the `files` section, which is used to configure the files that will be used in unit testing. The first set of entries includes the files required to support Angular unit testing and provide Karma with the Reactive Extensions and Angular framework files. The second set of files tells Karma how to find the application's JavaScript, HTML, and CSS files, as well as the test files.

■ **Tip** I like to keep my unit tests separate from the rest of the application in a folder called `tests`. Some developers prefer to mix tests and code side by side, and either approach can be used in Angular unit testing.

The final entry specifies a file called `karma-test-shim.js`, which is responsible for setting up the test environment required by Angular. I added this file in the exampleApp folder and added the code shown in Listing 29-5.

Listing 29-5. The Contents of the karma-test-shim.js File in the exampleApp Folder

```
__karma__.loaded = function () {};

let map = { "rxjs": "node_modules/rxjs" };

var angularModules = ["common", "compiler", "core", "platform-browser",
    "platform-browser-dynamic", "forms", "http", "router"];

angularModules.forEach(module => {
    map[`@angular/${module}`] =
        `node_modules/@angular/${module}/bundles/${module}.umd.js`;
    map[`@angular/${module}/testing`] =
        `node_modules/@angular/${module}/bundles/${module}-testing.umd.js`
});

System.config({ baseURL: "/base", map: map, defaultJSExtensions: true });

Promise.all([
  System.import("@angular/core/testing"),
  System.import("@angular/platform-browser-dynamic/testing")
]).then(providers => {
    var testing = providers[0];
    var testingBrowser = providers[1];

    testing.TestBed.initTestEnvironment(testingBrowser.BrowserDynamicTestingModule,
      testingBrowser.platformBrowserDynamicTesting());

}).then(() => Promise.all(Object.keys(window.__karma__.files)
    .filter(name => name.endsWith("spec.js"))
    .map(moduleName => System.import(moduleName))))
.then(__karma__.start, __karma__.error);
```

The first part of the file creates the SystemJS configuration that will be used to resolve JavaScript module dependencies. The second part creates a `Promise` that loads the basic testing modules, sets up the Angular testing framework, and imports the unit tests.

■ **Tip** In this chapter, I define unit tests in files whose names end with `spec.js`. There is a filter function in Listing 29-5 that uses this naming convention to locate the unit tests in the project. You will need to modify this function if you use a different naming convention.

Configuring TypeScript

TypeScript requires type annotations so that it can understand the Jasmine API. Run the following command in the `exampleApp` folder to download and install type information for Jasmine:

```
npm run typings -- install dt~jasmine --save --global
```

Creating a Simple Unit Test

To make sure that the unit testing framework is working, it is helpful to create a basic unit test. I added a file called `frameworkTest.spec.ts` in the `tests` folder and added the code shown in Listing 29-6.

Listing 29-6. The Contents of the frameworkTest.spec.ts File in the exampleApp/tests Folder

```
describe("Jasmine Test Environment", () => {
    it("is working", () => expect(true).toBe(true));
});
```

I explain the basics of working with the Jasmine API shortly, and you can ignore the syntax for the moment.

Starting the Tools

I am going to run the unit tests alongside the application, which will allow me to add features to the application and test the same time. This requires two command prompts. In the first, navigate to the `exampleApp` folder and run the following command:

```
npm start
```

This command starts the TypeScript compiler, the development HTTP server, and the RESTful web service. A new browser tab will open and show the content illustrated by Figure 29-1.

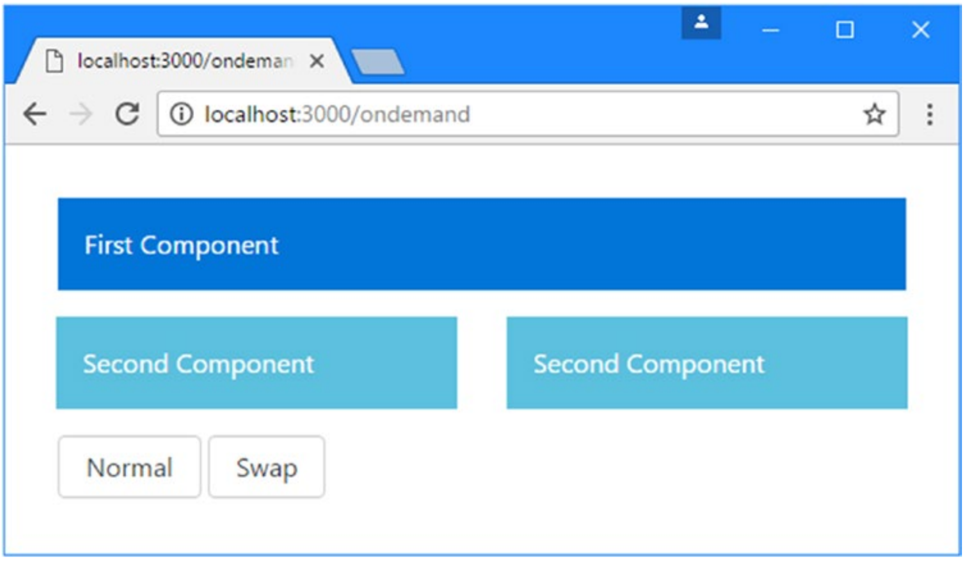
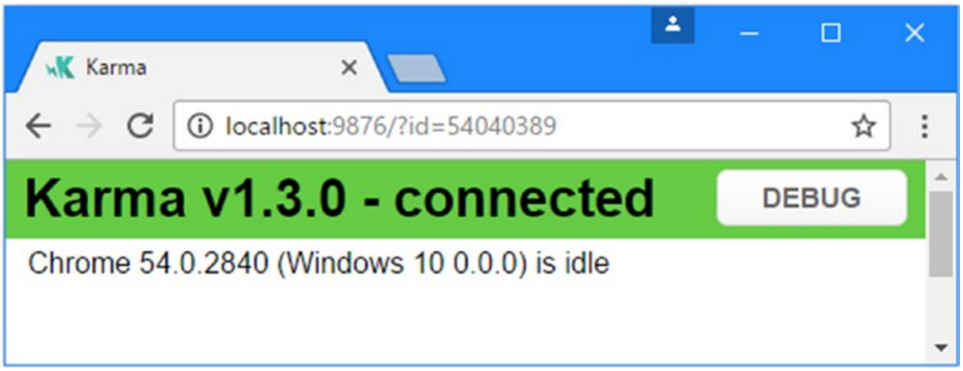


Figure 29-1. *Running the example application*

Using a second command prompt, navigate to the `exampleApp` folder and run the following command:

```
npm run tests
```

This command uses the `scripts` entry I added to the `package.json` file at the start of the chapter and starts the Karma test runner. A new tab will appear, as shown in Figure 29-2.



Karma v1.3.0 - connected

Chrome 54.0.2840 (Windows 10 0.0.0) is idle

Figure 29-2. *Starting the Karma test runner*

The browser window is used to run the tests, but the important information is written out to the command prompt used to start the test runner, where you will see a message like this:

```
Chrome 54.0.2840 (Windows 10 0.0.0): Executed 1 of 1 SUCCESS (0.002 secs / 0 secs)
```

This shows that the one unit test in the project has been located and has been executed successfully. Whenever you make a change that updates one of the JavaScript files in the project, the unit tests will be located and executed, and any problems will be written to the command prompt. To show what an error looks like, Listing 29-7 changes the unit test so that it will fail.

Listing 29-7. Making a Unit Test Fail in the frameworkTest.spec.ts File

```
describe("Jasmine Test Environment", () => {
    it("is working", () => expect(true).toBe(false));
});
```

This test will fail and will result in the following output, which indicates the test that has failed and what went wrong:

```
Chrome 54.0.2840 (Windows 10 0.0.0) Jasmine Test Environment is working FAILED
[1]     Expected true to be false.
[1]         at Object.eval (tests/frameworkTest.spec.js:2:56)
[1]         at ZoneDelegate.invoke (node_modules/zone.js/dist/zone.js:232:26)
[1]         at ProxyZoneSpec.onInvoke (node_modules/zone.js/dist/proxy.js:79:39)
[1]         at ZoneDelegate.invoke (node_modules/zone.js/dist/zone.js:231:32)
Chrome 54.0.2840 (Windows 10 0.0.0): Executed 1 of 1 (1 FAILED) ERROR
```

Working with Jasmine

The API that Jasmine provides chains together JavaScript methods to define unit tests. You can find the full documentation for Jasmine at `http://jasmine.github.io`, but Table 29-3 describes the most useful functions for Angular testing.

Table 29-3. *Useful Jasmine Methods*

Name	Description
`describe(description, function)`	This method is used to group together a set of related tests.
`beforeEach(function)`	This method is used to specify a task that is performed before each unit test.
`afterEach(function)`	This method is used to specify a test that is performed after each unit test.
`it(description, function)`	This method is used to perform the test action.
`expect(value)`	This method is used to identity the result of the test.
`toBe(value)`	This method specifies the expected value of the test.

You can see how the methods in Table 29-3 were used to create the unit test in Listing 29-7.

```
...
describe("Jasmine Test Environment", () => {
    it("is working", () => expect(true).toBe(false));
});
...
```

You can also see why the test has failed, since the `expect` and `toBe` methods have been used to check that `true` and `false` are equal. Since this cannot be the case, the test fails.

The `toBe` method isn't the only way to evaluate the result of a unit test. Table 29-4 shows other evaluation methods provided by Angular.

Table 29-4. *Useful Jasmine Evaluation Methods*

Name	Description
`toBe(value)`	This method asserts that a result is the same as the specified value (but need not be the same object).
`toEqual(object)`	This method asserts that a result is the same object as the specified value.
`toMatch(regexp)`	This method asserts that a result matches the specified regular expression.
`toBeDefined()`	This method asserts that the result has been defined.
`toBeUndefined()`	This method asserts that the result has not been defined.
`toBeNull()`	This method asserts that the result is null.
`toBeTruthy()`	This method asserts that the result is truthy, as described in Chapter 12.
`toBeFalsy()`	This method asserts that the result is falsy, as described in Chapter 12.
`toContain(substring)`	This method asserts that the result contains the specified substring.
`toBeLessThan(value)`	This method asserts that the result is less than the specified value.
`toBeGreaterThan(value)`	This method asserts that the result is more than the specified value.

Listing 29-8 shows how these evaluation methods can be used in tests, replacing the failing test from the previous section.

Listing 29-8. Replacing the Unit Test in the frameworkTest.spec.ts File

```
describe("Jasmine Test Environment", () => {
    it("test numeric value", () => expect(12).toBeGreaterThan(10));
    it("test string value", () => expect("London").toMatch("^Lon"));
});
```

When you save the changes to the file, the tests will be executed, and the results will be shown in the command prompt.

Testing an Angular Component

The building blocks of an Angular application can't be tested in isolation because they depend on the underlying features provided by Angular and by the other parts of the project, including the services, directives, templates, and modules it contains. As a consequence, testing a building block such as a component means using testing utilities that are provided by Angular to re-create enough of the application to let the component function so that tests can be performed against it. In this section, I walk through the process of performing a unit test on the `FirstComponent` class in the `OnDemand` feature module, which was added to the project in Chapter 27. As a reminder, here is the definition of the component:

```
import { Component } from "@angular/core";

@Component({
    selector: "first",
    template: `<div class="bg-primary p-a-1">First Component</div>`
})
export class FirstComponent { }
```

This component is so simple that it doesn't have functionality of its own to test, but it is enough to demonstrate how the test process is applied.

Working with the TestBed Class

At the heart of Angular unit testing is a class called `TestBed`, which is responsible for simulating the Angular application environment so that tests can be performed. Table 29-5 describes the most useful methods provided by the `TestBed` method, all of which are static, as described in Chapter 6.

Table 29-5. *Useful TestBed Methods*

Name	Description
`configureTestingModule`	This method is used to configure the Angular testing module.
`createComponent`	This method is used to create an instance of the component.
`compileComponents`	This method is used to compile components, as described in the "Testing a Component with an External Template" section.

The `configureTestingModule` method is used to configure the Angular module that is used in testing, using the same properties supported by the `@NgModel` decorator. Just like in a real application, a component cannot be used in a unit test unless it has been added to the `declarations` property of the module. This means that the first step in most unit tests is to configure the testing module. To demonstrate, I added a file called `first.component.spec.ts` in the `tests` folder and added the code shown in Listing 29-9.

Listing 29-9. The Contents of the first.component.spec.ts File in the tests Folder

```
import { TestBed } from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";

describe("FirstComponent", () => {
    beforeEach(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent]
        });
    });
});
```

The TestBed class is defined in the @angular/core/testing module, and the configureTestingModule accepts an object whose declarations property tells the test module that the FirstComponent class is going to be used.

■ **Tip** Notice that the TestBed class is used within the beforeEach function. If you try to use the TestBed outside of this function, you will see an error about using Promises.

The next step is to create a new instance of the component so that it can be used in tests. This is done using the createComponent method, as shown in Listing 29-10.

Listing 29-10. Creating an Instance of the Component in the first.component.spec.ts File

```
import { TestBed, ComponentFixture} from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";

describe("FirstComponent", () => {

    let fixture: ComponentFixture<FirstComponent>;
    let component: FirstComponent;

    beforeEach(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent]
        });
        fixture = TestBed.createComponent(FirstComponent);
        component = fixture.componentInstance;
    });

    it("is defined", () => {
        expect(component).toBeDefined()
    });
});
```

The argument to the createComponent method tells the test bed which component type it should instantiate, which is FirstComponent in this case. The result is a ComponentFixture<FirstComponent> object, which provides features for testing a component, using the methods and properties described in Table 29-6.

Table 29-6. *Useful ComponentFixture Methods and Properties*

Name	Description
`componentInstance`	This property returns the component object.
`debugElement`	This property returns the test host element for the component.
`nativeElement`	This property returns the DOM object representing the host element for the component.
`detectChanges()`	This method causes the test bed to detect state changes and reflect them in the component's template.
`whenStable()`	This method returns a `Promise` that is resolved when the effect of an operation has been fully applied. See the "Testing with Asynchronous Operations" section for details.

In the listing, I use the `componentInstance` property to get the `FirstComponent` object that has been created by the test bed and perform a simple test to ensure that it has been created by using the `expect` method to select the `component` object as the target of the test and the `toBeDefined` method to perform the test. I demonstrate the other methods and properties in the sections that follow.

■ **Tip** The initial configuration for the `TestBed` class is performed in the `karma-test-shim.js` file, which is shown in Listing 29-5, and prepares the testing environment so that it can be used in individual unit tests.

Configuring the Test Bed for Dependencies

One of the most important features of Angular applications is dependency injection, which allows components and other building blocks to receive services by declaring dependencies on them using constructor parameters. Listing 29-11 adds a dependency on the data model repository service to the `FirstComponent` class.

Listing 29-11. Adding a Service Dependency in the first.component.ts File

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";

@Component({
    selector: "first",
    template: `<div class="bg-primary p-a-1">
                There are
                    <span class="strong"> {{getProducts().length}} </span>
                products
               </div>`
})
```

```
export class FirstComponent {

    constructor(private repository: Model) {}

    category: string = "Soccer";

    getProducts(): Product[] {
        return this.repository.getProducts()
            .filter(p => p.category == this.category);
    }
}
```

The component uses the repository to provide a filtered collection of `Product` objects, which are exposed though a method called `getProducts` and filtered using a `category` property. The inline template has a corresponding data binding that displays the number of products that the `getProducts` method returns.

Being able to unit test the component means providing it with a repository service. The Angular test bed will take care of resolving dependencies as long as they are configured through the test module. Effective unit testing generally requires components to be isolated from the rest of the application, which means that mock or fake objects (also known as *test doubles*) are used as substitutes for real services in unit tests. Listing 29-12 configures the test bed so that a fake repository is used to provide the component with its service.

Listing 29-12. Providing a Service in the first.component.spec.ts File

```
import { TestBed, ComponentFixture} from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";
import { Product } from "../app/model/product.model";
import { Model } from "../app/model/repository.model";

describe("FirstComponent", () => {

    let fixture: ComponentFixture<FirstComponent>;
    let component: FirstComponent;

    let mockRepository = {
        getProducts: function () {
            return [
                new Product(1, "test1", "Soccer", 100),
                new Product(2, "test2", "Chess", 100),
                new Product(3, "test3", "Soccer", 100),
            ]
        }
    }

    beforeEach(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent],
            providers: [
                { provide: Model, useValue: mockRepository }
            ]
        });
        fixture = TestBed.createComponent(FirstComponent);
        component = fixture.componentInstance;
    });

    it("filters categories", () => {
        component.category = "Chess"
        expect(component.getProducts().length).toBe(1);
        component.category = "Soccer";
        expect(component.getProducts().length).toBe(2);
        component.category = "Running";
        expect(component.getProducts().length).toBe(0);
    });
});
```

The `mockRepository` variable is assigned an object that provides a `getProducts` method that returns fixed data that can be used to test for known outcomes. To provide the component with the service, the `providers` property for the object passed to the `TestBed.configureTestingModule` method is configured in the same way as a real Angular module, using the value provider to resolve dependencies on the `Model` class using the `mockRepository` variable. The test invokes the component's `getProducts` method and compares the results with the expected outcome, changing the value of the `category` property to check different filters.

Testing Data Bindings

The previous example showed how a component's properties and methods can be used in a unit test. This is a good start, but many components will also include small fragments of functionality in the data binding expressions contained in their templates, and these should be tested as well. Listing 29-13 checks that the data binding in the component's template correctly displays the number of products in the mock data model.

Listing 29-13. Unit Testing a Data Binding in the first.component.spec.ts File

```
import { TestBed, ComponentFixture} from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";
import { Product } from "../app/model/product.model";
import { Model } from "../app/model/repository.model";
import { DebugElement } from "@angular/core";
import { By } from "@angular/platform-browser";

describe("FirstComponent", () => {

    let fixture: ComponentFixture<FirstComponent>;
    let component: FirstComponent;
    let debugElement: DebugElement;
    let bindingElement: HTMLSpanElement;

    let mockRepository = {
        getProducts: function () {
            return [
                new Product(1, "test1", "Soccer", 100),
                new Product(2, "test2", "Chess", 100),
                new Product(3, "test3", "Soccer", 100),
            ]
        }
    }

    beforeEach(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent],
            providers: [
                { provide: Model, useValue: mockRepository }
            ]
        });
        fixture = TestBed.createComponent(FirstComponent);
        component = fixture.componentInstance;
        debugElement = fixture.debugElement;
        bindingElement = debugElement.query(By.css("span")).nativeElement;
    });

    it("filters categories", () => {
        component.category = "Chess"
        fixture.detectChanges();
        expect(component.getProducts().length).toBe(1);
        expect(bindingElement.textContent).toContain("1");

        component.category = "Soccer";
        fixture.detectChanges();
        expect(component.getProducts().length).toBe(2);
        expect(bindingElement.textContent).toContain("2");

        component.category = "Running";
        fixture.detectChanges();
        expect(component.getProducts().length).toBe(0);
        expect(bindingElement.textContent).toContain("0");
    });
});
```

The `ComponentFixture.debugElement` property returns a `DebugElement` object that represents the root element from the component's template, and Table 29-7 lists the most useful methods and properties described by the `DebugElement` class.

Table 29-7. *Useful DebugElement Properties and Methods*

Name	Description
`nativeElement`	This property returns the object that represents the HTML element in the DOM.
`children`	This property returns an array of `DebugElement` objects representing the children of this element.
`query(selectorFunction)`	The `selectorFunction` is passed a `DebugElement` object for each HTML element in the component's template, and this method returns the first `DebugElement` for which the function returns `true`.
`queryAll(selectorFunction)`	Similar to the `query` method, except the result is all the `DebugElement` objects for which the function returns `true`.
`triggerEventHandler(name, event)`	This method triggers an event. See the "Testing Component Events" section for details.

Locating elements is done through the `query` and `queryAll` methods, which accept functions that inspect `DebugElement` objects and return true if they should be included in the results. The `By` class, defined in the `@angular/platform-browser` module, makes it easier to locate elements in the component's template through the static methods described in Table 29-8.

Table 29-8. *The By Methods*

Name	Description
`By.all()`	This method returns a function that matches any element.
`By.css(selector)`	This method returns a function that uses a CSS selector to match elements.
`By.directive(type)`	This method returns a function that matches elements to which the specified directive class has been applied, as demonstrated in the "Testing Input Properties" section.

In the listing, I use the `By.css` method to locate the first `span` element in the template and access the DOM object that represents it through the `nativeElement` property so that I can check the value of the `textContent` property in the unit tests.

Notice that after each change to the component's `category` property, I call the `ComponentFixture` object's `detectChanges` method, like this:

```
...
component.category = "Soccer";
fixture.detectChanges();
expect(component.getProducts().length).toBe(2);
expect(bindingElement.textContent).toContain("2");
...
```

This method tells the Angular testing environment to process any changes and evaluate the data binding expressions in the template. Without this method call, the change to the value of the category component would not be reflected in the template, and the test would fail.

Testing a Component with an External Template

Angular components are compiled into factory classes, either within the browser or by the Ahead-of-Time compiler that I demonstrated in Chapter 10. As part of this process, Angular processes any external templates and includes them as text in the JavaScript code that is generated similar to an inline template. When unit testing a component with an external template, the compilation step must be performed explicitly. In Listing 29-14, I changed the @Component decorator applied to the FirstComponent class so that it specifies an external template.

Listing 29-14. Specifying an External Template in the first.component.ts File

```
import { Component } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";

@Component({
    selector: "first",
    moduleId: module.id,
    templateUrl: "first.component.html"
})
export class FirstComponent {

    constructor(private repository: Model) {}

    category: string = "Soccer";

    getProducts(): Product[] {
        return this.repository.getProducts()
            .filter(p => p.category == this.category);
    }
}
```

To provide the template, I created a file called first.component.html in the exampleApp/app/ondemand folder and added the elements shown in Listing 29-15.

Listing 29-15. The first.component.html File in the exampleApp/app/ondemand Folder

```
<div class="bg-primary p-a-1">
    There are
        <span class="strong"> {{getProducts().length}} </span>
    products
</div>
```

This is the same content that was previously defined inline. Listing 29-16 updates the unit test for the component to deal with the external template by explicitly compiling the component.

Listing 29-16. Compiling a Component in the first.component.spec.ts File

```
import { TestBed, ComponentFixture, async } from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";
import { Product } from "../app/model/product.model";
import { Model } from "../app/model/repository.model";
import { DebugElement } from "@angular/core";
import { By } from "@angular/platform-browser";

describe("FirstComponent", () => {

    let fixture: ComponentFixture<FirstComponent>;
    let component: FirstComponent;
    let debugElement: DebugElement;
    let spanElement: HTMLSpanElement;

    let mockRepository = {
        getProducts: function () {
            return [
                new Product(1, "test1", "Soccer", 100),
                new Product(2, "test2", "Chess", 100),
                new Product(3, "test3", "Soccer", 100),
            ]
        }
    }

    beforeEach(async(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent],
            providers: [
                { provide: Model, useValue: mockRepository }
            ]
        });
        TestBed.compileComponents().then(() => {
            fixture = TestBed.createComponent(FirstComponent);
            component = fixture.componentInstance;
            debugElement = fixture.debugElement;
            spanElement = debugElement.query(By.css("span")).nativeElement;
        });
    }));

    it("filters categories", () => {
        component.category = "Chess"
        fixture.detectChanges();
        expect(component.getProducts().length).toBe(1);
        expect(spanElement.textContent).toContain("1");
    });
});
```

Components are compiled using the `TestBed.compileComponents` method. The compilation process is asynchronous, and the `compileComponents` method returns a `Promise`, which must be used to complete the test setup when the compilation is complete. To make it easier to work with asynchronous operations in unit tests, the `@angular/core/testing` module contains a function called `async`, which is used with the `beforeEach` method.

Testing Component Events

To demonstrate how to test for a component's response to events, I defined a new property in the `FirstComponent` class and added a method to which the `@HostBinding` decorator has been applied, as shown in Listing 29-17.

Listing 29-17. Adding Event Handling in the first.component.ts File

```
import { Component, HostListener} from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";

@Component({
    selector: "first",
    moduleId: module.id,
    templateUrl: "first.component.html"
})
export class FirstComponent {

    constructor(private repository: Model) {}

    category: string = "Soccer";
    highlighted: boolean = false;

    getProducts(): Product[] {
        return this.repository.getProducts()
            .filter(p => p.category == this.category);
    }

    @HostListener("mouseenter", ["$event.type"])
    @HostListener("mouseleave", ["$event.type"])
    setHighlight(type: string) {
        this.highlighted = type == "mouseenter";
    }
}
```

The `setHighlight` method has configured so that it will be invoked when the host element's `mouseenter` and `mouseleave` events are triggered. Listing 29-18 updates the component's template so that it uses the new property in a data binding.

Listing 29-18. Binding to a Property in the first.component.html File

```
<div class="bg-primary p-a-1" [class.bg-success]="highlighted">
    There are
        <span class="strong"> {{getProducts().length}} </span>
    products
</div>
```

Events can be triggered in unit tests through the `triggerEventHandler` method defined by the `DebugElement` class, as shown in Listing 29-19.

Listing 29-19. Triggering Events in the first.component.spec.ts File

```
import { TestBed, ComponentFixture, async } from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";
import { Product } from "../app/model/product.model";
import { Model } from "../app/model/repository.model";
import { DebugElement } from "@angular/core";
import { By } from "@angular/platform-browser";

describe("FirstComponent", () => {

    let fixture: ComponentFixture<FirstComponent>;
    let component: FirstComponent;
    let debugElement: DebugElement;
    let divElement: HTMLDivElement;

    let mockRepository = {
        getProducts: function () {
            return [
                new Product(1, "test1", "Soccer", 100),
                new Product(2, "test2", "Chess", 100),
                new Product(3, "test3", "Soccer", 100),
            ]
        }
    }

    beforeEach(async(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent],
            providers: [
                { provide: Model, useValue: mockRepository }
            ]
        });
        TestBed.compileComponents().then(() => {
            fixture = TestBed.createComponent(FirstComponent);
            component = fixture.componentInstance;
            debugElement = fixture.debugElement;
            divElement = debugElement.children[0].nativeElement;
        });
    }));

    it("handles mouse events", () => {
        expect(component.highlighted).toBeFalsy();
        expect(divElement.classList.contains("bg-success")).toBeFalsy();
        debugElement.triggerEventHandler("mouseenter", new Event("mouseenter"));
        fixture.detectChanges();
        expect(component.highlighted).toBeTruthy();
        expect(divElement.classList.contains("bg-success")).toBeTruthy();
        debugElement.triggerEventHandler("mouseleave", new Event("mouseleave"));
        fixture.detectChanges();
        expect(component.highlighted).toBeFalsy();
        expect(divElement.classList.contains("bg-success")).toBeFalsy();
    });
});
```

The test in this listing checks the initial state of the component and the template and then triggers the `mouseenter` and `mouseleave` events, checking the effect that each has.

Testing Output Properties

Testing output properties is a simple process because the `EventEmitter` objects used to implement them are `Observable` objects that can be subscribed to in unit tests. Listing 29-20 adds an output property to the component under test.

Listing 29-20. Adding an Output Property in the first.component.ts File

```
import { Component, HostListener, Output, EventEmitter} from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";

@Component({
    selector: "first",
    moduleId: module.id,
    templateUrl: "first.component.html"
})
export class FirstComponent {

    constructor(private repository: Model) {}

    category: string = "Soccer";
    highlighted: boolean = false;

    @Output("pa-highlight")
    change = new EventEmitter<boolean>();

    getProducts(): Product[] {
        return this.repository.getProducts()
            .filter(p => p.category == this.category);
    }

    @HostListener("mouseenter", ["$event.type"])
    @HostListener("mouseleave", ["$event.type"])
    setHighlight(type: string) {
        this.highlighted = type == "mouseenter";
        this.change.emit(this.highlighted);
    }
}
```

The component defines an output property called `change`, which is used to emit an event when the `setHighlight` method is called. Listing 29-21 shows a unit test that targets the output property.

Listing 29-21. Testing an Output Property in the first.component.spec.ts File

```
import { TestBed, ComponentFixture, async } from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";
import { Product } from "../app/model/product.model";
import { Model } from "../app/model/repository.model";
import { DebugElement } from "@angular/core";
import { By } from "@angular/platform-browser";

describe("FirstComponent", () => {

    let fixture: ComponentFixture<FirstComponent>;
    let component: FirstComponent;
    let debugElement: DebugElement;

    let mockRepository = {
        getProducts: function () {
            return [
                new Product(1, "test1", "Soccer", 100),
                new Product(2, "test2", "Chess", 100),
                new Product(3, "test3", "Soccer", 100),
            ]
        }
    }

    beforeEach(async(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent],
            providers: [
                { provide: Model, useValue: mockRepository }
            ]
        });
        TestBed.compileComponents().then(() => {
            fixture = TestBed.createComponent(FirstComponent);
            component = fixture.componentInstance;
            debugElement = fixture.debugElement;
        });
    }));

    it("implements output property", () => {
        let highlighted: boolean;
        component.change.subscribe(value => highlighted = value);
        debugElement.triggerEventHandler("mouseenter", new Event("mouseenter"));
        expect(highlighted).toBeTruthy();
        debugElement.triggerEventHandler("mouseleave", new Event("mouseleave"));
        expect(highlighted).toBeFalsy();
    });
});
```

I could have invoked the component's `setHighlight` method directly in the unit test, but instead I have chosen to trigger the `mouseenter` and `mouseleave` events, which will activate the output property indirectly. Before triggering the events, I use the `subscribe` method to receive the event from the `output` property, which is then used to check for the expected outcomes.

Testing Input Properties

The process for testing input properties requires a little extra work. To get started, I added an input property to the FirstComponent class that is used to receive the data model repository, replacing the service that was received by the constructor, as shown in Listing 29-22. I have also removed the host event bindings and the output property in order to keep the example simple.

Listing 29-22. Adding an Input Property in the first.component.ts File

```
import { Component, HostListener, Input } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";

@Component({
    selector: "first",
    moduleId: module.id,
    templateUrl: "first.component.html"
})
export class FirstComponent {

    category: string = "Soccer";
    highlighted: boolean = false;

    getProducts(): Product[] {
        return this.model == null ? [] : this.model.getProducts()
            .filter(p => p.category == this.category);
    }

    @Input("pa-model")
    model: Model;
}
```

The input property is set using an attribute called pa-model and is used within the getProducts method. Listing 29-23 shows how to write a unit test that targets the input property.

Listing 29-23. Testing an Input Property in the first.component.spec.ts File

```
import { TestBed, ComponentFixture, async } from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";
import { Product } from "../app/model/product.model";
import { Model } from "../app/model/repository.model";
import { DebugElement } from "@angular/core";
import { By } from "@angular/platform-browser";
import { Component, ViewChild } from "@angular/core";

@Component({
    template: `<first [pa-model]="model"></first>`
})
class TestComponent {

    constructor(public model: Model) { }
    @ViewChild(FirstComponent)
    firstComponent: FirstComponent;
}

describe("FirstComponent", () => {

    let fixture: ComponentFixture<TestComponent>;
    let component: FirstComponent;
    let debugElement: DebugElement;

    let mockRepository = {
        getProducts: function () {
            return [
                new Product(1, "test1", "Soccer", 100),
                new Product(2, "test2", "Chess", 100),
                new Product(3, "test3", "Soccer", 100),
            ]
        }
    }

    beforeEach(async(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent, TestComponent],
            providers: [
                { provide: Model, useValue: mockRepository }
            ]
        });
        TestBed.compileComponents().then(() => {
            fixture = TestBed.createComponent(TestComponent);
            component = fixture.componentInstance.firstComponent;
            debugElement = fixture.debugElement.query(By.directive(FirstComponent));
        });
    }));

    it("receives the model through an input property", () => {
        component.category = "Chess";
        fixture.detectChanges();
        let products = mockRepository.getProducts()
            .filter(p => p.category == component.category);
        let componentProducts = component.getProducts();
        for (let i = 0; i < componentProducts.length; i++) {
            expect(componentProducts[i]).toEqual(products[i]);
        }
        expect(debugElement.query(By.css("span")).nativeElement.textContent)
            .toContain(products.length);
    });
});
```

The trick here is to define a component that is only required to set up the test and whose template contains an element that matches the selector of the component you want to target. In this example, I defined a component class called `TestComponent` with an inline template defined in the `@Component` decorator that contains a first element with a pa-model attribute, which corresponds to the @Input decorator applied to the FirstComponent class in Listing 29-22.

The test component class is added to the declarations array for the testing module, and an instance is created using the TestBed.createComponent method. I used the @ViewChild decorator in the TestComponent class so that I can get hold of the FirstComponent instance I require for the test. To get the FirstComponent root element, I used the DebugElement.query method with the By.directive method.

The result is that I am able to access both the component and its root element for the test, which sets the category property and then validates the results both from the component and through the data binding in its template.

Testing with Asynchronous Operations

Another area that requires special measures is dealing with asynchronous operations. To demonstrate how this is done, Listing 29-24 modifies the component under test so that it uses the RestDataSource class, defined in Chapter 24, to get its data. This isn't a class that was intended for use outside of the model feature module, but it provides a useful set of asynchronous methods that return Observable objects, so I have broken through the intended structure of the application so that I can demonstrate the test technique.

Listing 29-24. Performing an Asynchronous Operation in the first.component.ts File

```
import { Component, HostListener, Input } from "@angular/core";
import { Product } from "../model/product.model";
import { Model } from "../model/repository.model";
import { RestDataSource } from "../model/rest.datasource";
import { Observable } from "rxjs/Observable";

@Component({
    selector: "first",
    moduleId: module.id,
    templateUrl: "first.component.html"
})
export class FirstComponent {
    _category: string = "Soccer";
    _products: Product[] = [];
    highlighted: boolean = false;

    constructor(public datasource: RestDataSource) {}

    ngOnInit() {
        this.updateData();
    }

    getProducts(): Product[] {
        return this._products;
    }

    set category(newValue: string) {
        this._category;
        this.updateData();
    }
    updateData() {
        this.datasource.getData()
            .subscribe(data => this._products = data
                .filter(p => p.category == this._category));
    }
}
```

The component gets its data through the data source's `getData` method, which returns an `Observable` object. The component subscribes to the `Observable` and updates its `_product` property with the data objects, which is exposed to the template through the `getProducts` method.

Listing 29-25 shows how this kind of component can be tested using the tools Angular provides for working with asynchronous operations in unit tests.

Listing 29-25. Testing an Asynchronous Operation in the first.component.spec.ts File

```
import { TestBed, ComponentFixture, async } from "@angular/core/testing";
import { FirstComponent } from "../app/ondemand/first.component";
import { Product } from "../app/model/product.model";
import { Model } from "../app/model/repository.model";
import { DebugElement } from "@angular/core";
import { By } from "@angular/platform-browser";
import { Component, ViewChild } from "@angular/core";
import { RestDataSource } from "../app/model/rest.datasource";
import { Observable } from "rxjs/Observable";
import "rxjs/add/observable/from";
import { Injectable } from "@angular/core";

@Injectable()
class MockDataSource {
    public data = [
        new Product(1, "test1", "Soccer", 100),
        new Product(2, "test2", "Chess", 100),
        new Product(3, "test3", "Soccer", 100),
    ];

    getData(): Observable<Product[]> {
        return new Observable<Product>(obs => {
            setTimeout(() => obs.next(this.data), 1000);
        })
    }
}

describe("FirstComponent", () => {

    let fixture: ComponentFixture<FirstComponent>;
    let component: FirstComponent;
    let dataSource = new MockDataSource();

    beforeEach(async(() => {
        TestBed.configureTestingModule({
            declarations: [FirstComponent],
            providers: [
                { provide: RestDataSource, useValue: dataSource }
            ]
        });
        TestBed.compileComponents().then(() => {
            fixture = TestBed.createComponent(FirstComponent);
            component = fixture.componentInstance;
        });
    }));

    it("performs async op", () => {
        dataSource.data.push(new Product(100, "test100", "Soccer", 100));
        fixture.detectChanges();

        fixture.whenStable().then(() => {
            expect(component.getProducts().length).toBe(3);
        });
    });
});
```

The mock object in this example is more fully formed than the one I created previously, just to show different ways of achieving the same goal. The important point to note is that the getData method it implements introduces a one-second delay before it returns the sample data.

This delay is important because it means that the effect of calling the detectChanges method in the unit test won't affect the component immediately. To deal with this, I call the whenStable method defined by the ComponentFixture class, which returns a Promise that resolves when all the changes have been fully processed. This allows me to defer the assessment of the outcome of the test until the Observable returned by the mock data source has delivered its data to the component.

Testing an Angular Directive

The process for testing directives is similar to the one required to test input properties, in that a test component and template are used to create an environment for testing in which the directive can be applied. In order that I have a directive to test, I added a file called attr.directive.ts to the exampleApp/app/ondemand folder and added the code shown in Listing 29-26.

■ **Note** I have shown an attribute directive in this example, but the technique in this section can be used to test structural directives equally well.

Listing 29-26. The Contents of the attr.directive.ts File in the exampleApp/app/ondemand Folder

```
import {
    Directive, ElementRef, Attribute, Input, SimpleChange
} from "@angular/core";

@Directive({
    selector: "[pa-attr]"
})
```

```
export class PaAttrDirective {

    constructor(private element: ElementRef) { }

    @Input("pa-attr")
    bgClass: string;

    ngOnChanges(changes: { [property: string]: SimpleChange }) {
        let change = changes["bgClass"];
        let classList = this.element.nativeElement.classList;
        if (!change.isFirstChange() && classList.contains(change.previousValue)) {
            classList.remove(change.previousValue);
        }
        if (!classList.contains(change.currentValue)) {
            classList.add(change.currentValue);
        }
    }
}
```

This is an attribute directive based on an example from Chapter 15. To create a unit test that targets the directive, I added a file called `attr.directive.spec.ts` to the `exampleApp/tests` folder and added the code shown in Listing 29-27.

Listing 29-27. The Contents of the attr.directive.spec.ts File in the exampleApp/tests Folder

```
import { TestBed, ComponentFixture } from "@angular/core/testing";
import { Component, DebugElement, ViewChild } from "@angular/core";
import { By } from "@angular/platform-browser";
import { PaAttrDirective } from "../app/ondemand/attr.directive";

@Component({
    template: `<div><span [pa-attr]="className">Test Content</span></div>`
})
class TestComponent {
    className = "initialClass"

    @ViewChild(PaAttrDirective)
    attrDirective: PaAttrDirective;
}

describe("PaAttrDirective", () => {

    let fixture: ComponentFixture<TestComponent>;
    let directive: PaAttrDirective;
    let spanElement: HTMLSpanElement;

    beforeEach(() => {
        TestBed.configureTestingModule({
            declarations: [TestComponent, PaAttrDirective],
        });
        fixture = TestBed.createComponent(TestComponent);
        directive = fixture.componentInstance.attrDirective;
        spanElement = fixture.debugElement.query(By.css("span")).nativeElement;
    });

    it("generates the correct number of elements", () => {
        fixture.detectChanges();
        expect(directive.bgClass).toBe("initialClass");
        expect(spanElement.className).toBe("initialClass");

        fixture.componentInstance.className = "nextClass";
        fixture.detectChanges();
        expect(directive.bgClass).toBe("nextClass");
        expect(spanElement.className).toBe("nextClass");
    });
});
```

The text component has an inline template that applies the directive and a property that is referred to in the data binding. The `@ViewChild` decorator provides access to the directive object that Angular creates when it processes the template, and the unit test is able to check that changing the value used by the data binding has an effect on the directive object and the element it has been applied to.

Summary

In this chapter, I demonstrated the different ways in which Angular components and directives can be unit tested. I explained the process for installing the test framework and tools and how to create the test bed through which tests are applied. I demonstrated how to test the different aspects of components and how the same techniques can be applied to directives as well.

And that is all I have to teach you about Angular. I started by creating a simple application and then took you on a comprehensive tour of the different building blocks in the framework, showing you how they can be created, configured, and applied to create web applications.

I wish you every success in your Angular projects, and I can only hope that you have enjoyed reading this book as much as I enjoyed writing it.

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