Angular 2 Development with TypeScript

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MEAP

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Welcome

Thank you for purchasing the MEAP for Angular 2 Development with TypeScript. It's written for JavaScript developers who are open to working with new languages and frameworks to become more productive with developing Web applications. We expect the reader to know the current version of JavaScript (based on ECMAScript 5 spec) and have a basic understanding of how Web applications work. No prior experience with AngularJS is expected.

In this MEAP every chapter was updated to include changes related to the newly introduced modules (@NgModule) and modified bootstrap procedure. Chapter 3 was substantially modified to use the new new new Router, and now it has a new section on lazy loading. Chapter 7 uses new Forms API. Chapter 9 uses the latest testing API including the TestBed class. Chapter 10 was upgraded to use Webpack 2.

All code samples were updated to Angular RC.6, and we'll update the rest of the code sample to use Angular 2.0 Final by the end of September. The upgrade from RC.6 to Final is easey and it comes down to making the following changes in the package.json file of the project:

1. Remove the suffix "-rc.6" from all Angular core packages.
2. The router should be listed as ""@angular/router": "3.0.0".
3. The RX.js line should look as follows: "rxjs": "5.0.0-beta.12".
4. The Zone.js line should look like this: "zone.js": "0.6.21"

While Manning offers the source code for download on the MEAP page of this book, we also maintain a GitHub repository which has the latest version of the code samples. This repo also has a link to the screencast with the code review of one of the versions of the sample app Online Auction.

We'd love to receive your feedback in the Author's online forum so we can improve the content of the book.

Below is a brief overview of the book's content.

- Chapter 1 gives a high level overview of the Angular 2 architecture, a brief overview of popular JavaScript frameworks and libraries, and the introduction of the sample Online Auction application that you'll be developing with us starting from Chapter 2.

  We'll be developing this application in TypeScript. Appendix B will get you familiar with this excellent language, which is a superset of JavaScript. Not only will you learn how to write classes, interfaces, and generics, but you'll also learn how to compile TypeScript code into today's JavaScript (ECMAScript 5) that can be deployed in all Web browsers. TypeScript implements most of the syntax of the latest ECMAScript 6 specification (covered in Appendix A) and some syntax that should be included in ECMAScript 7.

- In Chapter 2 we'll start developing simple Angular 2 applications and will create first Angular components. You'll learn how to work with the module loader SystemJS and we'll offer you our version of the seed project that will be use as a starting point for all sample applications in the book. At the end of this chapter we'll create the firs version of the home page of Online Auction.
- Chapter 3 is about Angular router that allows a simple but flexible way of arranging the navigation in your applications. You'll learn how to configure routes in parent and child component, how to pass the data from one route to another, and how to lazy-load modules using the router. At the end of this chapter we'll refactor the Online Auction into several components and add the routing capabilities to it.
- In Chapter 4 you'll learn about Dependency Injection design pattern and how Angular implements it. In the new version of the Online Auction we'll apply dependency injection to populate the Product Details view with the data.
- In Chapter 5 we'll discuss different flavors of data binding, will introduce the role of observable data streams, and will show you how to work with pipes.
- Chapter 6 is about developing components that can communicate with each other in a loosely-coupled manner. We'll discuss components' input and output parameters, the Mediator design pattern and a component's life cycle.
- Chapter 7 is about handling forms in Angular. After covering the form basics and adding form validation we'll implement the new material in yet another version of Online Auction.
- Chapter 8 explains how an Angular client app can communicate with the servers using HTTP and WebSocket protocols. In this chapter we'll create a server app using the Node.js framework, and Angular application will be deployed and served by Node.
- Chapter 9 is about unit testing. We'll cover the basics of Jasmine and the Angular testing library. You'll learn how to test services, components and the router. We'll also configure and use Karma for running tests.
- Chapter 10 is about automating the build and deployment process. You'll see how to use the Webpack bundler for minimizing and packaging the code for deployment. The size of the deployed version of the Online Auction will be decreased from 5.5Mb (in dev) to 350Kb (in prod).

Enjoy reading Angular 2 Development with TypeScript!

— Yakov Fain and Anton Moiseev

brief contents

1 Introducing Angular 2

This chapter covers

- A brief overview of JavaScript frameworks and libraries
- A high-level overview of Angular 1 and 2
- A toolbox for the Angular developer
- Introducing the sample application

Angular 2 is an open source JavaScript framework maintained by Google. It's a complete rewrite of its popular predecessor, AngularJS. Angular applications can be developed in JavaScript (using the syntax of ECMAScript 5 or 6), Dart, or TypeScript. In this book we'll use TypeScript; our reasons for this are explained in appendix B.

NOTE **Prerequisites**
In this book, we don't expect you to have any experience with AngularJS. We do expect you to know the syntax of JavaScript and HTML and to understand what web applications consist of. We also assume that you know what CSS is and that you're familiar with the role of the DOM object in a browser.

We'll start this chapter with a very brief overview of some popular JavaScript frameworks. Then we'll review the architecture of the older AngularJS and the newer Angular 2, highlighting the improvements that the new version of this framework brings to the table. We'll also quickly run through the tools that Angular developers use. Finally, we'll introduce the sample application that we're going to build in this book.

> **NOTE** **Angular, Angular 2, AngularJS terminology**
> This book is about the Angular 2 framework, and for brevity we'll call it Angular throughout. If we mention AngularJS, we're talking about the 1.x versions of this framework. At the time of writing Angular 2 is in Release Candidate 6.

1.1 A sampler of JavaScript frameworks and libraries

Do you have to use frameworks? No, you can program the front end of web applications in pure JavaScript. In this case, there's nothing new to learn, as you already know JavaScript. The cons of not using a framework are the difficulties in maintaining cross-browser compatibility and longer development cycles. In contrast, frameworks can give you full control over the architecture, design patterns, and code styles in your application. Most modern web applications are written using some combination of frameworks and libraries.

Angular is one of many frameworks used for developing web apps, and this section will briefly cover some popular JavaScript frameworks and libraries. What's the difference between frameworks and libraries? *Frameworks* provide a structure for your code and force you to write the code in a certain way. *Libraries* usually offer a number of components and APIs that can be used à la carte in any code. In other words, frameworks are more opinionated than libraries about the design of your application.

FEATURE-COMPLETE FRAMEWORKS

Feature-complete frameworks include everything you need to develop a web application. They impose a certain structure on your code and come with a library of UI components and tools for building and deploying the application.

For example, *Ext JS* is a mature full-featured framework created and maintained by Sencha. It comes with an excellent set of rich UI components, including an advanced data grid and charts, which are crucial for developing back-office enterprise applications. Ext JS adds a substantial amount of code to your application, and you won't find an application built with Ext JS that's less than 1 MB in size. Ext JS is also intrusive—it's not easy to switch to a different framework if need be.

Sencha also has the Sencha Touch framework, which is used for creating web applications for mobile devices.

1.1.1 Lightweight frameworks

Lightweight frameworks add structure to your web application, offer a way to arrange navigation between different views, and typically split the application into layers implementing the Model-View-Controller (MVC) design pattern. There is also a group of lightweight frameworks specialized for testing applications written in JavaScript.

Angular is an open source framework for developing web applications. The framework makes it simpler to create custom components that can be added to HTML documents and to implement application logic. Angular uses data binding extensively, includes a dependency injection module, supports modularization, and offers a routing mechanism. Whereas AngularJS was MVC-based, Angular is not. This framework doesn't include UI components.

Ember.js is an open source MVC-based framework for developing web applications. It includes a routing mechanism and supports two-way data binding. This framework uses a lot of code conventions, which increases the productivity of software developers.

Jasmine is an open source framework for testing JavaScript code. Jasmine doesn't require a DOM object. It includes a set of functions that test whether certain parts of your application behave as expected. Jasmine is often used with Karma, which is a test runner that allows you to run tests in different browsers.

1.1.2 Libraries

The libraries discussed in this section serve different purposes and can be used in web applications with or without other frameworks.

jQuery is a popular JavaScript library. It's simple to use and doesn't require you to dramatically change the way you program for the web. jQuery helps in finding and manipulating DOM elements, processing browser events, and dealing with browser incompatibilities. jQuery is an extensible library, and thousands of plugins have been created by developers from around the world. If you can't find a plugin that fits your needs, you can create one yourself.

Bootstrap is an open source library of UI components developed by Twitter. The components are built using the responsive web design principles, which makes this library extremely valuable if your web application needs to automatically adjust its layout depending on the screen size of the user's device. In this book we'll use Bootstrap while developing a sample Online Auction application.

1. Google's Material Design libraries NOTE: Google developed a new library of UI components called Material Design, which may become an alternative to Bootstrap. Material Design is optimized for cross-device use and comes with a set of nice-looking UI components. At the time of writing, only the AngularJS version of Material Design is ready. The Angular version of this library is called Material Design 2, and it should be released shortly after this book is published.

React is an open source library by Facebook for building user interfaces. React represents the *V* in MVC. It's nonintrusive and can be used with any other library or a framework. React creates its own virtual DOM object, minimizing access to browser's

DOM, which results in better performance. For content rendering, React introduces the JSX format, which is a JavaScript syntax extension that looks like XML. Using JSX is recommended but optional.

Polymer is a library created by Google for building custom components based on the WebComponents standard. It comes with a set of nice-looking customizable UI components that can be included in the HTML markup as tags. Polymer also includes components for applications that need to work offline, as well as components that use various Google APIs (such as calendar, maps, and others).

RxJS is a set of libraries for composing asynchronous and event-based programs using observable collections. It allows applications to work with asynchronous data streams, such as the server-side stream of stock price quotes or mouse move events. With RxJS, the data streams are represented as observable sequences. This library can be used with or without any other JavaScript framework. In chapters 5 and 8 you'll see examples of using observables in Angular.

To see statistics on which top websites use a particular JavaScript framework or library, visit the BuiltWith JavaScript Usage Statistics page: http://trends.builtwith.com/javascript.

SIDEBAR **Moving from Flex to Angular**

We work for a company, Farata Systems, that over the years developed pretty complex software using the Adobe Flex framework. Flex is a very productive framework built on top of the strongly typed compiled ActionScript language, and the applications are deployed in the Flash Player browser plugin (a VM). When the web community started moving away from using plugins, we spent two years trying to find a replacement for Flex. We experimented with different JavaScript-based frameworks, but the productivity of our developers seriously suffered. Finally we saw a light at the end of the tunnel with a combination of the TypeScript language, Angular 2 framework, and a UI library such as Material Design 2.

1.1.3 What is Node.js?

Node.js (or *Node*) isn't just a framework or a library, but a runtime environment as well. In most of this book we'll use the Node runtime for running various utilities like Node Package Manager (npm). For example, to install the Angular framework, you can use npm from a command line:

```
npm install angular2
```

The Node.js framework can be used to develop JavaScript programs that run outside the browser. You can develop the server-side layer of a web application in JavaScript or

Typescript, and we'll write a web server using Node in chapter 8. Google developed a high-performance V8 JavaScript engine for the Chrome browser, and it can be used to run code written using the Node.js API. The Node.js framework includes an API to work with the filesystem, access databases, listen to HTTP requests, and more.

Members of the JavaScript community have built lots of utilities that are useful for developing web applications, and with the help of Node's JavaScript engine you can run them from a command line.

1.2 High-level overview of AngularJS

Let's now return to the main topic of this book: the Angular framework. This is the only section dedicated to AngularJS, the previous version of Angular.

Misko Hevery and Adam Abronsa started work on the AngularJS framework in 2009 as an effort to help web designers customize web pages, and AngularJS 1.0 was officially released in 2012. By 2015 several minor versions had been released, and at the time of writing the stable version of AngularJS is 1.5. Google continues improving the functionality of AngularJS 1.x and addressing its issues while developing Angular 2 in parallel. Let's see what made AngularJS so popular.

- AngularJS has a mechanism for creating custom HTML tags and attributes using the concept of directives, which allow you to extend the set of HTML tags according to your application's needs.
- AngularJS is not too intrusive. You can add an `ng-app` attribute to any `<div>` tag and only the content of this `<div>` will be controlled by AngularJS while the rest of the web page can be pure HTML and JavaScript.
- AngularJS allows you to bind data to views easily. Changing data results in automated updates of the corresponding view element and vice versa.
- AngularJS comes with a configurable router that allows you to map URL patterns to corresponding application components that change the view on the web page according to the mapping.
- The application data flow is defined in controllers, which are JavaScript objects containing properties and functions.
- AngularJS applications use a hierarchy of scopes, which are the objects for storing data shared by controllers and views.
- AngularJS includes a dependency injection module that allows you to develop applications in a loosely coupled manner.

While jQuery simplified DOM manipulations, AngularJS allowed developers to decouple the application logic from the UI by structuring the application according to the MVC design pattern. Figure 1.1 depicts a sample workflow of an AngularJS application that deals with products.

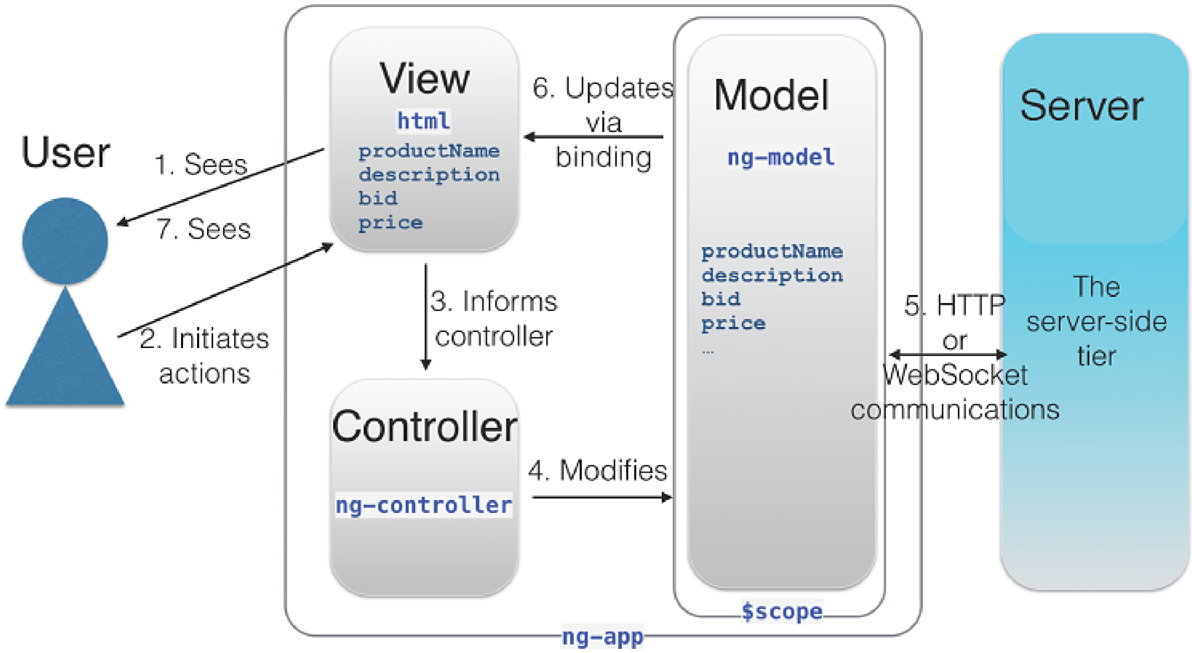


Figure 1.1 Sample architecture of an AngularJS app

If you want AngularJS to control the entire web application, include the `ng-app` directive to the `<body>` HTML tag:

```
<body ng-app="ProductApp">
```

In figure 1.1, to get the product data, the user loads the application (#1) and enters the product ID (#2). The view informs the controller (#3), which updates the model (#4) and makes an HTTP request (#5) to a remote server via the `$http` service. AngularJS populates the properties of the model with the retrieved data (#5), and the changes in the model are automatically reflected in the UI via a *binding expression* (#6). The user then sees the data about the requested product (#7).

To display a value of the model's `productName` property, you could add the following HTML template to the view: `<p>{{ productName }}</p>`. AngularJS will compile this template into the JavaScript code. The double curly braces will display (and automatically update) the product name in a view. The changes in the UI are propagated to the model if the user modifies the product data in the view. This two-directional update mechanism is called *two-way data binding* and it's illustrated in figure 1.2.

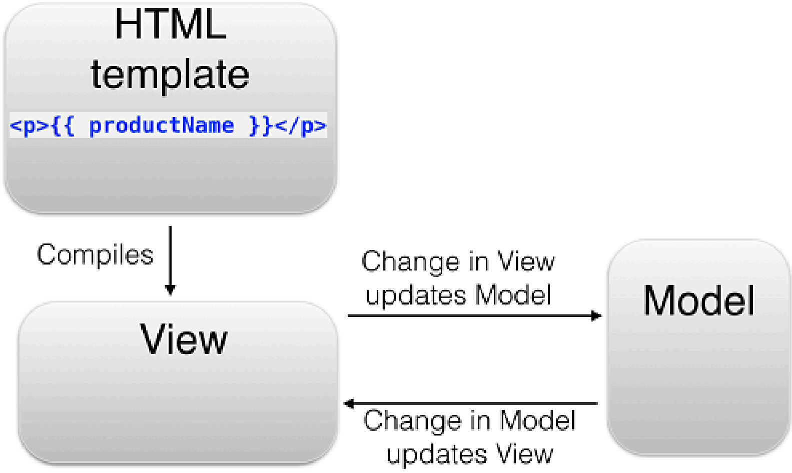


Figure 1.2 Two-way binding

In AngularJS, the model and the view are tightly bound because the two-way binding means each automatically updates the other. It's nice to have these automatic view updates without writing much code, but it doesn't come for free.

Every time the model is updated, AngularJS runs a special `$digest` cycle that runs through the entire application, applying the data bindings and updating the DOM when needed. Cascading updates result in multiple runs of the `$digest` cycle, which can affect performance in large applications that use multiple two-way bindings. Manipulating the browser's DOM object is the slowest operation—the less your application updates the DOM, the better it performs.

The model data exists in the context of a particular `$scope` object, and AngularJS scopes form a hierarchy of objects. The `$rootscope` is created for the entire application. Controllers and directives (custom components) have their own `$scope` objects, and understanding how AngularJS scopes work can be challenging.

You can implement modularization by creating and loading `module` objects. When a particular module depends on other objects (such as controllers, modules, or services) the instances of these objects are created and *injected* by AngularJS's Dependency Injection mechanism. The following code snippet illustrates one of the ways AngularJS injects one object into another.

```
var SearchController = function ($scope) {     ❶
       //..
};

SearchController['$inject'] = ['$scope'];     ❷

angular.module('auction').controller('SearchController', SearchController);     ❸
```

❶ Defines SearchController as a constructor function with the $scope argument.

2 Adds the $inject property on the controller, asking to inject the $scope object into this property.

3 Assigns the SearchController object to be a controller on the auction module.

In the preceding code snippet, the square brackets represent an array, and AngularJS can inject multiple objects as follows: `['$scope', 'myCustomService']`.

AngularJS is often used for creating single-page applications, where only certain portions of the page (sub-views) are updated as a result of the user's actions or data being sent from the server. A good example of these sub-views is a web application showing stock quotes: only the price element on the view is updated as the stock is traded.

Navigation between views in AngularJS is arranged by configuring the `ng-route` router component. You can specify a number of `.when` options to route the application to the appropriate view based on the URL pattern. The next code fragment instructs the router to use the markup from *home.html* and the controller `HomeController` unless the URL contains `/search`, in which case the view will render *search.html* and the `SearchController` object will be used as a controller.

```
angular.module('auction', ['ngRoute'])
   .config(['$routeProvider', function ($routeProvider) {
       $routeProvider
         .when('/', {
            templateUrl: 'views/home.html',
            controller: 'HomeController' })
         .when('/search', {
             templateUrl: 'views/search.html',
             controller: 'SearchController' })
         .otherwise({
             redirectTo: '/'
     });
   }]);
```

The AngularJS router supports *deep linking*, which is the ability to bookmark not just an entire web page, but a certain state within the page.

Now that you've got a very high-level overview of AngularJS, let's see what Angular 2 brings to the table.

1.3 High-level overview of Angular

The Angular framework is better performing than AngularJS. It's easier to learn, the application architecture has been simplified, and the code is simpler to write and read. This section contains a high-level overview of Angular, highlighting the improvements made since AngularJS. For a more detailed architectural overview of Angular, see the product documentation at https://angular.io/docs/ts/latest/guide/architecture.html.

1.3.1 Code simplification

First of all, an Angular application consists of standard modules in ES6 (ECMAScript 6), AMD (Asynchronous Module Definition), or CommonJS formats. Typically, one module is one file. There's no need to use a framework-specific syntax for loading and using modules. Just use the universal module loader `SystemJS` (covered in chapter 2) and add `import` statements to use functionality implemented in the loaded modules. You don't need to worry about the proper order of the `<script>` tags in your HTML files. If module A needs the functionality from module B, just import module B into module A.

The HTML file for your application's landing page includes Angular modules and their dependencies. Your application code is bootstrapped simply by loading the top-level component of your application. All child modules will be loaded automatically based on the `import` statements.

The following snippet shows typical content for the index.html file of an Angular application, where you include the required framework modules, and the script systemjs.config.js contains the configuration of the SystemJS loader. The `System.import('app')` loads the top-level app component configured in systemjs.config.js (shown in chapter 2). The custom tag <app> is a value defined in the `selector` property of the root component.

```
<!DOCTYPE html>
<html>
<head>
  <title>Angular seed project</title>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1">

  <script src="node_modules/core-js/client/shim.min.js"></script>
  <script src="node_modules/zone.js/dist/zone.js"></script>
  <script src="node_modules/reflect-metadata/Reflect.js"></script>

  <script src="node_modules/typescript/lib/typescript.js"></script>
  <script src="node_modules/systemjs/dist/system.src.js"></script>
  <script src="node_modules/rxjs/bundles/Rx.js"></script>
  <script src="systemjs.config.js"></script>
  <script>
    System.import('app').catch(function(err){ console.error(err); });
  </script>
</head>

<body>
<app>Loading...</app>
</body>
</html>
```

The HTML fragment of each application component is either inlined inside the component (the `template` property) or in the file referenced from the component using the `templateURL` property. The latter option allows designers to work on the UI of your application without the need to learn Angular.

The Angular component is the centerpiece of the new architecture. Figure 1.3 shows a high-level diagram of a sample Angular application that consists of four components and two services, and all of them are packaged inside a module. Angular's Dependency Injection (DI) module injects the `Http` service into `Service1`, which in turn is injected into the `GrandChild2` component. This diagram is quite different from figure 1.1, which illustrated AngularJS.

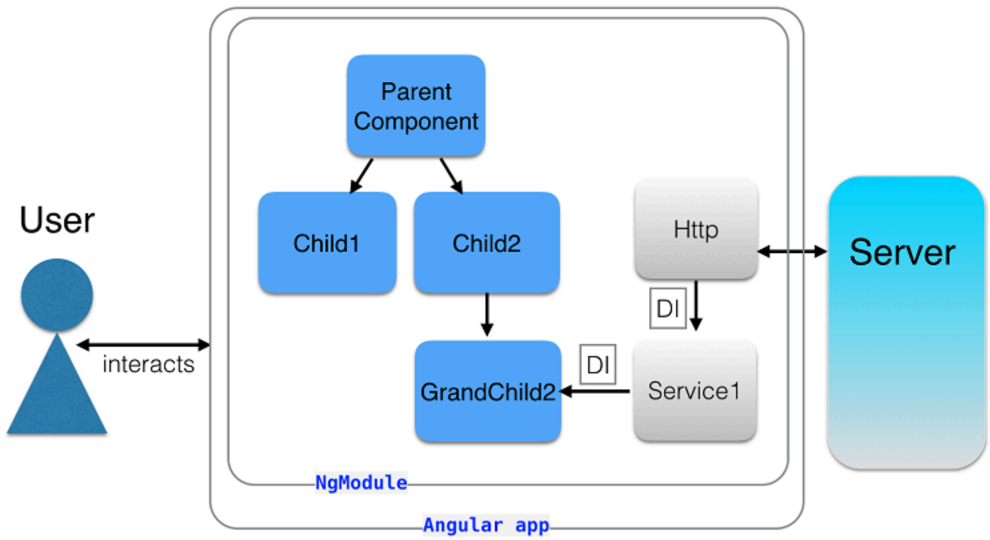


Figure 1.3 Sample architecture of an Angular app

The simplest way of declaring a component is by writing a class in TypeScript (you can use ES5, ES6, or Dart as well). We're going to give you a super-brief intro on how to write Angular components in TypeScript followed by the sample code. See if you can understand the code with minimum explanation.

A TypeScript class prepended with a `@NgModule` metadata annotation represents a module. A TypeScript class prepended with a `@Component` metadata annotation represents a component. The `@Component` annotation (a.k.a. decorator) contains the `template` property that declares an HTML fragment to be rendered by the browser. Metadata annotations allow you to modify the properties of the component during design time. The HTML template may include the data-binding expressions, which are surrounded by double curly braces. If the component depends on other components, the `@Component` annotation must list them in the `directives` property. The references to the event handlers are placed in the `template` property of the `@Component` annotation and are implemented as methods of the class.

Another example of a metadata annotation is `@Injectable`, which allows you to mark a component to be handled by the dependency injection module.

The `@Component` annotation also contains a selector declaring the name of the custom tag to be used in the HTML document. When Angular sees an HTML element whose name matches the selector, it knows which component implements it. The following HTML fragment illustrates the `<auction-application>` parent component with one child component, `<search-product>`:

```
<body>
  <auction-application>
    <search-product [productID]= "123"></search-product>
  </auction-application>
</body>
```

A parent component sends data to its child components using bindings to the input properties of the child (note the square brackets in the preceding code), and children communicate with their parents by emitting events via their output properties. At the end of the chapter you'll see figure 1.7, which shows the main page (the parent component) with its child components surrounded with thick borders.

The following code snippet shows a `SearchComponent`, and you can include it in an HTML document as `<search-product>` because its declaration includes the `selector` property with the same name.

```
@Component({
  selector: 'search-product',
  template:
     `<form>
        <div>
          <input id="prodToFind" #prod>
          <button (click)="findProduct(prod.value)">Find Product</button>
          Product name: {{product.name}}
        </div>
      </form>
    `
})
class SearchComponent {
   @Input() productID: number;

   product: Product; // code of the Product class is omitted

   findProduct(prodName: string){
    // Implementation of the click handler goes here
   }
   // Other code can go here
}
```

If you're familiar with any object-oriented language that has classes, you should understand most of the preceding code. The annotated class `SearchComponent` declares a `product` variable, which may represent an object with multiple properties, one of which (`name`) is bound to the view (`{{product.name}}`). The template local variable `#prod` will have a reference to the hosting `<input>` element, so you don't need to query the DOM to get the entered value.

The `(click)` notation represents a click event, and the event handler function gets the argument value from the `productID` input parameter that will be populated by the parent component via binding.

This was just a quick look at the sample component. We'll be providing a detailed description of what components are made up of starting in the next chapter. If you've never worked with classes before, no worries. They're covered in appendixes A and B.

Figure 1.4 illustrates the inner working of a sample component that searches for some products.

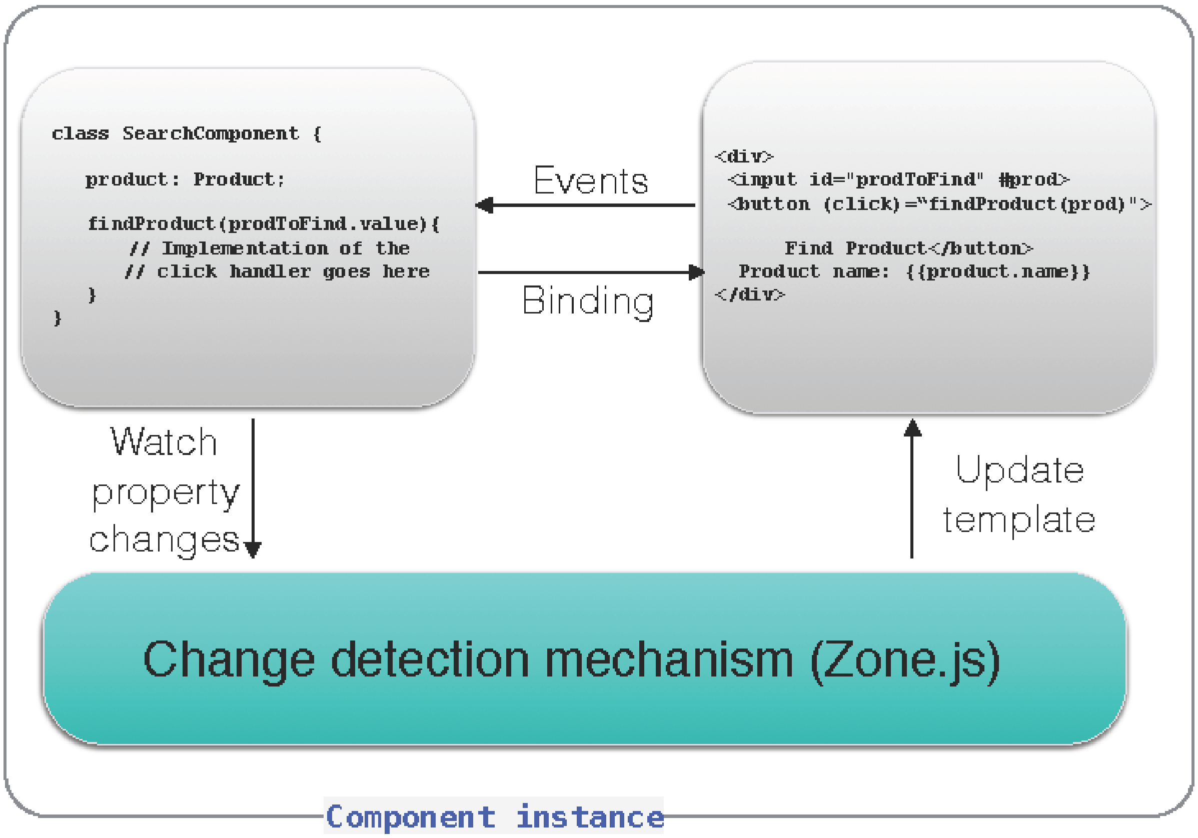


Figure 1.4 Component internals

A component renders the product data from the service represented by a class. In TypeScript, the `Product` class could look like this:

```
class Product{
    id: number,
    name: string;
    description: string;
    bid: number;
    price: number;

    // constructor and other methods go here
}
```

Note that TypeScript allows you to declare class variables with types. To let the UI component `SearchComponent` know about its data, you can declare a class variable, such as `product`:

```
@Component { // code omitted for brevity}
class SearchComponent {
   product: Product;

   findProduct(productID){
       // The implementation of the click handler
       // for the Find Components button goes here
   }
}
```

If the search component may return multiple products, you can declare an array to store them:

```
products: Array<Product>;
```

The *generics* notation is explained in appendix B. In the preceding code snippet, `<Product>` tells the TypeScript compiler that only objects of the type `Product` are allowed to be stored in this array.

Angular is not an MVC-based framework, and your app won't have separate controllers (the *C* in the MVC pattern). The component and injected services (if need be) includes all required code. In our example, the `SearchProduct` class would contain the code that performs the controller's responsibilities in addition to the code required for a UI component on the HTML view. For a cleaner separation of TypeScript and HTML, the content of the `template` section of the `@Component` annotation can be stored in a separate file by using `templateURL` instead of `template`, but that's a matter of preference.

Now let's look at how the design of Angular is simpler than that of AngularJS. In AngularJS, all directives were loaded to the global memory, whereas in Angular you specify the required directives on the component level, providing better encapsulation.

You don't have to deal with the hierarchy of scope objects as in AngularJS. Angular is component-based, and the properties are created on the `this` object, which becomes the component's scope.

One way of creating object instances is by using the `new` operator. If an object A depends on the object B, in the code of object A you can write `let myB = new B();`. Dependency Injection is a design pattern that inverts the way of creating objects your code depends on. Instead of explicitly creating object instances (such as with `new`) the framework will create and inject them into your code. Angular comes with a dependency injection module, and we'll cover that topic in chapter 4.

In AngularJS there were several ways of injecting dependencies, which could be confusing at times. In Angular, you can only inject dependencies into the component via its constructor. The following TypeScript code fragment shows how you'd inject the `ProductService` component into `SearchComponent`. You just need to specify a provider and declare the constructor argument with the type that matches provider's type.

```
@Component({
  selector: 'search-product',
  providers: [ProductService],
  template:`<div>...<div>`
})
class SearchComponent {
  products: Array<Product> = [];

  constructor(productService: ProductService) {
    this.products = productService.getProducts();
  }
}
```

This code doesn't use the `new` operator—Angular will instantiate the `ProductService` and provide its reference to the `SearchComponent`.

To summarize, Angular is simpler than AngularJS for several reasons:

- Each building block of your app is a component with the well-encapsulated functionality of a view, controller, and auto-generated change detector.
- Components can be programmed as annotated classes.
- You don't have to deal with scope hierarchies.
- Dependent components are injected via the component's constructor.
- Two-way binding is turned off by default.
- The change detection mechanism was rewritten and works faster.

The concepts of Angular are easy to understand for Java, C#, and C++ programmers, which represent the majority of enterprise software developers. Like it or not, a framework becomes popular when it's adopted by enterprises. AngularJS has been widely adopted by enterprises, and AngularJS skills are in big demand. Because developing applications with Angular is easier than with AngularJS, this trend should continue.

1.3.2 Performance improvements

The Repaint Rate Challenge website (http://www.roblog.io/js-repaint-perfs) compares the rendering performance of various frameworks. You can compare the performance of AngularJS with Angular 2—Angular shows serious performance improvements.

The rendering improvements mainly result from the internal redesign of the Angular framework. The UI rendering and application API were separated into two layers, which allows you to run the non-UI related code in a separate web worker thread. Besides the ability to run the code of these layers concurrently, web browsers allocate different CPU cores to these threads when possible. You can find a detailed description of the new rendering architecture in the document on Google Docs titled “Angular 2 Rendering Architecture” available at https://mng.bz/K403.

Creating a separate layer for rendering has an additional important benefit: you can use different renderers for different devices. Every component includes the `@Component` annotation that contains an HTML template defining the look of the component. If you want to create a `<stock-price>` component to display stock prices in the web browser, its UI portion might look like this:

```
@Component({
  selector: 'stock-price',
  renderer: 'DOMRenderer',
  template: '<div>The price of an IBM share is $165.50</div>'
})
class StockPriceComponent {
...
}
```

Currently, `DOMRenderer` is the default renderer, so you don’t need to include it in the `@Component` annotation.

Angular’s rendering engine is a separate module, which allows third-party vendors to replace the default DOM renderer with one that targets non-browser-based platforms. For example, this allows you reuse the TypeScript code across devices with third-party UI renderers for mobile devices that render native components. The TypeScript portion of the components remains the same, but the content of the `template` property of the `@Component` decorator may contain XML or another language for rendering native components.

One such custom Angular 2 renderer is already implemented in the NativeScript framework, which serves as a bridge between JavaScript and native iOS and Android UI components. With NativeScript you can reuse the component’s code by just replacing the HTML in the template with XML. Another custom UI renderer allows you to use Angular 2 with React Native, which is an alternative way of creating native (not hybrid) UIs for iOS and Android.

A new and improved change-detection mechanism is another contributor to Angular’s better performance. Angular doesn’t use two-way binding unless you manually program it. One-way binding simplifies the detection of changes in an application that may have lots of interdependent bindings. You can now mark a component to be excluded from the change-detection workflow, so it won’t be checked when a change is detected in another component.

NOTE	Although Angular is a complete redesign of AngularJS, if you use AngularJS you can start writing code in Angular style by using `ng-forward` (see https://github.com/ngUpgraders/ng-forward). The other approach (`ng-upgrade`) is to start gradually switching to a newer version of this framework by running Angular and AngularJS in the same application (see https://angular.io/docs/ts/latest/guide/upgrade.html), but this will increase the size of the application.

1.4 An Angular developer's toolbox

Say you need to hire a web developer experienced with Angular. What would you expect the developer to know? They'd need to understand the architecture, components, and concepts of Angular applications mentioned in the previous sections, but that's not enough. The following rather long list identifies languages and tools that professional Angular developers use. Not all of them are needed for developing and deploying any given application. We'll use only half of them in this book.

- JavaScript is a de facto standard programming language for the front end of web applications. ES6 is the latest standardized specification for scripting languages, and JavaScript is its most popular implementation.
- TypeScript is a superset of JavaScript that makes developers more productive. TypeScript supports most of the features of ES6 and adds optional types, interfaces, metadata annotations, and more.
- The TypeScript code analyzer uses type definition files for code that's not originally written in TypeScript. DefinitelyTyped is a popular collection of such files describing the APIs of hundreds of JavaScript libraries and frameworks. Using type definition files allows the IDEs to provide context-sensitive help and highlight errors. We'll use the type-definition manager Typings (see Appendix B) to download the required files.
- Because most web browsers support only the ES5 (ECMAScript 5) syntax, you'll need to *transpile* (convert and compile) the code written in TypeScript or ES6 to ES5 for deployment. Angular developers may use Babel, Traceur, and the TypeScript compiler for code transpiling (see appendixes A and B for details).
- SystemJS is a universal module loader that loads modules created in ES6, AMD, or CommonJS standards.
- Angular CLI is a code generator that allows you to generate new Angular projects, components, services, and routes, as well as build the application for deployment.
- Node.js is a platform built on Chrome's JavaScript engine. Node includes both a framework and a runtime environment for running JavaScript code outside of the browser. We won't be using the Node.js framework in this book, but we'll use its runtime to install the required tools for developing Angular applications.
- npm is a package manager that allows you to download tools as well as JavaScript libraries and frameworks. This package manager has a repository of thousands of items, and we'll use it for installing pretty much everything from developer tools (such as the TypeScript compiler) to application dependencies (such as Angular 2, jQuery, and others). npm can also be used for running scripts, and we'll use this feature to start HTTP servers as well as for build automation.

- Bower used to be a popular package manager for resolving application dependencies (such as for Angular 2 and jQuery). We don't use Bower any longer because everything we need can be downloaded using npm.
- jspm is yet another package manager. Why do we need another one if npm can take care of all dependencies? Modern web applications consist of loadable modules, and jspm integrates SystemJS, which makes loading modules a breeze. In chapter 2 we'll give you a brief comparison of npm and jspm.
- Grunt is a task runner. Lots of steps need to be performed between developing and deploying the code, and all these steps must be automated. You may need to transpile the code written in TypeScript or ES6 into widely supported ES5 syntax, and the code, images, and CSS files need to be minimized. You may also want to include the tasks that will check the code quality and unit test your application. With Grunt, you can configure all the tasks and their dependencies in a JSON file so the process is 100% automated.
- Gulp is yet another task runner. It can automate tasks just as Grunt does, but instead of configuring the process in JSON, you simply program it in JavaScript. This allows you to debug it if need be.
- JSLint and ESLint are code analyzers that look for problematic patterns in JavaScript programs or JSON-formatted documents. These are code-quality tools. Running a JavaScript program through JSLint or ESLint results in a number of warning messages suggesting how you can improve the code quality of the program.
- TSLint is is a code-quality tool for TypeScript. It has a collection of extendable rules to enforce the recommended coding style and patterns.
- Minifiers, like UglifyJS, make files smaller. In JavaScript they remove code comments and line breaks, and they make variable names shorter. Minification can also be applied to HTML, CSS, and image files.
- Bundlers, such as Webpack, combine multiple files and their dependencies into a single file.
- Because JavaScript syntax is very forgiving, the application code requires testing, so you'll need to pick one of the testing frameworks. We'll use the Jasmine framework and the test runner called Karma.
- Both JavaScript and TypeScript are well supported by modern IDEs and text editors such as WebStorm, Visual Studio, Visual Studio Code, Sublime Text, Atom, and others.
- All major web browsers come with developer tools that allow you to debug your programs right inside the browser. Even if the program was written in TypeScript and deployed in JavaScript, you can debug the original source code using source maps. We use Chrome Developer Tools.
- Web applications should be usable on mobile devices. You should use UI components that internally support a responsive web design approach to ensure that the UI layout automatically changes depending on the screen size of the user's device.[1]

Footnote 1 See Wikipedia for an explanation of responsive web design: https://en.wikipedia.org/wiki/Responsive_web_design.

This list may look intimidating, but you don't have to use each and every tool mentioned. In this book we'll use the following tools:

- npm for configuring applications, installing utilities, and dependencies. We'll use npm scripts for starting web servers and as task runners in build automation.

- Node.js as a runtime environment for running utilities and as a framework for writing a web server (chapter 8).
- SystemJS for loading the application code and transpiling TypeScript on the fly in the browser.
- The command-line TypeScript compiler tsc for running examples from appendix B and programming a Node application in chapter 8.
- Jasmine for programming unit tests, and Karma for running them (chapter 9).
- Webpack for minimizing and bundling applications for deployment (chapter 10).

NOTE	**Developing in Angular vs. AngularJS** Programming in Angular is much simpler than in AngularJS, but the initial setup of the application is more involved because you'll be using transpilers and module loaders, which were not required for developing with JavaScript and AngularJS. In general, the introduction of ES6 modules changes the way applications will be loaded to the browser in the future, and we'll use the new approach in this book.

Figure 1.5 illustrates how tools can be applied at different stages of the development and deployment process. The tools that we'll use in this book are shown in bold.

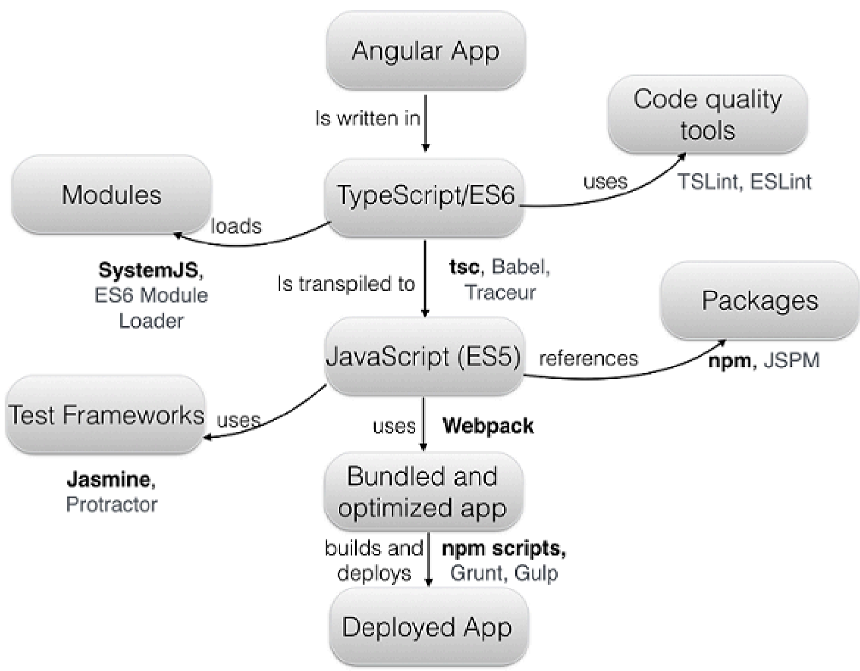


Figure 1.5 Using tools

Programming in Angular is easier than in AngularJS, but the initial environment setup must be done right so you can really enjoy the development process. In the next chapter we'll discuss the initial project setup and tooling in greater detail.

1.5 How things are done in Angular

To give you a taste of how things done in Angular, we came up with table 1.1, which lists the tasks that you may want to do (the left column) and what the Angular/TypeScript combo offers to accomplish this task (the right column). This is not a complete list of tasks that you can do, and we show you just fragments of the syntax but it may help you to get general idea. All these features will be explained in the book.

Table 1.1 How things are done in Angular

Task	How
Implement business logic	Create a class and Angular will instantiate and inject it into your component. You can also use the `new` operator.
Implement a component with UI	Create a class annotated with `@Component`
Specify the HTML template to be rendered by a component	Either inline the HTML code in the `@Component` annotation using its `template` property, or specify the name of the HTML file in `templateURL`
Manipulate HTML	Use one of the structural directives (`*ngIf`, `*ngFor`) or create a custom class annotated with `@Directive`
Refer to the class variable on the current object	Use the `this` keyword: `this.userName="Mary";`
Arrange navigation on a single-page app	Configure the component-based router, mapping components to URL segments, and add the `<router-outlet>` tag to the template where you want the component to be rendered
Display a value of a component's property on the UI	Place the variables inside double curly brackets on the template: `{{customerName}}`
Bind a component property to the UI	Use property binding with square brackets: `<input [value]="greeting" >`
Handle UI events	Surround the event name with parentheses and specify the handler: `<button (click)="onClickEvent()">Get Products</button>`
Use two-way binding	Use the `[()]` notation: `<input [(ngModel)] = "myComponentProperty">`
Pass data to a component	Annotate component properties as `@Input` and bind the values to it
Pass data from a component	Annotate component properties as `@Output` and use `EventEmitter` to emit events
Make an HTTP request	Inject the `Http` object into a component and invoke one of the HTTP methods: `this.http.get('/products')`
Handle HTTP responses	Use the `subscribe()` method on the result that arrives as an observable stream: `this.http.get('/products').subscribe(…);`
Pass an HTML fragment to a child component	Use the `<ng-content>` in the child's template
Intercept modifications of components	Use the component's lifecycle hooks
Deploy	Use third-party bundlers like Webpack to package the application files and frameworks into JavaScript bundles

1.6 Introducing the online auction example

To make this book more practical, we'll start every chapter by showing you small applications that illustrate Angular syntax or techniques, and at the end of each chapter we'll use the new concepts in a working application. You'll see how components and services are combined into a working application.

Imagine an online auction where people can browse and search the products. When the results are displayed, the user can select a product and bid on it. Each new bid will be validated on the server and will either be accepted or rejected. The information on the latest bids will be pushed by the server to all users subscribed for such notifications.

The functionality of browsing, searching, and placing bids will be implemented by making requests to the server's RESTful endpoints, implemented in the server developed with Node.js. The server will use WebSockets to push notifications about the user's bid acceptance or rejection and about the bids placed by other users. Figure 1.6 depicts sample workflows for the online auction.

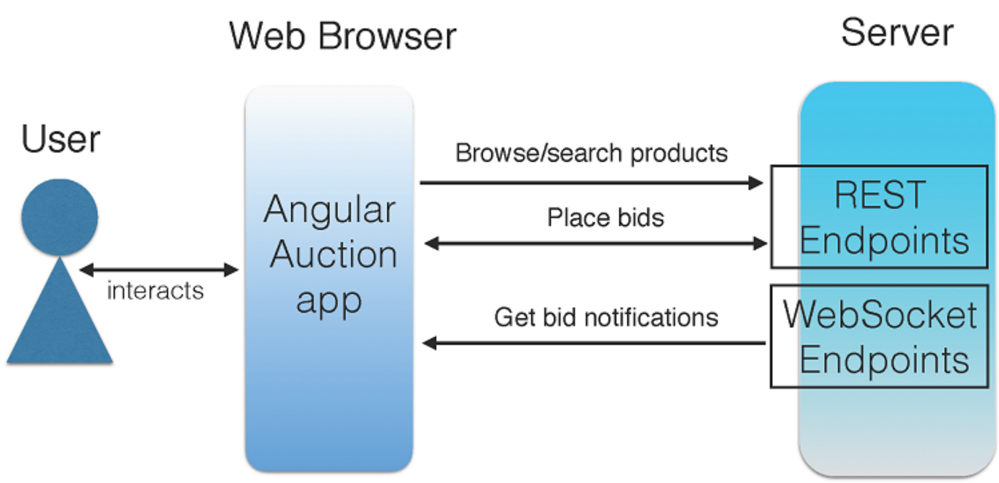


Figure 1.6 The online auction workflow

Figure 1.7 shows how the auction home page will be rendered on desktop computers. Initially we'll use gray placeholders instead of product images.

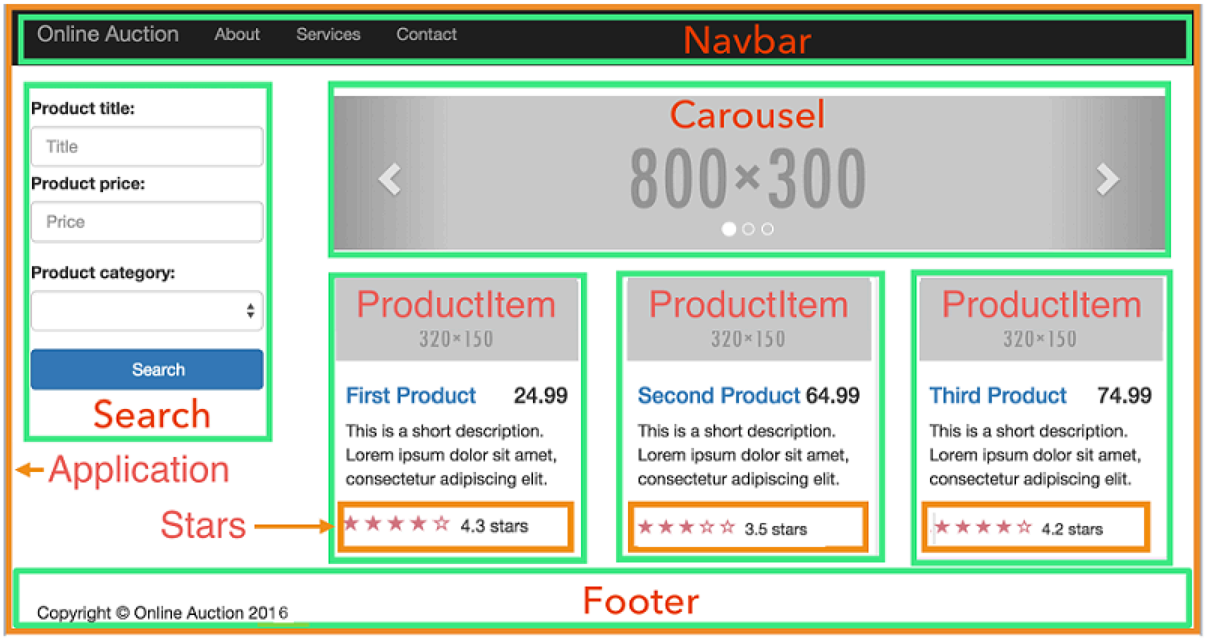


Figure 1.7 The online auction home page with highlighted components

We'll use responsive UI components, so on smartphones the home page will be rendered as in figure 1.8.

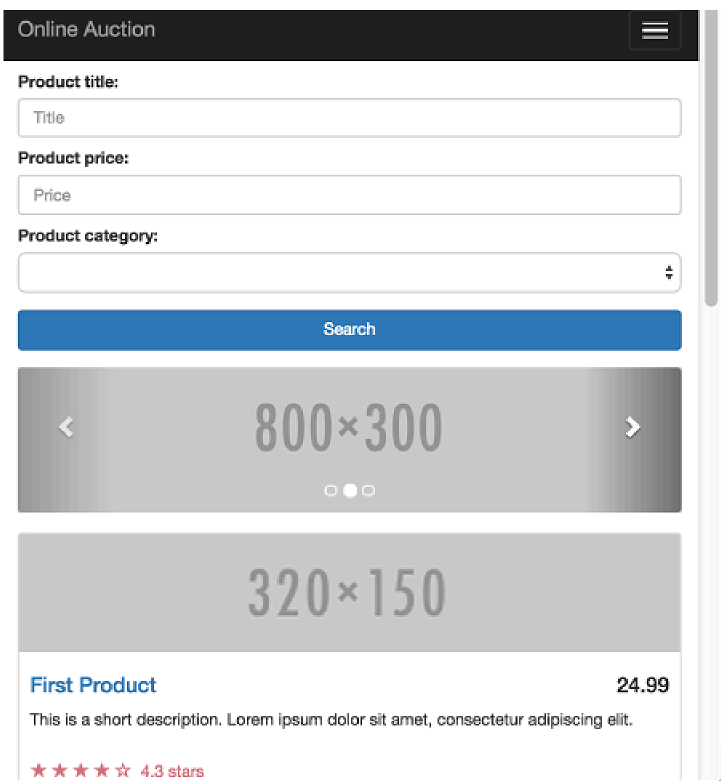


Figure 1.8 The online auction home page on smartphones

The development of an Angular application comes down to creating and composing components. The code of our online auction will be written in TypeScript, and the view portion of the components will be developed as HTML templates with data binding. Figure 1.9 shows the initial project structure for the online auction app.

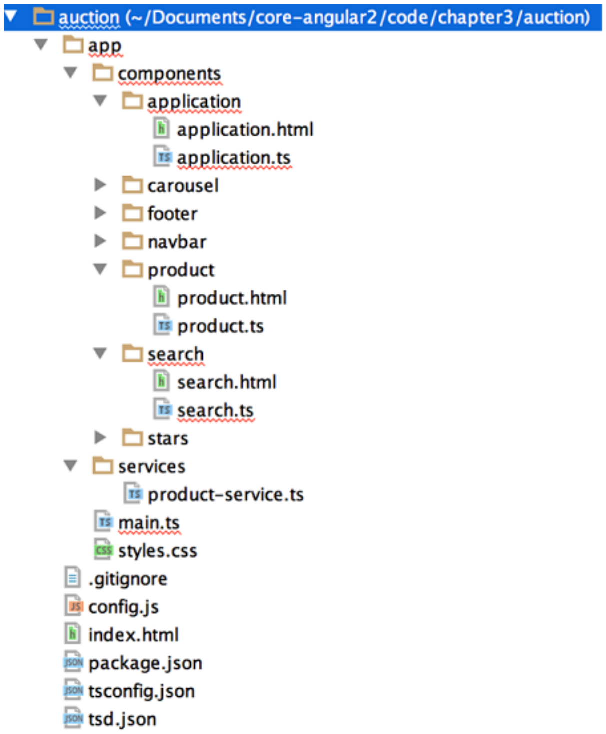


Figure 1.9 The initial project structure for the online auction app

The index.html file will just load the main application component represented by two files: application.html and application.ts. The application component will include other components like product, search, and so on. All dependencies of the application component will be loaded automatically.

1.7 Summary

In this chapter we took a high-level look at the Angular 2 framework in comparison with its previous version, AngularJS. We also introduced a sample online auction application that we'll be developing throughout this book.

- The architecture of Angular is simpler than that of AngularJS
- Angular applications can be developed in TypeScript or JavaScript
- The source code has to be transpiled into JavaScript before deployment
- The Angular developer has to be familiar with multiple tools
- Angular is a component-based framework
- Good frameworks allow application developers write less code, and Angular is a good one

2 Getting started with Angular

This chapter covers

- Writing your first Angular application
- Getting familiar with the SystemJS universal module loader
- The role of package managers
- The first version of the online auction application

In this chapter we'll start developing Angular applications using modern tools and web technologies like annotations, ES6 modules, and module loaders. Angular changes the way we'll develop JavaScript applications. We'll write three versions of a Hello World application, and we'll briefly discuss package managers and the SystemJS universal module loader.

After that, we'll create a small project that can serve as boilerplate for creating your own Angular projects.

Then we'll discuss the main building blocks of Angular applications, such as components and views, and we'll briefly cover dependency injection and data binding. At the end of the chapter we'll go over the online auction application that we'll be developing throughout the book.

NOTE **The Angular version used in code samples**
All code samples in this book are based on the Angular 2 Release Candidate 6 version. If the API of future releases of Angular changes, we'll update the code samples at https://github.com/Farata/angular2typescript accordingly.

NOTE **Not familiar with the TypeScript syntax?**
If you're not familiar with the syntax of TypeScript and ECMAScript 6, we suggest you read appendixes A and B first, and then start reading from this chapter on.

2.1 A first Angular application

In this section we'll show you three versions of the Hello World application written in TypeScript, ES5, and ES6. This will be the only section where you'll see Angular applications written in ES5 and ES6—all other code samples will be written in TypeScript.

2.1.1 Hello World in TypeScript

Our first application will be quite minimalistic to get you quickly started programming with Angular. This application will consist of two files:

```
index.html
main.ts
```

Both files are located in the hello-world-ts directory in the downloadable code for the book. The index.html file is the entry point for the application. It will contain references to the Angular framework, its dependencies, and the main.ts file, which contains the code to bootstrap your application. Some of these references can be located in the configuration file of the module loader (we'll use the SystemJS and Webpack loaders in this book).

LOADING ANGULAR IN THE HTML FILE

The code of the Angular framework consists of modules (one file per module), which are combined into libraries, which are logically grouped into packages, such as `@angular/core`, `@angular/common`, and so on. Your application has to load required packages before the application code.

Let's create an index.html file, which will start by loading the required Angular scripts, the TypeScript compiler, and the SystemJS module loader. In the first code samples we'll load these scripts from the unpkg.com content delivery network (CDN).

```
<!DOCTYPE html>
<html>
<head>

  <script src="//unpkg.com/zone.js@0.6.12"></script>           ❶

  <script src="//unpkg.com/typescript@2.0.0"></script>          ❷

  <script src="//unpkg.com/systemjs@0.19.37/dist/system.src.js"></script>    ❸
  <script src="//unpkg.com/core-js/client/shim.min.js"></script>
  <script>
```

```
    System.config({
      transpiler: 'typescript',
      typescriptOptions: {emitDecoratorMetadata: true},
      map: {
        'rxjs': 'https://unpkg.com/rxjs@5.0.0-beta.11',
        '@angular/core'                    :
            'https://unpkg.com/@angular/core@2.0.0-rc.6',
        '@angular/common'                  :
            'https://unpkg.com/@angular/common@2.0.0-rc.6',
        '@angular/compiler'                :
            'https://unpkg.com/@angular/compiler@2.0.0-rc.6',
        '@angular/platform-browser'        :
            'https://unpkg.com/@angular/platform-browser@2.0.0-rc.6',
        '@angular/platform-browser-dynamic':
            'https://unpkg.com/@angular/platform-browser-dynamic@2.0.0-rc.6'
      },
      packages: {
        '@angular/core'                    : {main: 'index.js'},
        '@angular/common'                  : {main: 'index.js'},
        '@angular/compiler'                : {main: 'index.js'},
        '@angular/platform-browser'        : {main: 'index.js'},
        '@angular/platform-browser-dynamic': {main: 'index.js'}
      }
    });
    System.import('main.ts');
  </script>
</head>
<body>
  <hello-world></hello-world>
</body>
</html>
```

1. Zone.js is a library that powers the change-detection mechanism.
2. The TypeScript compiler transpiles your source code into JavaScript right in the browser.
3. The SystemJS library dynamically loads the application code into the browser. We'll discuss SystemJS later in this chapter.
4. Configures SystemJS loader for loading and transpiling TypeScript code.
5. Maps the names of the Angular modules to their CDN locations.
6. Specifies the main script for each Angular module.
7. Instructs SystemJS to load the main module from the main.ts file.
8. The <hello-world></hello-world> custom HTML element represents the component that's implemented in main.ts.

When the application is launched, the <hello-world> tag will be replaced with the content of the template from the `@Component` annotation shown in the next code listing.

NOTE	**Using Angular in Internet Explorer** If you use Internet Explorer, you may need to add additional scripts es6-shim.min.js and system-polyfills.

> **NOTE** **Content delivery networks (CDNs)**
> unpkg (https://unpkg.com) is a CDN for packages published to the npm (https://www.npmjs.com/) package manager's registry. Check npmjs.com to find the latest version of a particular package. If you want to see which other versions of the package are available, run the `npm info packagename` command.
>
> Generated files aren't committed into a version control system and Angular 2 doesn't include ready-to-use bundles in its Git repository. They're generated on the fly and published along with the npm package (https://www.npmjs.com/~angular), so you can use unpkg to directly reference production-ready bundles in HTML files. Instead, we prefer using a local install of Angular and its dependencies, so we'll install them using npm in section 2.4.2. Everything that's installed by npm will be stored in the node_modules directory in each of our projects.

THE TYPESCRIPT FILE

Now let's create a main.ts file, which has the TypeScript/Angular code and three parts: . Declare the Hello World component. . Wrap it into a module. . Load the module.

Later in this chapter we'll implement these parts in three separate files, but here, for simplicity, we'll keep all the code of this tiny app in one file.

```
import {Component} from '@angular/core';   1
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';

// Component
@Component({
  selector: 'hello-world',   2
  template: '<h1>Hello {{ name }}!</h1>'   3
})
class HelloWorldComponent {   4
  name: string;   5

  constructor() {
    this.name = 'Angular';   6
  }
}

// Module
@NgModule({   7
  imports:      [ BrowserModule ],
  declarations: [ HelloWorldComponent ],
  bootstrap:    [ HelloWorldComponent ]
})
export class AppModule { }   8
```

```
// App bootstrap
platformBrowserDynamic().bootstrapModule(AppModule);  ❾
```

❶ Imports the bootstrap method and the @Component annotation from the corresponding Angular packages, making them available for the application's code.

❷ The @Component annotation placed above the HelloWorldComponent class turns it into an Angular component.

❸ The template property defines the HTML markup for rendering this component.

❹ The annotated HelloWorldComponent class represents the component.

❺ The name property is used in the data-binding expression on the component's template.

❻ Inside the constructor, you initialize the name property with the value Angular 2 bound to the template.

❼ Declares the content of the module.

❽ Declares the class representing the module.

❾ Loads the module.

We'll introduce the annotations `@Component` and `@NgModule` in section 2.2.

SIDEBAR **What's metadata?**

In general, metadata is additional information about data. For example, in an MP3 file, the audio is the data, but the name of the artist, the song title, and the album cover are metadata. The MP3 player includes a metadata processor that reads the metadata and displays some of it while playing the song.

In the case of classes, metadata is additional information about the class. For example, the `@Component` decorator (a.k.a annotation) tells Angular (the metadata processor) that this is not a regular class, but a component. Angular generates additional JavaScript code based on the information provided in the properties of the `@Component` decorator.

In the case of class properties, the `@Input` decorator tells Angular that this class property should support binding and be able to receive data from the parent component.

You can also think of a decorator as a function that attaches some data to the decorated element. The `@Component` decorator doesn't change the decorated class but adds some data describing the class so the Angular compiler can properly generate the final code of the component, either in the browser's memory (dynamic compilation) or in the file on disk (static compilation).

Any app component can be included in an HTML file (or a template of another component) by using the tag that matches the component's name in the `selector` property of the `@Component` annotation. Component selectors are similar to CSS selectors, so given the `'hello-world'` selector, you'd render this component in an HTML page with an element named `<hello-world>`. Angular will convert this line into `document.querySelectorAll(selector)`.

Notice how in the preceding code sample the entire template is wrapped in backticks to turn the template into a string. That way you can use single and double quotes inside the template and break it into multiple lines for better formatting.

The template contains the data-binding expression `{{ name }}`, and during runtime Angular will find the `name` property on your component and replace the data-binding expression in curly braces with a concrete value.

We'll use TypeScript for all the code examples in this book except for the two versions of Hello World shown next. One example will show an ES5 version, and the other is written in ES6.

2.1.2 Hello World in ES5

To create applications with ES5 (ECMAScript 5), you should use a special Angular bundle distributed in Universal Module Definition (UMD) format (note the *umd* in the URLs). It publishes all Angular APIs on the global `ng` object.

The HTML file of the ES5 Angular Hello World application might look like the following (see the hello-world-es5 folder):

```
<!DOCTYPE html>
<html>
<head>
  <script src="//unpkg.com/zone.js@0.6.12/dist/zone.js"></script>
  <script src="//unpkg.com/rxjs@5.0.0-beta.11/bundles/Rx.umd.js"></script>
  <script src="//unpkg.com/core-js/client/shim.min.js"></script>
  <script src="//unpkg.com/@angular/core@
    2.0.0-rc.6/bundles/core.umd.js"></script>
  <script src="//unpkg.com/@angular/common@
    2.0.0-rc.6/bundles/common.umd.js"></script>
  <script src="//unpkg.com/@angular/compiler@
    2.0.0-rc.6/bundles/compiler.umd.js"></script>
  <script src="//unpkg.com/@angular/platform-browser@
    2.0.0-rc.6/bundles/platform-browser.umd.js"></script>
  <script src="//unpkg.com/@angular/platform-browser-dynamic@
    2.0.0-rc.6/bundles/platform-browser-dynamic.umd.js"></script>
</head>
<body>
<hello-world></hello-world>
<script src="main.js"></script>
</body>
</html>
```

Because ES5 doesn't support the annotations syntax and has no native module system, the main.js file should be written differently from its TypeScript version:

```
// Component
(function(app) {
```

```
  app.HelloWorldComponent =
      ng.core.Component({
        selector: 'hello-world',
        template: '<h1>Hello {{name}}!</h1>'
      })
      .Class({
        constructor: function() {
          this.name = 'Angular 2';
        }
      });
})(window.app || (window.app = {}));

// Module
(function(app) {
  app.AppModule =
      ng.core.NgModule({
        imports: [ ng.platformBrowser.BrowserModule ],
        declarations: [ app.HelloWorldComponent ],
        bootstrap: [ app.HelloWorldComponent ]
      })
          .Class({
            constructor: function() {}
          });
})(window.app || (window.app = {}));

// App bootstrap
(function(app) {
  document.addEventListener('DOMContentLoaded', function() {
    ng.platformBrowserDynamic
        .platformBrowserDynamic()
        .bootstrapModule(app.AppModule);
  });
})(window.app || (window.app = {}));
```

The first immediately invoked function expression (IIFE) invokes the `Component()` and `Class` methods on the global Angular core namespace `ng.core`. We define the `HelloWorldComponent` object and the `Component` method attaches the metadata defining its selector and template. By doing this, we turn the JavaScript object into a visual component.

The business logic of the component is coded inside the `Class` method. In this case we declared and initialized the `name` property that's bound to the component's template.

The second IIFE invokes the `NgModule` method to create a module that declares our `HelloWorldComponent` and specifies it as a root component by assigning its name to the `bootstrap` property.

Finally, the third IIFE launches the app by invoking `bootstrapModule()`, which loads the module, instantiates `HelloWorldComponent`, and attaches it to the browser's DOM.

2.1.3 Hello World in ES6

The ES6 (ECMAScript 6) version of the Hello World application looks very similar to the TypeScript version, but we'll use Traceur as the transpiler for SystemJS. The index.html file will look like this:

```
<!DOCTYPE html>
<html>
<head>
  <script src="//unpkg.com/zone.js@0.6.12"></script>
  <script src="//unpkg.com/reflect-metadata@0.1.3"></script>
  <script src="//unpkg.com/traceur@0.0.111/bin/traceur.js"></script>
  <script src="//unpkg.com/systemjs@0.19.37/dist/system.src.js"></script>
  <script>
    System.config({
      transpiler: 'traceur',    ❶
      traceurOptions: {annotations: true},
      map: {
        'rxjs': 'https://unpkg.com/rxjs@5.0.0-beta.11',

        '@angular/core'                    :
            'https://unpkg.com/@angular/core@2.0.0-rc.6',
        '@angular/common'                  :
            'https://unpkg.com/@angular/common@2.0.0-rc.6',
        '@angular/compiler'                :
            'https://unpkg.com/@angular/compiler@2.0.0-rc.6',
        '@angular/platform-browser'        :
            'https://unpkg.com/@angular/platform-browser@2.0.0-rc.6',
        '@angular/platform-browser-dynamic':
            'https://unpkg.com/@angular/platform-browser-dynamic@2.0.0-rc.6'
      },
      packages: {
        '@angular/core'                    : {main: 'index.js'},
        '@angular/common'                  : {main: 'index.js'},
        '@angular/compiler'                : {main: 'index.js'},
        '@angular/platform-browser'        : {main: 'index.js'},
        '@angular/platform-browser-dynamic': {main: 'index.js'}
      }
    });
    System.import('main.js');    ❷
  </script>
</head>
<body>
  <hello-world></hello-world>
</body>
</html>
```

❶ ES6 isn't fully supported across browsers, and we use Traceur to transpile (in the browser) ES6 code into an ES5 version.

❷ The extension of the script file is .js now.

The only difference between the ES6 main.js file compared to the TypeScript main.ts file is that now we don't have the predeclared `name` class member:

```
import {Component} from '@angular/core';
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';

// Component
@Component({
  selector: 'hello-world',
  template: '<h1>Hello {{ name }}!</h1>'
})
class HelloWorldComponent {

  constructor() {
    this.name = 'Angular 2';
```

```
  }
}

// Module
@NgModule({
  imports:      [ BrowserModule ],
  declarations: [ HelloWorldComponent ],
  bootstrap:    [ HelloWorldComponent ]
})
export class AppModule { }

// App bootstrap
platformBrowserDynamic().bootstrapModule(AppModule);
```

LAUNCHING APPLICATIONS

To run any web application, you'll need a basic HTTP server, such as http-server or live-server. The latter performs live reloads of the web page as soon as you modify the code and save the file of the running application.

To install http-server, use the following npm command:

```
npm install http-server -g
```

To start the server from the command line in the project root directory, use this command:

```
http-server
```

We prefer to see live reloads in the browser, so we'll install and start live-server using a similar routine:

```
npm install live-server -g

live-server
```

If you use http-server, you'll need to manually open the web browser and enter the URL http://localhost:8080, whereas live-server will open the browser for you.

To run the Hello World application, launch `live-server` in the root directory of the project and it'll load index.html in your web browser. You should see "Hello Angular 2!" rendered on the page (see 2.1figure 2.1). In the browser's Developer Tools panel you can see that the template we specified for `HelloWorldComponent` becomes the content of the `<hello-world>` element, and the data-binding expression is replaced with the actual value we used to initialize the `name` property in the constructor of the component.

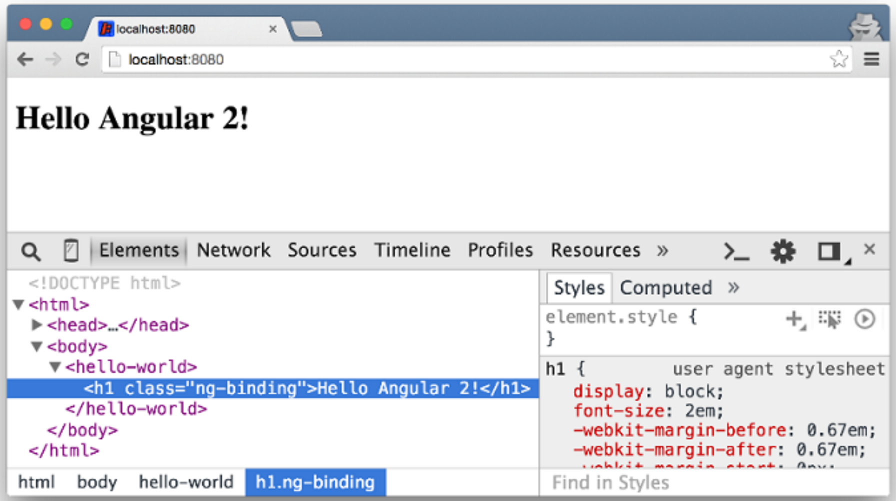


Figure 2.1 Running Hello World

2.2 The building blocks of an Angular application

In this section we'll give you a high-level overview of the main building blocks of an Angular application so that you can read and understand Angular code. We'll discuss each of these topics in detail in future chapters.

2.2.1 Modules

An Angular module is a container for a group of related components, services, directives, and so on. You can think of a module as a library of components and services that implements certain functionality from the business domain of your application, such as a shipping module or a billing module. All elements of a small application can be located in one module (the root module), whereas larger apps may have more than one module (feature modules). All apps must have at least a root module that is bootstrapped during the app launch.

NOTE	**Angular vs. ES6 modules** ES6 modules just offer you a way to hide and protect functions or variables and create loadable scripts. Angular modules, in contrast, are used for packaging related application functionality.

From the syntax perspective, a module is a class annotated with the `NgModule` decorator and that can include other resources. In section 2.1.1 we already used a module, which looked like this:

```
@NgModule({
  imports:      [ BrowserModule ],   ❶
```

```
  declarations: [ HelloWorldComponent ],  ❷
  bootstrap:    [ HelloWorldComponent ]  ❸
})
export class AppModule { }
```

❶ Every browser app must import BrowserModule and can import other modules (such as FormsModule) if need be.

❷ Declares that HelloWorldComponent belongs to the AppModule. Each module member must be listed here.

❸ During app launch, the module renders the root component that's assigned to the bootstrap property of @NgModule.

Importing `BrowserModule` is a must in the root module, but if your app will consist of the root and feature modules, the latter will need to import `CommonModule` instead.

All imported modules (such as `FormsModule` and `RouterModule`) are available to all components of the module and don't have to be repeatedly declared inside each component.

To load and compile a module on application startup, you need to invoke the `bootstrapModule` module:

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

Your app modules can be loaded either immediately (eagerly) as in the preceding code snippet, or lazily (as needed) by the router (see chapter 3). We'll use `@NgModule` in every chapter of this book, so you'll have a chance to see how to declare modules with multiple members. For a detailed description of Angular modules read the documentation at https://angular.io/docs/ts/latest/guide/ngmodule.html#.

2.2.2 Components

The main building block of an Angular application is *component*. Each component consists of two parts: a view that defines the user interface (UI) and a class that implements the logic behind the view.

Any Angular application represents a hierarchy of components packaged in modules. An app must have at least one module and one component, which is called the *root component*. There's nothing special about the root component compared to other components. Any component assigned to the `bootstrap` property of the module becomes the root component.

To create a component, declare a class and attach the `@Component` annotation to it:

```
@Component({
 selector: 'app-component',
 template: '<h1>Hello !</h1>'
```

```
})
class HelloComponent {}
```

Each `@Component` annotation must define `selector` and `template` (or `templateURL`) properties, which determine how the component should be discovered and rendered on the page.

The `selector` property is similar to a CSS selector. Each HTML element that matches the selector is rendered as an Angular component. You can think of the `@Component` decorator as a configuration function that complements the class. If you look at the transpiled code of the main.ts file from section 2.1.1, you'll see what the Angular compiler did with the `@Component` decorator:

```
var core_1;
var HelloWorldComponent;

HelloWorldComponent = (function () {
      function HelloWorldComponent() {
          this.name = 'Angular 2';
      }
      HelloWorldComponent = __decorate([
          core_1.Component({
              selector: 'hello-world',
              template: '<h1>Hello {{ name }}!</h1>'
          }),
          __metadata('design:paramtypes', [])
      ], HelloWorldComponent);
      return HelloWorldComponent;
  })
```

Each component must define a view, which is specified either in a `template` or a `templateUrl` property of the `@Component` decorator:

```
@Component({
  selector: 'app-component',
  template: '<h1>App Component</h1>' })
class AppComponent {}
```

For Web applications, a `template` contains HTML markup. You can also use another markup language for rendering native mobile applications provided by third-party frameworks. If the markup consists of a couple of dozen lines or less, we keep it inline using the `template` property. We didn't use backticks in the preceding example because it's a single line of markup and it doesn't contain single or double quotes. Larger HTML markup should be located in a separate HTML file referred to in `templateURL`.

Components are styled with regular CSS. You can use the `styles` property for inline CSS, and `styleURLs` for an external file with styles. External files allow web designers to work on the styles without modifying the application code. Ultimately, the decision of where to keep the HTML or CSS is yours.

You can think of a view as the result of merging UI layout with data. The code snippet for `AppComponent` has no data to merge, but the TypeScript version of Hello World (see the main.ts file in section 2.9) would merge the HTML markup with the value of the `name` variable to produce the view.

NOTE	In Angular, the view rendering is decoupled from components, so the template can represent a platform-specific native UI, such as Native Script (https://www.nativescript.org) or React Native (https://facebook.github.io/react-native).

2.2.3 Directives

The `@Directive` decorator allows you to attach custom behavior to an HTML element (for example, you can add an autocomplete feature to an `<input>` element). Each component is basically a directive with an associated view, but unlike a component, a directive doesn't have its own view.

The following example shows a directive that can be attached to an input element in order to log the input's value to the browser's console as soon as the value is changed:

```
@Directive({
  selector: 'input[log-directive]',      ❶
  host: {
    '(input)': 'onInput($event)'       ❷
  }
})
class LogDirective {
  onInput(event) {      ❸
    console.log(event.target.value);
  }
}
```

❶ This selector requires the target HTML element to have an input element and the log-directive attribute.

❷ Host element is the one you attach your directive to.

❸ The handler for the <input> element logs its value to the console.

To bind events to event handlers, enclose the event name in parentheses. When the `input` event occurs on the host element, the `onInput()` event handler is invoked and the event object is passed to this method as an argument.

Here's an example of how you can attach the directive to an HTML element:

```
<input type="text" log-directive/>
```

The next example shows a directive that changes the background of the attached element to blue.

```
import { Directive, ElementRef, Renderer } from '@angular/core';

@Directive({ selector: '[highlight]' })

export class HighlightDirective {
  constructor(renderer: Renderer, el: ElementRef) {
    renderer.setElementStyle(el.nativeElement, 'backgroundColor', 'blue');
  }
}
```

This directive can be attached to various HTML elements, and the constructor of this directive gets the references to the renderer and the UI element injected by Angular. Here's how this directive can be attached to the `<h1>` HTML element:

```
<h1 highlight>Hello World</h1>
```

All directives that are used in the module need to be added to the declaration property of the `@NgModule` decorator, as in this example:

```
@NgModule({
  imports:      [ BrowserModule ],
  declarations: [ HelloWorldComponent,
                  HighlightDirective ],
  bootstrap:    [ HelloWorldComponent ]
})
```

2.2.4 A brief introduction to data binding

Angular has a mechanism called *data binding* that allows you to keep a component's properties in sync with the view. This mechanism is quite sophisticated, and we'll cover data binding in detail in chapter 5. In this section we'll just cover the most common forms of data-binding syntax.

To display a value as a string in the template, use double curly braces:

```
<h1>Hello {{ name }}!</h1>
```

Use square brackets to bind an HTML element's property to a value:

```
<span [hidden]="isValid">The field is required</span>
```

To bind an event handler for an element's event, use parentheses:

```
<button (click)="placeBid()">Place Bid</button>
```

If you want to reference a DOM object's property within the template, add a local template variable (its name must start with #) that will automatically store a reference to the corresponding DOM object, and use dot notation:

```
<input #title type="text"  />
<span>{{ title.value }}</span>
```

We'll provide more details on data binding in chapter 5.

Now that you know how to write a simple Angular application, let's see how the code can be loaded into the browser with the SystemJS library.

2.3 The SystemJS universal module loader

Most existing web applications load JavaScript files into an HTML page using `<script>` tags. Although it's possible to add Angular code to a page the same way, the recommended way is to load code using the SystemJS library. Angular also uses SystemJS internally.

In this section we'll give you a brief overview of SystemJS so you can get started developing Angular applications. For a detailed tutorial on SystemJS, see the SystemJS page on GitHub: https://github.com/systemjs/systemjs.

2.3.1 An overview of module loaders

The final ES6 specification introduces modules and covers their syntax and semantics (http://www.ecma-international.org/ecma-262/6.0/#sec-modules). The early specification drafts included a definition of the global `System` object responsible for loading modules into the execution environment, whether that's a web browser or a standalone process. But the definition of the `System` object was removed from the final version of the ES6 spec and is currently tracked by the Web Hypertext Application Technology Working Group (see http://whatwg.github.io/loader). The `System` object may become a part of the ES7 specification.

The ES6 Module Loader polyfill (https://github.com/ModuleLoader/es6-module-loader) offers one way to use the `System` object today (without waiting for future EcmaScript specifications). It strives to match the future standard, but this polyfill supports only ES6 modules.

Because ES6 is fairly new, most third-party packages hosted on the NPM registry don't use ES6 modules yet. In the first nine chapters of this book we'll use SystemJS, which not only includes the ES6 Module Loader but also allows you to load modules written in AMD, CommonJS, UMD, and global module formats. The support for these formats is completely transparent for the SystemJS user, as it automatically figures out what module format the target script uses. In chapter 10 we'll use another module loader called Webpack.

2.3.2 Module loaders vs. <script> tags

Why even use module loaders as opposed to loading JavaScript with a `<script>` tag? The `<script>` tags have several issues:

- A developer is responsible for maintaining `<script>` tags in the HTML file. Some of them can become redundant over time, but if you forget to clean them up, they will still be loaded by the browser, increasing the load time and wasting network bandwidth.
- Often the order in which scripts are loaded matters. Browsers can only guarantee the execution order of the scripts if you place the `<script>` tags in the `<head>` section of the HTML document. But it's considered bad practice to put all your scripts in the `<head>`, because it prevents the page from being rendered until all the scripts are downloaded.

Let's consider the benefits of using module loaders both during development and while preparing a production version of your application.

- In development environments, the code is usually split into multiple files, and each file represents a module. Whenever you import a module in your code, the loader will match the module name to a corresponding file, download it into the browser, and then execute the rest of the code. Modules allow you to keep projects well organized, the module loader automatically assembles everything together in the browser when you launch the application. If a module has dependencies on other modules, all of them will be loaded.
- When you're preparing a production version of an application, a module loader takes the main file, traverses the tree of all modules reachable from it, and combines all of them into a single bundle. This way the bundle contains only the code that's actually used by the application. It also solves the problem with script loading order and cyclic references.

These benefits apply not only to your application's code but also to third-party packages (such as Angular).

NOTE	In this book we use the terms "module" and "file" interchangeably. A module can't span multiple files, and usually a file contains only one module, except for production bundles. A bundle is usually represented by a single file and contains multiple modules registered in it. When the difference between "module" and "file" is important, we'll explicitly mention it.

2.3.3 Getting started with SystemJS

When you use SystemJS in an HTML page, this library becomes available as a global `System` object that has a number of static methods. The two primary methods you'll use are `System.import()` and `System.config()`.

To load a module, use `System.import()`, which accepts the module name as an argument. A module name can be either a path to the file or a logical name mapped to the file path:

```
System.import('./my-module.js'); // A path to the file
System.import('@angular2/core'); // A logical name
```

If the module name starts with `./` it's a path to the file even when the name extension is omitted. SystemJS first tries to match the module name against the configured mapping provided either as an argument to the method `System.config()` or in a file (such as systemjs.config.js). If the mapping for the name isn't found, it's considered to be a path to a file.

NOTE In this book we'll use both the prefix `./` as well as the mapping configuration to find out which file will be loaded. If you see `System.import('app')` and can't find the file named app.ts, check the mapping configuration of your project.

The `System.import()` method immediately returns a `Promise` (see appendix A). When the `Promise` is resolved with a module object, the `then()` callback is invoked when the module is loaded. If the `Promise` is rejected, the errors are handled in the `catch()` method.

A module object contains a property for each exported value in the loaded module. The following code snippet from two files shows how you can export a variable in the module and use it in another script:

```
// lib.js
export let foo = 'foo';

// main.js
System.import('./lib.js').then(libModule => {
  libModule.foo === 'foo'; // true
});
```

Here you use the `then()` method to specify the callback function to be invoked when lib.js is loaded. The loaded object is passed as an argument to the fat arrow expression.

In ES5 scripts, we use the `System.import()` method to load the code either eagerly or lazily (dynamically). For example, if an anonymous user browses our website, we may not need a module that implements the user profile functionality. But as soon as the user logs in, we can dynamically load the profile module. This way we decrease initial page load size and time.

But what about the ES6 `import` statements? In our first Angular application we used `System.import()` inside the index.html file to load the root application module, main.ts. In turn, the main.ts script imports Angular's modules using its own `import` statement.

When SystemJS loads main.ts, it automatically transpiles it into ES5-compatible code, so there are no `import` statements in the code that browsers execute. In the future, when ES6 modules are natively supported by major browsers, this step won't be required and `import` statements will work similarly to `System.import()` method, except they won't control the moment when the module is loaded.

NOTE	**Source maps** When SystemJS transpiles files, it automatically generates the source map for each .js file, which allows you to debug the TypeScript code in the browser.

A DEMO APPLICATION

Let's consider an application that needs to load both ES5 and ES6 scripts. This application will consist of three files (see the systemjs-demo folder):

```
index.html
es6module.js
es5module.js
```

In a typical web application, the index.html file would contain the `<script>` tags referencing both es6module.js and es5module.js. Each of these files would be automatically loaded and executed by the browser. But this approach has several issues that we discussed in section 2.3.2. Let's see how we can address these issues with SystemJS in our demo application.

We use the ES6 `export` statement to make the es6module.js module's name available from outside of the script. The presence of the `export` statement automatically turns the file into an ES6 module.

```
export let name = 'ES6';

console.log('ES6 module is loaded');
```

The es5module.js file doesn't include any ES6 syntax and uses the CommonJS module format to export the name of the module. Basically we just attach to the `exports` object the variables we want to be visible outside of the module.

```
exports.name = 'ES5';

console.log('ES5 module is loaded');
```

The following index.html file seamlessly imports both CommonJS and ES6 modules with the help of SystemJS.

Listing 2.1 index.html

```
<!DOCTYPE html>
<html>
<head>
  <script src="//unpkg.com/es6-promise@3.0.2/dist/es6-promise.js"></script>
  <script src="//unpkg.com/traceur@0.0.111/bin/traceur.js"></script>
  <script src="//unpkg.com/systemjs@0.19.37/dist/system.src.js"></script>
  <script>
    Promise.all([                                  ❶
      System.import('./es6module.js'),             ❷
      System.import('./es5module.js')              ❸
    ]).then(function (modules) {                   ❹
      var moduleNames = modules                    ❺
        .map(function (m) { return m.name; })      ❻
        .join(', ');                               ❼

      console.log('The following modules are loaded: ' + moduleNames);
    });
  </script>
</head>
<body></body>
</html>
```

❶ The ES6 Promise.all() method returns a Promise that resolves (or rejects) when all iterable arguments are complete.

❷ Here we use the relative path to the file es6module.js that uses the ES6 module syntax.

❸ Load es5module.js similarly to the previous one, but this time SystemJS uses the CommonJS format.

❹ We don't use the ES6 arrow function here because the index.html file itself isn't processed by SystemJS, so the code wouldn't be transpiled and wouldn't work in all browsers.

❺ After the arguments of Promise.all() are loaded, they're given to the then() method as the modules array.

❻ This map() method invokes the function that transforms the result by extracting the name property exported from each module.

❼ The method join() combines all module names into a comma separated string.

Because `System.import()` returns a `Promise`, we can start loading multiple modules at once and execute some other code when all modules are loaded.

When the application is launched, the following result is printed to the browser's console (keep the Developer Tools panel open to see it):

```
Live reload enabled.
ES6 module is loaded
```

```
ES5 module is loaded
The following modules are loaded: ES6, ES5
```

The first line comes from the `live-server`, not from the app. As soon as one of the modules is loaded, it immediately prints its log message. When all modules are loaded, the callback function is executed and the last log message is printed.

CONFIGURING SYSTEMJS

We've used a default SystemJS configuration so far, but you can configure almost any aspect of its work using the `System.config()` method, which accepts a configuration object as an argument. `System.config()` can be invoked multiple times with different configuration objects. If the same option is set more than once, the latest value is applied.

You can either inline the script with `System.config()` in the HTML file using the `<script>` tag (see section 2.1.1), or store the code for `System.config()` in a separate file (such as systemjs.config.js) and include it into the HTML file using the `<script>` tag.

The complete list of configuration options for SystemJS is available on GitHub (https://github.com/systemjs/systemjs/blob/master/docs/config-api.md). We'll just briefly discuss some of the configuration options used in this book.

BASEURL

All modules are loaded relative to this URL unless the module name represents an absolute or a relative URL.

Listing 2.2 baseURL example

```
System.config({ baseURL: '/app' });
System.import('es6module.js');   // GET /app/es6module.js
System.import('./es6module.js'); // GET /es6module.js
System.import('http://example.com/es6module.js'); // GET http://example.com/es6module.js
```

DEFAULTJSEXTENSIONS

If `defaultJSExtensions` is `true`, the .js extension will be automatically added to all file paths. If a module name already has an extension other than .js, the .js will be appended anyway.

Listing 2.3 defaultJSExtensions example

```
System.config({ defaultJSExtensions: true });
System.import('./es6module');    // GET /es6module.js
System.import('./es6module.js'); // GET /es6module.js
System.import('./es6module.ts'); // GET /es6module.ts.js
```

WARNING The `defaultJSExtensions` property exists for backward compatibility and will be deprecated in future versions of SystemJS.

MAP

The `map` option allows you to create an alias for a module name. When you import a module, the module name is replaced with an associated value, unless the original module name represents any kind of path (absolute or relative). The `map` parameter is applied before `baseURL`.

Listing 2.4 map example 1

```
System.config({ map: { 'es6module.js': 'esSixModule.js' } });
System.import('es6module.js');   // GET /esSixModule.js
System.import('./es6module.js'); // GET /es6Module.js
```

Listing 2.5 map example 2

```
System.config({
  baseURL: '/app',
  map: { 'es6module': 'esSixModule.js' }
});
System.import('es6module'); // GET /app/esSixModule.js
```

PACKAGES

Packages provide a convenient way to set metadata and a map configuration that’s specific to a common path. For example, the following fragment instructs SystemJS that `System.import('app')` should load the module located in the main_router_sample.ts file by providing just the name of the file and the default extension `ts` for TypeScript:

```
System.config({
  packages: {
    app: {
      defaultExtension: "ts",
      main: "main_router_sample"
    }
  }
});
System.import('app');
```

PATHS

The `paths` option is similar to `map`, but it supports wildcards. It's applied after `map` but before `baseURL` (see the following example). You can use both `map` and `paths`, but remember that `paths` is part of the Loader specification (see http://whatwg.github.io/loader) and the ES6 Module Loader implementation (see https://github.com/ModuleLoader/es6-module-loader/blob/master/docs/loader-config.md), but `map` is only recognizable by SystemJS.

Listing 2.6 paths example

```
System.config({
  baseURL: '/app',
  map: { 'es6module': 'esSixModule.js' },
  paths: { '*': 'lib/*' }
});

System.import('es6module'); // GET /app/lib/esSixModule.js
```

In many code examples in this book, you'll find `System.import('app')`, which opens a file with a different name (that is, not `app`) because the `map` or `packages` property was configured. When you see something like `import {Component} from '@angular/core';`, the `@angular2` refers to the name mapped to the actual directory where the Angular framework is located. The `core` is a subdirectory, and the main file in that subdirectory is specified in the SystemJS configuration, as in this example:

```
packages: {
        '@angular/core' : {main: 'index.js'}
}
```

TRANSPILER

The `transpiler` option allows you to specify the names of the transpiler module that should be used while loading application modules. The transpiler is automatically used for all ES6 modules. If a file doesn't contain at least one `import` or `export` statement, it won't be transpiled. The `transpiler` option can contain one of the following values: `typescript`, `traceur`, and `babel`.

Listing 2.7 transpiler example

```
System.config({
  transpiler: 'traceur',
  map: {
    traceur: '//unpkg.com/traceur@0.0.108/bin/traceur.js'
  }
});
```

TYPESCRIPTOPTIONS

The `typescriptOptions` option allows you to set the TypeScript compiler options. The list of all available options can be found in the TypeScript documentation: http://www.typescriptlang.org/docs/handbook/compiler-options.html.

2.4 Selecting a package manager

It's very unlikely that you'll be writing a web application without using any library. Even in this book we'll use several of them in the code samples. We'll use the Angular framework for most of the code samples, and for the online auction app we'll also use Twitter's library called Bootstrap, which has jQuery as a dependency. Your application may require specific versions of these dependencies.

The loading of libraries, frameworks, and their dependencies is managed by a package manager, and we need to decide which of several popular ones to choose. JavaScript developers may be overwhelmed by the variety of package managers available: npm, Bower, jspm, Jam, and Duo, to name a few.

A typical project includes a configuration file that lists the names and versions of the required libraries and frameworks. Here's a fragment from the package.json npm configuration, which we'll use for the online auction application:

```
"scripts": {
  "start": "live-server"
},
"dependencies": {
  "@angular/common": "2.0.0-rc.6",
  "@angular/compiler": "2.0.0-rc.6",
  "@angular/core": "2.0.0-rc.6",
  "@angular/forms": "2.0.0-rc.6",
  "@angular/http": "2.0.0-rc.6",
  "@angular/platform-browser": "2.0.0-rc.6",
  "@angular/platform-browser-dynamic": "2.0.0-rc.6",
  "@angular/router": "^3.0.0-rc.2",

  "core-js": "^2.4.0",
  "rxjs": "5.0.0-beta.11",
  "systemjs": "0.19.37",
  "zone.js": "0.6.17",

  "bootstrap": "^3.3.6",
  "jquery": "^2.2.2"
},
"devDependencies": {
  "live-server": "0.8.2",
  "typescript": "^2.0.0"
}
```

The `scripts` section specifies the command to run if the developer enters `npm start` on the command line. In this case, we'll want to start the `live-server`.

The `dependencies` section lists all the third-party libraries and tools required for the runtime environment where the application is deployed.

> **NOTE** **Angular file suffixes**
> The suffix *rc.6* stands for the Angular version called “Release Candidate 6”. By the time you read this book, a newer version of Angular will be available, so you’ll need to consult the latest product documentation for the proper suffix, if any.

The `devDependencies` section adds the tools that must be present on the developer’s computer. For example, we won’t be using `live-server` in production as it’s a pretty simple server that suffices for development only. The preceding configuration also states that the TypeScript compiler is needed only during development, and you can guess that during deployment all TypeScript code will be transpiled into JavaScript.

The preceding configuration includes version numbers as well. If you see a `^` sign in front of the version number, it indicates that the project requires either the specified or any newer minor version of this library or package. At the time of writing we used the beta version of Angular, and we wanted to specify the exact package version because newer ones might have some breaking changes.

When we started working with Angular, we knew that we’d use the SystemJS module loader. Then we learned that the author of SystemJS (Guy Bedford) has also created a jspm package manager that uses SystemJS internally, so we decided to use jspm. For some time we’ve been using npm for installing tools and jspm for application dependencies. This setup worked, but with jspm a web browser was making 400+ requests to the server to show the first page of a rather simple application. Waiting for 3.5 seconds just to start the app on a local machine is a little too long.

We decided to try using npm for dependency management during development. The results were much better: only 30 server requests and 1.5 seconds to start the same app.

We’ll still give you a brief overview of both package managers and will show you how to start a new project with each of them. jspm is pretty young and it may improve over time, but we decided to use npm for our Angular projects.

2.4.1 Comparing npm and jspm

npm is a package manager for Node.js. It was originally created to manage Node.js modules, which are written in the CommonJS format. CommonJS wasn’t designed for web applications, because modules were supposed to be loaded synchronously. Consider the following code snippet:

```
var x = require(‘module1’);
var y = require(‘module2’);
var z = require(‘module3’);
```

The loading of `module2` won’t start until `module1` is loaded, and the loading of `module3` will wait for `module2`. This is OK for desktop applications written in Node.js because the loading is done from the local computer, but such a synchronous loading process would slow the downloading of applications.

Another weak point of npm was that historically used *nested* dependencies. If packages A and B depended on package C, each of them would keep a copy of C in its directory because A and B might depend on different versions of C. Although this was OK for Node.js applications, this didn't work well for applications loaded into a web browser. Even loading the same version of a library twice in a browser can cause issues. If two different versions are loaded, the chances of breaking the app are even higher.

The nested dependencies issue was addressed in npm 3, but the problem is only partially solved. By default, npm attempts to install package C in the same directory as A and B, so a single copy of C is shared between A and B. But if A and B require conflicting versions of C, npm falls back to the nested dependencies approach. Libraries created for client-side applications usually include built versions (single-file bundles) in their npm packages. The bundles don't contain third-party dependencies, so developers should manually load them on the page. This helps avoid the nested dependencies issue.

jspm is a package manager created with ES6 modules and module loaders in mind. jspm doesn't host packages itself. It has a concept of registries, which allow you to create custom source locations for packages. Out of the box, jspm allows you to install packages either from the npm registry or directly from the GitHub repositories.

It's designed to work together with SystemJS. When you initialize a new project or install a package with jspm, it automatically creates a configuration for SystemJS to load modules. Unlike npm, it uses the *flat* dependencies approach, so there's always only one copy of a library in a project. This allows you to use `import` statements to load even third-party code. It solves the issue with the loading order of scripts and makes sure the application loads only those modules that it actually uses.

jspm packages usually don't include bundles. Instead they preserve the original project structure and files, so each module can be loaded individually. Although having the original version of a file might improve the debugging experience, it doesn't pay off in practice. Importing each module individually leads to loading hundreds of files into the browser before starting the app. This slows down development and doesn't suit production deployment.

Another weak point of jspm is that you can't necessarily use any npm package or GitHub repository as a jspm package right away. They may require additional configuration so jspm can properly set up SystemJS to load the modules from the package. At the time of writing, there are fewer than 500 packages in the jspm registry that are SystemJS-ready, compared with 250,000 packages hosted by npm.

2.4.2 Starting an Angular project with npm

To start a new project managed by npm, create a new directory (such as angular-seed) and open it in the command window. Then run the `npm init -y` command, which will create the initial version of the package.json configuration file. Normally `npm init` asks several questions while creating the file, but the `-y` flag makes it accept the default values for all options. The following example shows this command running in the empty angular-seed directory.

```
$ npm init -y
Wrote to /Users/username/angular-seed/package.json:

{
  "name": "angular-seed",
  "version": "1.0.0",
  "description": "",
  "main": "index.js",
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1"
  },
  "keywords": [],
  "author": "",
  "license": "ISC"
}
```

Most of the generated configuration is needed either for publishing the project into the npm registry or while installing the package as a dependency for another project. We'll use npm only for managing project dependencies and automating development and build processes.

Because we're not going to publish it into the npm registry, you should remove all of the properties except `name`, `description`, and `scripts`. Also, add a `"private": true` property because it's not created by default. It will prevent the package from being accidentally published to the npm registry. The package.json file should look like this:

```
{
  "name": "angular-seed",
  "description": "An initial npm-managed project for Chapter 2",
  "private": true,
  "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1"
  }
}
```

The `scripts` configuration allows you to specify commands that you can run in the command window. By default, `npm init` creates the `test` command, which can be run like this: `npm test`. Let's replace it with the `start` command that we'll be using for launching the live-server that we installed in section 2.13. Here's the configuration of the `scripts` property:

```
{
  ...
  "scripts": {
    "start": "live-server"
  }
}
```

You can run any npm command from the `scripts` section using the `npm run mycommand` syntax, such as `npm run start`. You can also use the shorthand `npm start` command instead of `npm run start`. The shorthand syntax is available only for predefined npm scripts (see the npm documentation at https://docs.npmjs.com/misc/scripts).

Now we want npm to download Angular to this project as a dependency. In the TypeScript version of the Hello World application, we used the Angular code located at unpkg CDN server, but here we want it to be downloaded to our project directory. We also want local versions of SystemJS, live-server, and the TypeScript compiler.

npm packages often consist of bundles optimized for production use that don't include the source code of the libraries. Let's add the section to the package.json file that uses the source code (not the optimized bundles) of specific packages. We'll add this section right after the license line (update the versions of the dependencies so you're current):

```
"dependencies": {
    "@angular/common": "2.0.0-rc.6",
    "@angular/compiler": "2.0.0-rc.6",
    "@angular/core": "2.0.0-rc.6",
    "@angular/forms": "2.0.0-rc.6",
    "@angular/http": "2.0.0-rc.6",
    "@angular/platform-browser": "2.0.0-rc.6",
    "@angular/platform-browser-dynamic": "2.0.0-rc.6",
    "@angular/router": "^3.0.0-rc.2",

    "core-js": "^2.4.0",
    "rxjs": "5.0.0-beta.11",
    "systemjs": "0.19.37",
    "zone.js": "0.6.17"
  },
  "devDependencies": {
    "live-server": "0.8.2",
    "typescript": "^2.0.0"
  }
```

Now run the `npm install` command on the command line from the directory where your package.json is located, and npm will start downloading the preceding packages and their dependencies into the node_modules folder. After this process is complete, you'll see dozens of subdirectories in node_modules, including @angular, systemjs, live-server, and typescript.

```
angular-seed
 index.html
```

```
 package.json
 app
     app.ts
node_modules
     @angular
     systemjs
     typescript
     live-server
     ...
```

In the angular-seed folder, let’s create a slightly modified version of index.html with the following content:

```
<!DOCTYPE html>
<html>
<head>
  <title>Angular seed project</title>
  <meta charset="UTF-8">
  <meta name="viewport" content="width=device-width, initial-scale=1">

  <script src="node_modules/typescript/lib/typescript.js"></script>
  <script src="node_modules/core-js/client/shim.min.js"></script>
  <script src="node_modules/zone.js/dist/zone.js"></script>
  <script src="node_modules/systemjs/dist/system.src.js"></script>
  <script src="systemjs.config.js"></script>
  <script>
    System.import('app').catch(function(err){ console.error(err); });
  </script>
</head>

<body>
<app>Loading...</app>
</body>
</html>
```

Note that the script tags now load the required dependencies from the local directory node_modules. The same applies to the SystemJS configuration file systemjs.config.js shown here:

```
System.config({
    transpiler: 'typescript',
    typescriptOptions: {emitDecoratorMetadata: true},
    map: {
      '@angular': 'node_modules/@angular',
      'rxjs'    : 'node_modules/rxjs'
    },
    paths: {
      'node_modules/@angular/*': 'node_modules/@angular/*/bundles'
    },
    meta: {
      '@angular/*': {'format': 'cjs'}
    },
    packages: {
      'app'                              : {main: 'main', defaultExtension: 'ts'},
      'rxjs'                             : {main: 'Rx'},
      '@angular/core'                    : {main: 'core.umd.min.js'},
      '@angular/common'                  : {main: 'common.umd.min.js'},
      '@angular/compiler'                : {main: 'compiler.umd.min.js'},
      '@angular/platform-browser'        : {main: 'platform-browser.umd.min.js'},
      '@angular/platform-browser-dynamic': {main: 'platform-browser-dynamic.umd.min.js'}
    }
});
```

The preceding SystemJS configuration is a little different than the one shown in section 2.1.1. This time we don't use the source code of Angular packages, we use their bundled and minimized versions instead. This will minimize the number of network requests required to load the Angular framework, and this version of the framework is smaller. Each Angular package comes with a directory called bundles that contains the minimized code. In the section packages of the SystemJS config file we mapped the name `app` to the main script located in main.ts, so when we write `System.import(app)` in index.html, it'll load main.ts.

We'll add one more config file in the root of the project, where we'll specify the tsc compiler's options:

```
{
  "compilerOptions": {
    "target": "ES5",
    "module": "commonjs",
    "experimentalDecorators": true,
    "noImplicitAny": true
  }
}
```

If you're new to TypeScript, read appendix B, which explains that in order to run TypeScript code it must first be transpiled to JavaScript with the TypeScript compiler `tsc`. The code samples in chapters 1-7 work without explicitly running `tsc` because SystemJS uses `tsc` internally to transpile TypeScript to JavaScript on the fly as it loads a script file. But we'll still keep the tsconfig.json file in the project root because some IDEs rely on it.

NOTE **JIT vs. AoT compilation**
If the Angular code is dynamically compiled in the browser (not to be confused with transpiling), this is called just-in-time (JIT) compilation. If the code is precompiled with a special ngc compiler, it's called ahead-of-time (AoT) compilation. In this chapter we'll describe the app with JIT compilation.

The app code will consist of three files:

- *app.component.ts*—The one and only component of our app
- *app.module.ts*—The declaration of the module that will include our component
- *main.ts*—The bootstrap of the module

In section 2.2.4, we mapped the name `app` to `main.ts`, so let's create a directory called app containing an app.component.ts file with the following content:

```
import {Component} from '@angular/core';
```

```
@Component({
    selector: 'app',
    template: `<h1>Hello {{ name }}!</h1>`
})
export class AppComponent {
    name: string;

    constructor() {
        this.name = 'Angular 2';
    }
}
```

Now we need to create a module that will contain our `AppComponent`. We'll place this code in the app.module.ts file:

```
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 { }
```

This file just contains the definition of the Angular module. The class is annotated with `@NgModule`, which includes the `BrowserModule` that every browser must import. Because our module contains only one class, we need to list it in the `declarations` property and list it as the bootstrap class.

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

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

Start the application by executing the `npm start` command from the angular-seed directory, and it'll open your browser and show the message "Loading…" for a split second, followed by "Hello Angular 2!" Figure 2.2 shows what this application looks like in the Chrome browser. The figure shows the browser with its Developer Tools panel opened in the Network tab, so you can see a fragment of what's been downloaded by the browser and how long it took.

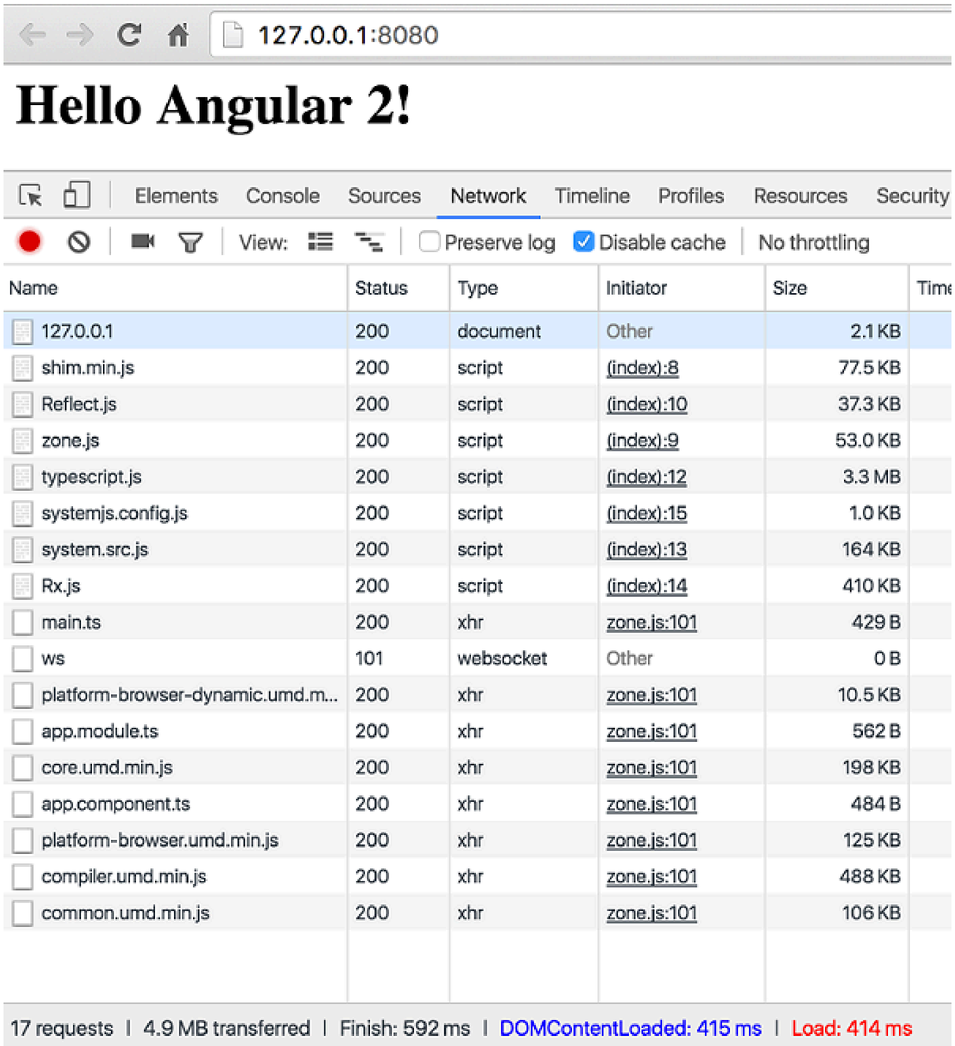


Figure 2.2 Running the app from the npm-managed project

Don't be scared by the size of the download; we'll optimize it in chapter 10. Because we're using `live-server`, as soon as you modify and save the code of this application, it'll reload the page in the browser with the latest code version. Now let's apply what we've learned to an application that's more complex than Hello World.

2.5 Hands-on: getting started with the online auction

Every chapter from here on will end with a hands-on section containing instructions for developing a certain aspect of the online auction, where people can see a list of featured products, view details for a specific product, perform a product search, and monitor bidding by other users. We'll gradually add code to this application to practice what you'll learn in each chapter. The source code that comes with this book includes the completed version of each chapter's hands-on section in the auction folder, but we encourage you to try these exercises on your own.

In this exercise you'll set up the development environment and create the initial auction project layout. You'll create the home page, split it into Angular components, and create a service to fetch products. If you follow all the instructions in this section, the auction's home page should look like what you can see in 2.3.

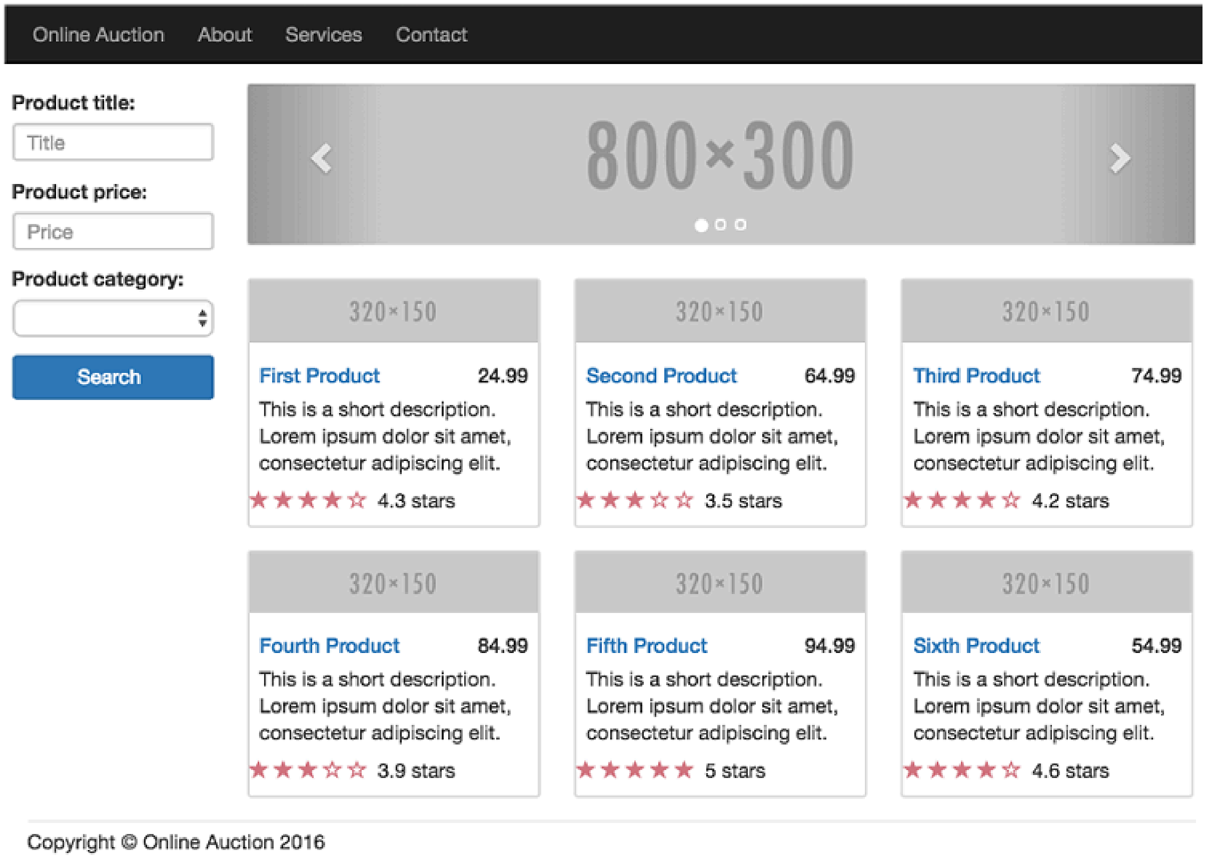


Figure 2.3 The online auction home page

We'll use gray rectangles provided by the convenient Placehold.it service (http://placehold.it), which generates placeholders of specified sizes. To see these generated images, you'll have to be connected to the internet while running this application.

The following sections contain the instructions that you should follow to complete this hands-on exercise.

NOTE If you prefer to just read the code of the working version of the online auction, use the code for the directory auction that comes with this chapter. To run the provided code, switch to the auction directory, run `npm install` to install all the required dependencies in the node_modules directory, and start the application by running the `npm start` command.

2.5.1 Initial project setup

To set up the project, first copy the contents of the angular-seed directory into a separate location and rename it “auction”. Next, modify the name and description fields in the package.json file. Open a command window and switch to the newly created auction directory. Run the command `npm install`, which will create the node_modules directory with dependencies specified in package_json.

In this project we’ll use Twitter Bootstrap as a CSS framework, and the UI library of responsive components. Responsive web design is an approach that allows you to create sites that change layout based on the width of the user’s device viewport. The term *responsive components* means that the components’ layout can adapt to the screen size.

Because the Bootstrap library is built on top of jQuery, you need to run the following commands to install them:

```
npm install bootstrap --save   ❶
npm install jquery --save   ❷
```

❶ Install Bootstrap. The --save option will add this dependency to the package.json file.

❷ The Bootstrap package doesn’t specify jQuery as a dependency, so you have to install it separately. Such dependencies are also known as peer dependencies.

> **NOTE** **Choosing an IDE**
> We recommend you use an IDE like WebStorm or Visual Studio Code. Most of the steps required to complete this hands-on project can be performed inside the IDE. WebStorm even allows you to open the Terminal window inside the IDE.

Now create a systemjs.config.js file to store the SystemJS configuration. You’ll include this file in the `<script>` tag in index.html.

Listing 2.8 systemjs.config.js

```
System.config({
    transpiler: 'typescript',
    typescriptOptions: {emitDecoratorMetadata: true,   ❶
        target: "ES5",   ❷
        module: "commonjs"},   ❸
    map: {
        '@angular': 'node_modules/@angular',
        'rxjs'    : 'node_modules/rxjs'
    },
    paths: {
        'node_modules/@angular/*': 'node_modules/@angular/*/bundles'
    },
```

```
    meta: {
        '@angular/*': {'format': 'cjs'}
    },
    packages: {
        'app'                              : {main: 'main', defaultExtension: 'ts'},   ❹
        'rxjs'                             : {main: 'Rx'},
        '@angular/core'                    : {main: 'core.umd.min.js'},
        '@angular/common'                  : {main: 'common.umd.min.js'},
        '@angular/compiler'                : {main: 'compiler.umd.min.js'},
        '@angular/platform-browser'        : {main: 'platform-browser.umd.min.js'},
        '@angular/platform-browser-dynamic': {main: 'platform-browser-dynamic.umd.min.js'}
    }
});
```

❶ Instructs the TypeScript compiler of SystemJS to preserve decorators metadata in the transpiled code, because Angular relies on annotations to discover and register components.

❷ Transpiles the code into the ES5 syntax.

❸ Uses CommonJS module format.

❹ We'll keep our application code in the app directory, and the code to launch the auction application will be located in the main.ts file.

The systemjs.config.js file has to be included in index.html as shown in listing 2.9. This configuration of the package app allows us to use the line `<script>System.import('app')</script>` in index.html, which will actually load the content of app/main.ts.

This completes the configuration of the development environment for the auction project. You're now ready to start writing the application code.

NOTE	**Material Design 2** At the time of writing, the Angular team is developing Material Design 2 components for Angular (see https://material.angular.io), which you may want to use instead of Twitter Bootstrap when it's ready.

2.5.2 Developing the home page

In this exercise you'll create a home page that will be split into several Angular components. This makes the code easier to maintain and allows you to reuse components in other views. In figure 2.4 you can see the home page with all the components highlighted.

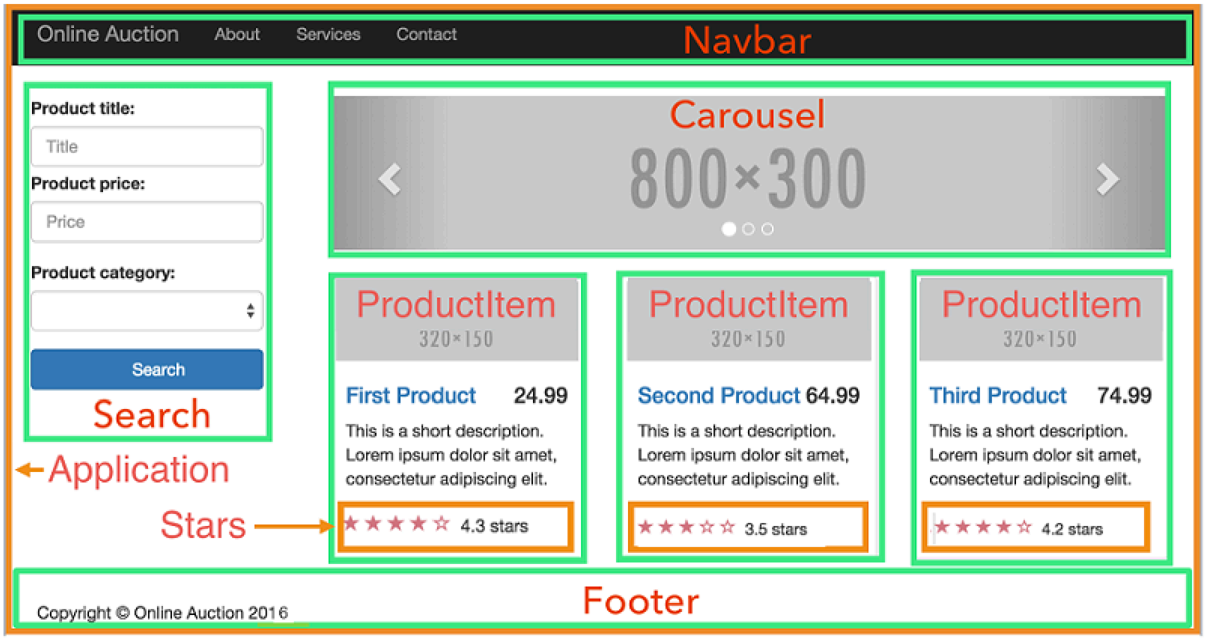


Figure 2.4 The online auction home page with highlighted components

You'll need to create directories for storing all the components and services of the application, as follows:

```
app
 components
     application
     carousel
     footer
     navbar
     product-item
     search
     stars
 services
```

Each directory inside the components directory has code for the corresponding component. This allows you to keep all files related to a single component together. Most of the components consist of two files—an HTML and a TypeScript file. But sometimes you may want to add a CSS file with component-specific styling. The services directory will contain the file with classes that serve data to the application.

The first version of the home page consists of seven components. In this exercise, we'll discuss and you'll create the three the most interesting components, located in the application, product-item, and stars directories. This will give you a chance to write some code, and at the end of this exercise you can copy the rest of the components into your project directory.

NOTE	In the hands-on section in chapter 3, you'll refactor the code to integrate the carousel and products into `HomeComponent`.

The entry point of the application is index.html. You've copied this file from the angular-seed directory, and now you'll need to modify it. The index.html file is rather small, and it won't grow much because most of your dependencies will be loaded by SystemJS, and the entire UI is represented by a single Angular root (top level) component that will internally use child components. This is what it should look like:

Listing 2.9 index.html

```
<!DOCTYPE html>
<html>
<head>
  <title>CH2: Online Auction</title>
  <link rel="stylesheet" href="node_modules/bootstrap/dist/css/bootstrap.css">   ❶

  <script src="node_modules/jquery/dist/jquery.min.js"></script>
  <script src="node_modules/bootstrap/dist/js/bootstrap.min.js"></script>   ❷

  <script src="node_modules/core-js/client/shim.min.js"></script>
  <script src="node_modules/zone.js/dist/zone.js"></script>

  <script src="node_modules/typescript/lib/typescript.js"></script>
  <script src="node_modules/systemjs/dist/system.src.js"></script>
  <script src="systemjs.config.js"></script>

  <script>
    System.import('app').catch(function (err) {console.error(err);});   ❸
  </script>
</head>
<body>
<auction-application></auction-application>
</body>
</html>
```

❶ Adds the Bootstrap CSS.

❷ Adds Bootstrap and jQuery to support the carousel component.

❸ Loads main.ts according to the configuration in systemjs.config.js.

The content of the main.ts file in the app directory remains the same as it was in the angular-seed project:

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

Let's update the app.module.ts file to declare all the components and services that we'll use in the auction app:

```
import { BrowserModule } from '@angular/platform-browser';
import ApplicationComponent from '. /components/application/application';
import CarouselComponent from "./components/carousel/carousel";
import FooterComponent from "./components/footer/footer";
```

```
import NavbarComponent from "./components/navbar/navbar";
import ProductItemComponent from "./components/product-item/product-item";
import SearchComponent from "./components/search/search";
import StarsComponent from "./components/stars/stars";
import {ProductService} from "./services/product-service";

@NgModule({
    imports:      [ BrowserModule ],
    declarations: [ ApplicationComponent,
                    CarouselComponent,
                    FooterComponent,
                    NavbarComponent,
                    ProductItemComponent,
                    SearchComponent,
                    StarsComponent],
    providers:    [ProductService],
    bootstrap:    [ ApplicationComponent ]
})
export class AppModule { }
```

1. Declares all components that our module will use.
2. Declares the provider for the ProductService that we'll inject into the ApplicationComponent a bit later.

In our module we declared all the components and the provider for one service that we're about to create. Declaring a provider for a service is required by the dependency injection mechanism. We'll talk about providers and injection in 4.

THE APPLICATION COMPONENT

Our application component is the root component of the auction and is declared as such in the `AppModule`. It serves as a host for all the other components. The component's source code consists of three files: application.ts, application.html, and application.css. We'll assume you know the basics of CSS, so we won't be going into that file here. We will go through the first two files.

Let's create `ApplicationComponent` and save it in the application.ts file located in the app/components/application directory. The content of this file is shown here:

```
import {Component, ViewEncapsulation} from '@angular/core';
import {Product, ProductService} from '../../services/product-service';

@Component({
  selector: 'auction-application',
  templateUrl: 'app/components/application/application.html',
  styleUrls: ['app/components/application/application.css'],
  encapsulation:ViewEncapsulation.None
})

export default class ApplicationComponent {
  products: Array<Product> = [];
```

```
  constructor(private productService: ProductService) {  ❽

    this.products = this.productService.getProducts();  ❾
  }
}
```

❶ Imports the classes that implement the product service. These classes will serve us data.

❷ Turns the ApplicationComponent class into an Angular component by annotating it with the @Component decorator.

❸ Selector defines the name of the custom HTML tag used in index.html.

❹ The HTML template will be located in the application.html file.

❺ CSS is located in the application.css file.

❻ Exports the ApplicationComponent because it's used in another class: AppModule.

❼ Uses generics (see appendix B) to ensure that the products array contains only objects of type Product.

❽ In TypeScript you can ask Angular to inject required objects (such as ProductService) via constructor arguments.

❾ Gets a list of products and assigns them to the products property. All of a component's properties become available in the view template via data binding.

Just declaring the constructor's arguments with a type will instruct Angular to instantiate and inject this object (`ProductService`). Injectable objects need to be configured with providers, and we declared one in the `AppModule` earlier. The `private` qualifier will turn `productService` into a member variable of the class, so we'll access it as `this.productService`.

NOTE **View encapsulation strategies**
The preceding example uses the view encapsulation strategy `ViewEncapsulation.None` to apply the styles from application.css not only to the `ApplicationComponent`, but to the entire application and. We'll discuss different view encapsulation strategies in chapter 6.

Create the application.html file with the following content:

```
<auction-navbar></auction-navbar>

<div class="container">
  <div class="row">

    <div class="col-md-3">
      <auction-search></auction-search>
    </div>

    <div class="col-md-9">
      <div class="row carousel-holder">
```

```
        <div class="col-md-12">
          <auction-carousel></auction-carousel>
        </div>
      </div>
      <div class="row">
        <div *ngFor="let prod of products" class="col-sm-4 col-lg-4 col-md-4">
          <auction-product-item [product]="prod"></auction-product-item>
        </div>
      </div>
    </div>
  </div>
</div>

<auction-footer></auction-footer>
```

You’ll be using multiple custom HTML elements that represent your components: `<auction-navbar>`, `<auction-search>`, `<auction-carousel>`, `<auction-product-item>`, and `<auction-footer>`. You’ll add them the same way as `<auction-application>` in index.html.

The most interesting part in this file is how you can display the list of products. Each product will be represented by the same HTML fragment on the web page. Because there are multiple products, you need to render the same HTML multiple times. The `NgFor` directive is used inside a component’s `template` to loop through the list of items in the data collection rendering HTML markup for each item. We’ll be using the shorthand syntax `*ngFor` to represent the `NgFor` directive.

```
<div *ngFor="let prod of products" class="col-sm-4 col-lg-4 col-md-4">
  <auction-product-item [product]="prod"></auction-product-item>
</div>
```

Because `*ngFor` is inside `<div>`, each loop iteration will render a `<div>` with the content of the corresponding `<auction-product-item>` inside. To pass an instance of a product to `ProductComponent`, you use the square brackets for property binding: `[product]="prod"`, where `[product]` refers to the property-named product inside the component represented by `<auction-product-item>`, and `prod` is a local template variable declared on the fly in the `*ngFor` directive as `let prod`. We’ll discuss property bindings in detail in chapter 5.

The `col-sm-4 col-lg-4 col-md-4` styles come from Twitter’s Bootstrap library where the window’s width is divided into 12 invisible columns. In this example you want to allocate 4 columns (one third of the `<div>`’s width) if a device has small (`sm` means 768 pixels or more), large (`lg` is for 1200 px or more), and medium (`md` is for 992 px or more) screen sizes.

Because this doesn’t specify any columns for extra-small devices (`xs` is for screens under 768 px) the entire width of a `<div>` will be allocated for a single `<auction-product>`. To see how the page layout changes for different screen sizes, narrow your browser's window to make it less than 768 pixels wide. You can read more about the Bootstrap grid system in the Bootstrap documentation at http://getbootstrap.com/css/#grid.

NOTE `ApplicationComponent` relies on the existence of other components (such as `ProductItemComponent`) that you'll create in the subsequent steps. If you try to run the auction now, you'll see errors in the Developer Console of your browser.

THE PRODUCT ITEM COMPONENT

In the product-item directory, create a product-item.ts file that declares a `ProductItemComponent` representing a single product item from the auction. The source code of product-item.ts is structured much like the code of application.ts: the `import` statements go on top, then comes the component class declaration annotated with `@Component`:

```
import {Component, Input} from '@angular/core';
import StarsComponent from 'app/components/stars/stars';
import {Product} from 'app/services/product-service';

@Component({
  selector: 'auction-product-item',
  templateUrl: 'app/components/product-item/product-item.html'
})
export default class ProductItemComponent {
  @Input() product: Product;
}
```

The component's `product` property is annotated with `@Input()`, which means that the value for this property will be exposed to the parent component, which can bind a value to it. We'll discuss input properties in detail in chapter 6.

Create a product-item.html file to contain the following template of the product component (which will be represented by its price, title, and description):

```
<div class="thumbnail">
  <img src="http://placehold.it/320x150">
  <div class="caption">
    <h4 class="pull-right">{{ product.price }}</h4>
    <h4><a>{{ product.title }}</a></h4>
    <p>{{ product.description }}</p>
  </div>
  <div>
    <auction-stars [rating]="product.rating"></auction-stars>
  </div>
</div>
```

Here you'll use another type of data binding: an expression within double curly braces. Angular evaluates the value of the expression within the braces, turns the result into a string, and replaces this expression in the template with the resulting string. Internally this process is implemented using string interpolation.

Note the `<auction-stars>` tag that represents the `StarsComponent` and was declared in `AppModule.` We bind the value of `product.rating` to the `rating` property of the `StarsComponent`. For this to work, `rating` must be declared as an input property in the `StarsComponent` that we'll create next.

THE STARS COMPONENT

The stars component will display the rating of a product. In 2.5 you can see that it displays an average rating number of 4.3 as well as star icons representing the rating:

Figure 2.5 Stars component

Angular provides component lifecycle hooks (see chapter 6) that allow you to define the callback methods that will be invoked at certain moments of the component's lifecycle. In this component, you'll use the `ngOnInit()` callback, which will be invoked as soon as an instance of the component is created and its properties are initialized.

Create the stars.ts file in the stars directory with the following content:

```
import {Component, Input, OnInit} from '@angular/core';   ❶

@Component({
  templateUrl: 'app/components/stars/stars.html',
  styles: [` .starrating { color: #d17581; }`],
  selector: 'auction-stars'
})
export default class StarsComponent implements OnInit {
  @Input() count: number = 5;   ❷
  @Input() rating: number = 0;   ❷
  stars: boolean[] = [];   ❸

  ngOnInit() {   ❹
    for (let i = 1; i <= this.count; i++) {
      this.stars.push(i > this.rating);
    }
  }
}
```

❶ Imports the interface OnInit, where ngOnInit() is declared.

❷ Marks rating and count as inputs so that other components can assign values to them via data-binding expressions.

❸ Each element of the array represents a single star to be rendered.

❹ Initializing stars based on the value provided by the parent component.

The `stars` property specifies the total number of stars to be rendered. If this property isn't initialized by the parent, the component renders 5 stars by default.

The `rating` property stores the average rating that determines how many stars should be filled with the color and how many should remain empty.

In the `stars` array, the elements with the `false` value represent empty stars, and those with `true` represent stars filled with color.

We initialize the `stars` array in the `ngOnInit()` lifecycle callback, which will be used in the template to render stars. `ngOnInit()` is called only once, right after the component's data-bound properties have been checked for the first time, and before any of its children have been checked. When `ngOnInit()` is invoked, all properties passed from the parent view are already initialized, so you can use the `rating` value to compute the values in the `stars` array.

Alternatively you could turn `stars` into a getter to compute it on the fly, but the getter would be invoked each time Angular synchronizes the model with the view. Exactly the same array would be computed multiple times.

Create the template of the `StarsComponent` in the stars.html file:

```
<p>
  <span *ngFor="let star of stars"
        class="starrating glyphicon glyphicon-star"
        [class.glyphicon-star-empty]="star">
  </span>
  <span>{{ rating }} stars</span>
</p>
```

You already used the `NgFor` directive and curly braces data-binding expression in `ApplicationComponent`. Here you bind a CSS class name to an expression: `[class.glyphicon-star-empty]="star"`.

If an expression within the double quotes on the right evaluates to `true`, the `glyphicon-star-empty` CSS class will be added to the `class` attribute of the `<span>` element.

COPYING THE REST OF THE CODE

To finish this project, copy the missing components from the chapter2/auction directory to the corresponding directories of your project:

- The services directory contains the product-service.ts file that declares two classes: `Product` and `ProductService`. This is where the data for the auction comes from. We'll provide more details about the content of this file in the hands-on section of chapter 3.
- The navbar directory contains the code for the top navigation bar.
- The footer directory contains the code for the footer of the page.
- The search directory contains the initial code for the `SearchComponent`, which is a form

that you'll develop in chapter 7.

- The carousel directory contains the code that implements a Bootstrap slider in the top portion of the home page.

2.5.3 Launching the online auction application

To launch the auction application, open a command window and start live-server in your project directory. You can do it by running the `npm start` command, which is configured in the package.json file to start the live-server. It'll open the browser, and you should be able to see the home page as shown in figure 2.4. The product details page isn't implemented yet, so the product title links won't work.

We recommend that you use the Chrome browser for development, as it has the best tools for debugging your code. Keep the Developer Tools panel open while running all code samples. If you see unexpected results, check the Console tab for error messages.

Also, there's a great Chrome browser extension called Augury, which is a convenient debugging tool for Angular apps. After installing this extension, you'll see an additional Augury tab in the Chrome development tools panel (see figure 2.6), which allows you to see and modify the values of your app components at runtime.

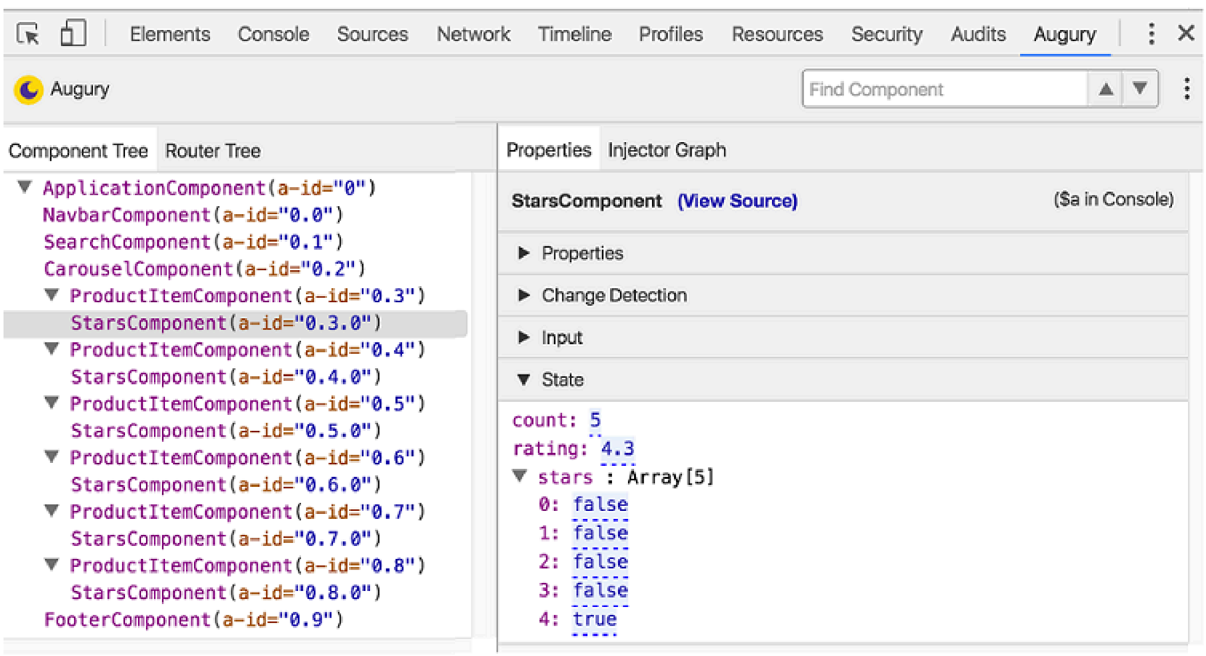


Figure 2.6 The Augury panel

2.6 Summary

In this chapter you've had your first experience writing an Angular application. We briefly covered the main principles and most important building blocks of an Angular application. In future chapters we'll discuss them in detail. You've also created an initial version of the online auction application. This has shown you how to set up a development environment and structure an Angular project.

- An Angular application is represented by a hierarchy of components that are packaged into modules.
- Each Angular component contains a template for the UI rendering and an annotated class implementing this component's functionality.
- Templates and styles can be either inlined or stored in separate files.
- The SystemJS module loader allows you to split the application into ES6 modules and dynamically assembles everything together at runtime.
- Configuration parameters for SystemJS can be specified in a separate configuration file.
- Using npm for managing dependencies is the simplest way of configuring a new Angular project.

3 Navigation with the Angular router

This chapter covers

- How to configure routes
- How to pass data while navigating from one route to another
- How to have more than one area for navigation (a.k.a. outlet) on the same page using auxiliary routes
- How to lazy-load modules with the router

In chapter 2 we built the home page of the online auction with the intent to create a single-page application (SPA): the main page won't be reloaded, but its parts may change. We now want to add navigation to this application so it'll change the content area of the page (we'll define that a bit later) based on the user's actions. Imagine that the user needs to be able to see product details, bid on products, and chat with sellers. The Angular router allows you to configure and implement such navigation without performing a page reload.

Not only do we want to be able to change the view inside the page, but we may also want to bookmark its URL so we can get to specific product details faster. To do this, we need to assign a unique URL for each view.

In general, you can think of a router as an object responsible for the view state of the application. Every application has one router, and you need to configure the router to make it work.

We'll first cover the main features of the router, and then we'll add a second view (Product Details) to the online auction so that if the user clicks on a particular product on the home page, the page's content will change to display the details of the selected product.

3.1 Routing basics

You can think of a SPA as a collection of states, such as Home state, Product Details state, and Shipping state. Each state represents a different view of the same SPA. So far our online auction has only one view state: the home page.

The online auction (see figure 2.4) has a navigation bar (a component) on top, a search form (another component) on the left, and a footer (yet another component) at the bottom, and we want these components to remain visible all the time. The rest of the page consists of a content area that displayed the `<auction-carousel>` and several `<auction-product>` components. We'll reuse this content area (the *outlet*) for displaying different views based on the user's actions.

To do this, we'll need to configure the router so it can display different views in the outlet, *replacing one view with another*. This content area is represented by the tag `<router-outlet>`. Figure 3.1 shows the area we'll use for displaying different views.

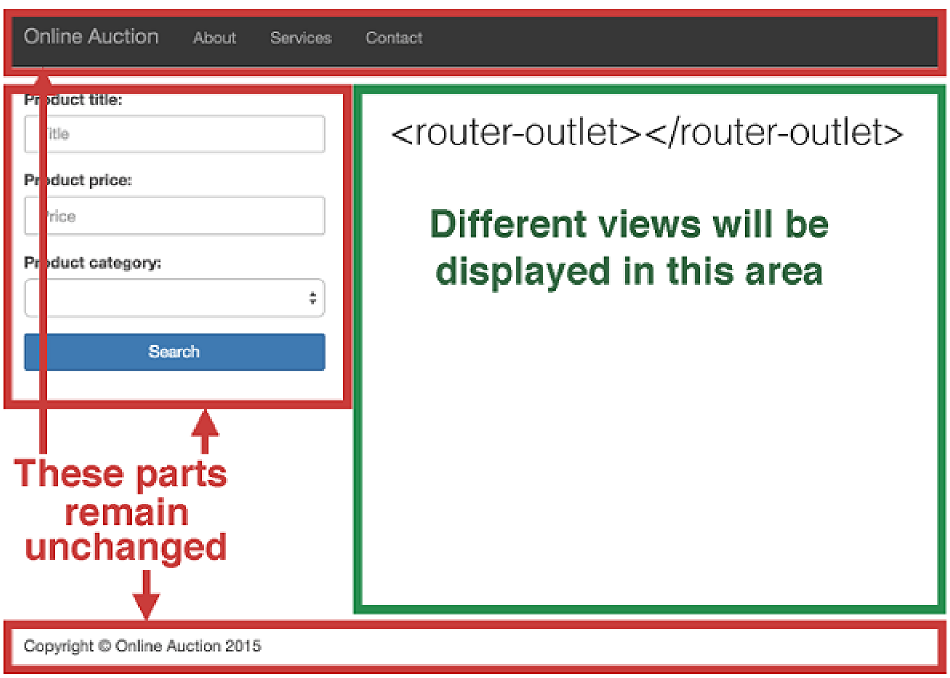


Figure 3.1 Allocating the area for changing views

NOTE	**Multiple router outlets** There could be more than one outlet on the page. We'll cover that in section 3.5.

We'll be assigning a component for each view that we want to display in this area. In chapter 2 we didn't create a parent component that would encapsulate the carousel and auction products, but by the end of this chapter we'll refactor the code to create a `HomeComponent` to serve as a parent for the carousel and products. We'll also create

`ProductDetailComponent` to represent each product's details. At any given time, the user will see either `HomeComponent` or `ProductDetailComponent` in the `<router-outlet>` area.

The router is responsible for managing client-side navigation, and in section 3.1.2 we'll do a high-level overview of what the router is made up of. In the non-SPA world, site navigation is implemented as a series of requests to a server, which would refresh the entire page by sending the appropriate HTML documents to the browser. With SPA, the code for rendering components is already on the client (except for the lazy loading scenarios), and we just need to replace one view with another.

As the user navigates the application, it can still make requests to the server to retrieve or send data. Sometimes a view (the combination of the UI code and the data) has everything it needs already downloaded to the browser, but other times a view will communicate with the server by issuing AJAX requests or via WebSockets. Each view will have a unique URL shown in the location bar of the browser, and we'll discuss that next.

3.1.1 Location strategies

At any given time, the browser's location bar displays the URL of the current view. A URL can contain different parts (segments). It starts with a protocol followed by a domain name, and it may include a port number. Parameters that need to be passed to the server may follow a question mark (this is true for HTTP `GET` requests), like this:

http://mysite.com:8080/auction?someParam=123

Changing any character in the preceding URL results in a new request to the server.

In SPAs we need the ability to modify the URL without making a server-side request so the application can locate the proper view on the client. Angular offers two location strategies for implementing client-side navigation:

- `HashLocationStrategy`—A hash sign (#) is added to the URL, and the URL segment after the hash uniquely identifies the route to be used as a web page fragment. This strategy works with all browsers, including the old ones.
- `PathLocationStrategy`—This History API-based strategy is supported only in browsers that support HTML5. This is the default location strategy in Angular.

HASH-BASED NAVIGATION

A sample URL that uses hash-based navigation is shown in figure 3.2:

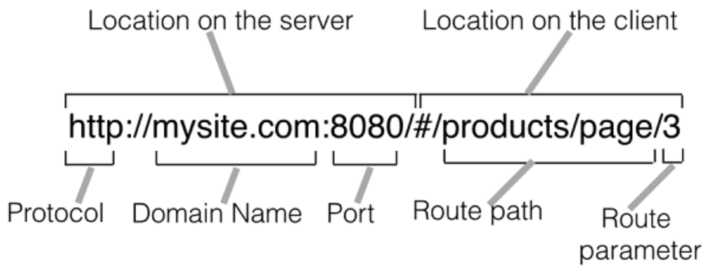


Figure 3.2 Dissecting the URL

Changing any character to the right of the hash sign doesn't cause a direct server-side request, but navigates to the view represented by the path (with or without parameters) after the hash. The hash sign serves as a separator between the base URL and the client-side locations of the required content.

Try to navigate a SPA like Gmail, and watch the URL. For the Inbox it looks like this: https://mail.google.com/mail/u/0/#inbox. Now go to the Sent folder, and the hash portion of the URL will change from *inbox* to *sent*. The client-side JavaScript code invokes the necessary functions to display the Sent view.

But why does the Gmail app still shows you the "Loading…" message when you switch to the Sent box? The JavaScript code of the Sent view can still make AJAX requests to the server to get the new data, but it doesn't load any additional code, markup, or CSS from the server.

In this book we'll use hash-based navigation, and `@NgModule` will include the following `providers` value (providers are explained in chapter 4):

```
providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}]
```

HISTORY API-BASED NAVIGATION

The browser's History API allows you to move back and forth through the user's navigation history as well as programmatically manipulate the history stack (see "Manipulating the browser history" in the Mozilla Developer Network, http://mng.bz/i64G). In particular, the `pushState()` method is used to attach a segment to the base URL as the user navigates your SPA.

Consider the following URL: http://mysite.com:8080/products/page/3. The products/page/3 URL segment can be pushed (attached) to the base URL programmatically without using the hash tag. If the user navigates from page 3 to 4, the application's code will push products/page/4, saving the previous products/page/3 state in the browser history.

Angular spares you from invoking `pushState()` explicitly—you just need to configure the URL segments and map them to the corresponding components. With the

History API-based location strategy, you need to tell Angular what to use as a base URL in your application so it can properly append the client-side URL segments. You can do it in one of two ways:

- Add the `<base>` tag to the header of your index.html, such as `<base href="/">`.
- Assign a value for the `APP_BASE_HREF` Angular constant in the root module, and use it as the `providers` value. The following code snippet uses `/` as a base URL, but it can be any URL segment that denotes the end of the base URL:

```
import { APP_BASE_HREF } from '@angular/common';
...
@NgModule({
...
  providers:[{provide: APP_BASE_HREF, useValue: '/'}]
})
class AppModule { }
```

3.1.2 The building blocks of client-side navigation

Let's get familiar with the main concepts of implementing client-side navigation using the Angular router. In the Angular framework, the implementation of routing functionality is implemented in a separate `RouterModule` module. If your application needs routing, make sure your package.json file includes the dependency `@angular/router`. At the time of writing, the latest version of Angular is Release Candidate 5, and our package.json includes the following line: `"@angular/router": "3.0.0-rc.1"`.

Remember, the goal of this chapter is to explain how to navigate between the different views of a SPA, so the first thing we need to focus on is how to configure the router and add it to the module declaration.

Angular offers the following main players for implementing routing in your application:

- `Router`—An object that represents the router in the runtime. You can use its `navigate()` and `navigateByUrl()` methods to navigate to a route either by the configured route `path` or by the URL segment respectively.
- `RouterOutlet`—A directive that serves as a placeholder within your web page (`<router-outlet>`) where the router should render the component.
- `Routes`—An array of routes that map URLs to components to be rendered inside the `<router-outlet>`.
- `RouterLink`—A directive for declaring a link to a route if the navigation is done using HTML anchor tags. The `RouterLink` may contain parameters to be passed to the route's component.
- `ActivatedRoute`—An object that represents the route or routes that are currently active.

You configure routes in a separate array of objects of type `Route`. Here's an example:

```
const routes: Routes = [
    {path: '',        component: HomeComponent},
    {path: 'product', component: ProductDetailComponent}
];
```

Because route configuration is done on the module level, you need to import routes in the `@NgModule` decorator. If you declare routes for the root modules, you should use the `forRoot()` method, like this:

```
import { BrowserModule } from '@angular/platform-browser';
import { RouterModule } from '@angular/router';
...
@NgModule({
  imports: [ BrowserModule, RouterModule.forRoot(routes)],
    ...
})
```

If you're configuring routes for a feature module (not for the root one), use the `forChild()` method:

```
import { CommonModule } from '@angular/common';
import { RouterModule } from '@angular/router';
...
@NgModule({
  imports: [ CommonModule, RouterModule.forChild(routes)],
    ...
})
```

Note that in feature modules we import `CommonModule` instead of `BrowserModule`.

In a typical scenario, you'll be implementing navigation by performing the following steps:

1. Configure your app routes to map the URL segments to the corresponding components, and pass the configuration object to either `RouterModule.forRoot()` or `RouterModule.forChild()` as an argument. If some of the components expect to receive input values, you can use route parameters.
2. Import the returned value of `forRoot()` or `forChild()` in the `@NgModule` decorator.
3. Define the outlet where the router will render components by using the `<router-outlet>` tag.
4. Add HTML anchor tags with bounded `[routerLink]` properties (square brackets denote property binding), so that when the user clicks on the link, the router will render the corresponding component. Think of a `[routerLink]` as a client-side replacement for the `href` attribute of the HTML anchor tag.

Invoking the router's `navigate()` method is an alternative to using `[routerLink]` for navigating to a route. In either case, the router will find a match to the provided path, will create (or find) the instance of the specified component, and will update the URL accordingly.

Let's illustrate these steps in a sample application (see the router_samples folder in the code samples). Say we want to create a root component that has two links, Home and Product Details, at the top of the page. The application should render either `HomeComponent` or `ProductDetailComponent`, depending on which link the user clicks. `HomeComponent` will render the text “Home Component” on the red background, and `ProductDetailComponent` will render “Product Details Component” on cyan. Initially the web page should display `HomeComponent`, as shown in figure 3.3.

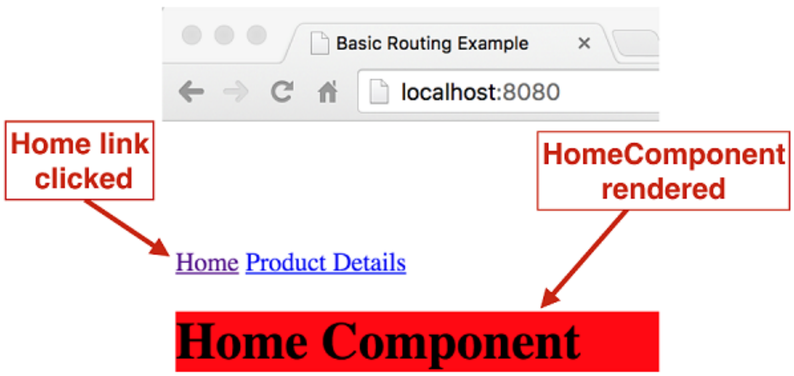


Figure 3.3 The Home route of the basic_routing sample

After the user clicks on the Product Details link, the router should display `ProductDetailComponent`, as shown in figure 3.4.

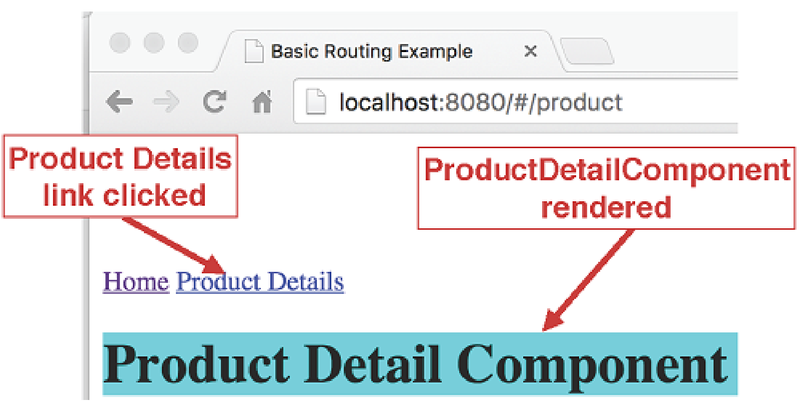


Figure 3.4 The Product Details route of the basic_routing sample

The main goal of this exercise is to get familiar with the router, so our components will be very simple. Here is the code of `HomeComponent`:

```
import {Component} from '@angular/core';

@Component({
    selector: 'home',
    template: '<h1 class="home">Home Component</h1>',
    styles: ['.home {background: red}']})
export class HomeComponent {}
```

The code of `ProductDetailComponent` looks similar, but instead of red it uses a cyan background:

```
import {Component} from '@angular/core';

@Component({
    selector: 'product',
    template: '<h1 class="product">Product Details Component</h1>',
    styles: ['.product {background: cyan}']})
export class ProductDetailComponent {}
```

We'll configure the routes in a separate file called app.routing.ts:

```
import { Routes, RouterModule } from '@angular/router';   ❶
import {HomeComponent} from "./home";
import {ProductDetailComponent} from "./product";

const routes: Routes = [

    {path: '',        component: HomeComponent},   ❷

    {path: 'product', component: ProductDetailComponent}   ❸
];

export const routing = RouterModule.forRoot(routes);   ❹
```

❶ Imports Routes and RouterModule.

❷ If there are no URL segments after the base URL, renders the HomeComponent in the router outlet.

❸ If the URL has the "product" segment after the base URL, renders ProductDetailComponent in the router outlet.

❹ Exports the router configuration so it can be imported by the root module.

In the preceding example, HomeComponent is mapped to a path containing an empty string, which implicitly makes it a default route.

The `Routes` type is just a collection of the objects with properties declared in the `Route` interface, as shown here:

```
export interface Route {
    path?: string;
    pathMatch?: string;
    component?: Type | string;
    redirectTo?: string;
    outlet?: string;
    canActivate?: any[];
    canActivateChild?: any[];
    canDeactivate?: any[];
    canLoad?: any[];
    data?: Data;
    resolve?: ResolveData;
    children?: Route[];
    loadChildren?: string;
}
```

TypeScript interfaces are described in appendix B, but we'd like to remind you that the question mark after the property name means that this property is optional. You can pass to the function `forRoot()` or `forChild()` a configuration object that only has a couple of properties filled in. In our basic app, we used just two properties of `Route`: `path` and `component`.

The next step is to create a root component that will contain the links for navigating between the Home and Product Details views. Our root `AppComponent` will be located in the app.component.ts file:

```
import {Component} from '@angular/core';
@Component({
    selector: 'app',
    template: `
      <a [routerLink]="['/']">Home</a>   ❶
      <a [routerLink]="['/product']">Product Details</a>   ❷
      <router-outlet></router-outlet>   ❸
    `
})
export class AppComponent {}
```

❶ Creates a link that binds routerLink to the empty path.

❷ Creates a link that binds routerLink to the path /product.

❸ The <router-outlet> specifies the area on the page where the router will render our components (one at a time).

Note the use of brackets in the `<a>` tags. The square brackets around `routerLink` denote property binding, and the brackets on the right represent an array with one element (for example, `['/']`). We'll show you examples of an array with two or more elements later in this chapter. The second anchor tag has the `routerLink` property bound to the component configured for the `/product` path. The matched components will be rendered in the area marked with `<router-outlet>`, which in our app is located below the anchor tags.

None of our components is aware of the router configuration, because it's the module's business. Let's declare and bootstrap the root module. For simplicity, we'll implement these two actions in the same main.ts file:

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { AppComponent }  from './components/app.component';
import {HomeComponent} from "./components/home";
import {ProductDetailComponent} from "./components/product";
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
```

```
import {routing} from './components/app.routing';   ❶

@NgModule({
    imports:      [ BrowserModule,
                    routing ],   ❷
    declarations: [ AppComponent,
                    HomeComponent,
                    ProductDetailComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}],   ❸
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

❶ Imports our routes configuration.

❷ Adds our routes configuration to @NgModule.

❸ Lets the dependency injection mechanism know that we want HashLocationStrategy.

❹ Loads the app.

The module's `providers` property is an array of registered providers (there's just one in our example) for dependency injection, which will be covered in chapter 4. At this point, you just need to know that although the default location strategy is `PathLocationStrategy`, we want Angular to use the `HashLocationStrategy` class for routing (note the hash sign in the URL in figure 3.4).

NOTE	**Trailing slashes in URLs** Angular removes trailing slashes from URLs. See how the URLs for these routes look in figures 3.3 and 3.4. Child components may have their own route configurations, and we'll discuss that later in this chapter.

SIDEBAR **Running the sample applications in this book**

Typically the code that comes with each chapter has several sample applications. To run a particular application, you'll need to make a one-line change in the configuration file of SystemJS to specify the name of the main script that you want to run.

To run this application using the code that comes with the book, make sure that the main script that bootstraps your root module is properly mapped in systemjs.config.js. For example, this is how to specify that the main script is located in the main-param.ts file:

```
packages: {
  'app': {main: 'main-param', defaultExtension: 'ts'}
}
```

The same applies to the other sample applications in this and other chapters.

The main script of this application is located in the main.ts file in the directory samples. To run this app, make sure that the systemjs.config.js file lists main.ts in the app package, and then start the `live-server` from the project root directory.

SIDEBAR **SystemJS and on-the-fly transpiling**

TypeScript offers an elegant declarative syntax for implementing many Angular features, including routing. We use SystemJS in our code samples, and the transpiling of TypeScript into JavaScript is done on the fly when the application code is loaded into the browser.

But what if the application doesn't work as expected? If you open the Developer Tools panel in your browser, you'll see that each file with the extension .ts has a corresponding .ts!transpiled file. This is a transpiled version of the code that may be handy if you need to see the actual JavaScript code that runs in the browser. Figure 3.5 shows the Chrome Developer Tools panel with the source code of product.ts!transpiled.

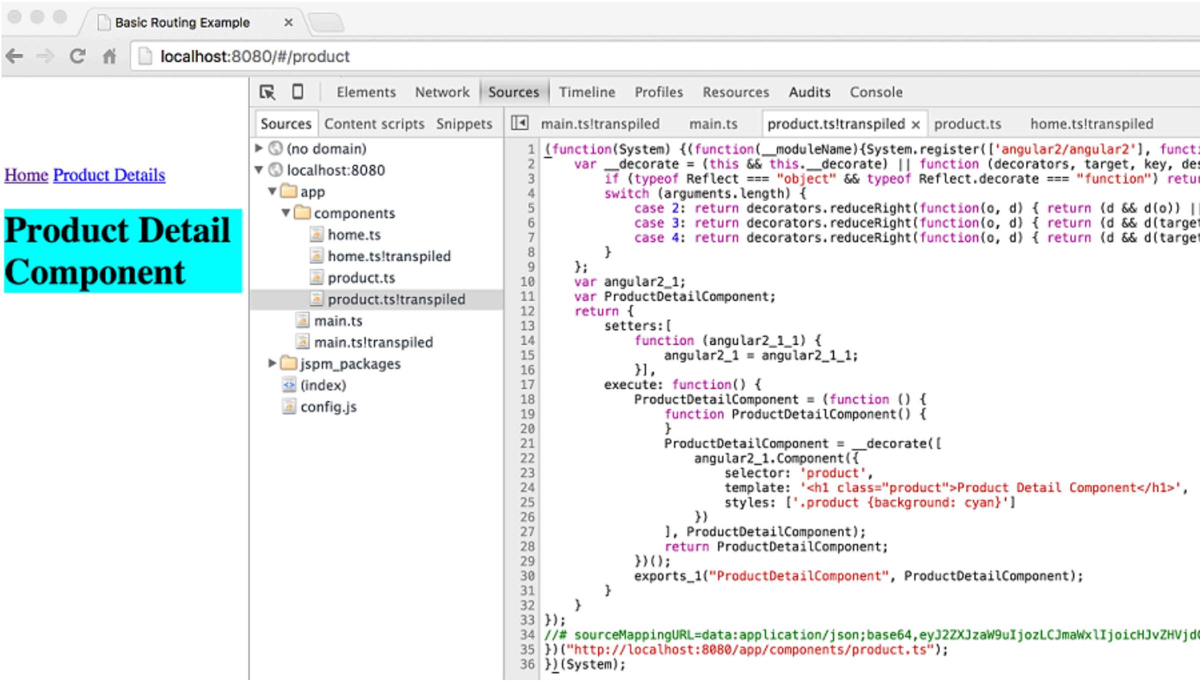


Figure 3.5 Monitoring the SystemJS-transpiled code

> **NOTE** **The `Location` class**
>
> Angular comes with a `Location` class that allows you to navigate to an absolute URL by invoking its `go()`, `forward()`, and `back()` methods, along with some others. `Location` should be used only if you need to interact with the URL outside of the Angular router. You'll see an example of using `Location` in chapter 9 where we'll write scripts for unit testing.

3.1.3 Navigating to routes with navigate()

In the basic_routing code example in the previous section, we arranged the navigation using `routerLink` in HTML anchor tags. But what if you need to arrange navigation programmatically without asking the user to click on a link? Let's modify that code sample to navigate by using the `navigate()` method. We'll add a button that will also navigate to the `ProductDetailComponent`, but this time no HTML anchors will be used.

The following code sample (main-navigate.ts) will invoke the `navigate()` method on the `Router` instance that will be injected into the `RootComponent` via its constructor. For simplicity, we placed the module and routes declaration, the bootstrap, and the `AppComponent` in the same file, but in real-world projects you should keep them separate as we did in the previous section.

```
import {Component} from '@angular/core';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
import { Router, Routes, RouterModule } from '@angular/router';
```

```
import {HomeComponent} from "./components/home";
import {ProductDetailComponent} from "./components/product";

const routes: Routes = [
    {path: '',        component: HomeComponent},
    {path: 'product', component: ProductDetailComponent}
];

@Component({
    selector: 'app',
    template: `
        <a [routerLink]="['/']">Home</a>
        <a [routerLink]="['/product']">Product Details!!!</a>
        <input type="button" value="Product Details"
               (click)="navigateToProductDetail()" />      ❶
        <router-outlet></router-outlet>
    `
})
class AppComponent {

    constructor(private _router: Router){}     ❷

    navigateToProductDetail(){
        this._router.navigate(["/product"]);     ❸
    }
}

@NgModule({
    imports:      [ BrowserModule, RouterModule.forRoot(routes)],
    declarations: [ AppComponent, HomeComponent, ProductDetailComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

❶ Clicking this button invokes the navigateToProductDetail() method.

❷ Angular will inject the instance of the Router into the router variable.

❸ Navigates to the configured product route programmatically.

In this example we used a button to navigate to the `product` route, but this can be done programmatically without requiring user actions. Just invoke the `navigate()` method (or `navigateByUrl()`) from your application code when necessary. You'll see another example of using this API in chapter 9, where we'll explain how to unit-test the router.

NOTE	**Checking if the route is active** Having a reference to the `Router` instance allows you to check if a particular route is active by calling `isRouteActive()`.

SIDEBAR **Handling 404 errors**

If the user enters a nonexistent URL in your application, the router won't be able to find a matching route and will print an error message on the browser's console, leaving the user to wonder why no navigation is happening. Consider creating an application component that will be displayed whenever the application can't find the matching component.

For example, you could create a component named `_404Component` and configure it with the wildcard path `**`:

```
[
  {path: '',        component: HomeComponent},
  {path: 'product', component: ProductDetailComponent},
  {path: '**', component: _404Component}
])
```

Now whenever the router can't match the URL to any component, it'll render the content of `_404Component` instead. You can see it in action by running the application `main-with-404.ts` that comes with the book. Just enter a nonexistent URL in the browser, such as http://localhost:8080/#/wrong.

The wildcard route configuration has to be the last element in the array of routes. The router always treats the wildcard route as a match, so any routes listed after the wildcard one won't be considered.

3.2 Passing data to routes

Our basic routing application showed how you can display different components in a predefined outlet on the window, but we often need not only to display a component, but to pass some data to it. For example, if we navigate from the Home to the Product Details route, we need to pass the product ID to the component that represents the destination route, such as `ProductDetailComponent`.

The component that represents the destination route can receive passed parameters via its constructor argument of type `ActivatedRoute`. Besides the passed parameters, `ActivatedRoute` stores the route's URL segment, the outlet. We'll show you how to extract route parameters from an `ActivatedRoute` object in this section.

3.2.1 Extracting parameters from ActivatedRoute

When the user navigates to the Product Details route, we need to pass the product ID to this route to display details for the particular product. Let's modify the code of the application in the previous section so `RootComponent` can pass the product ID to `ProductDetailComponent`.

The new version of this component will be called `ProductDetailComponentParam`, and Angular will inject an object of type `ActivatedRoute` into this component. The

`ActivatedRoute` object will contain the information about the component loaded into the outlet.

```
import {Component} from '@angular/core';
import {ActivatedRoute} from '@angular/router';

@Component({
  selector: 'product',
  template: `<h1 class="product">Product Details for Product: {{productID}}</h1>`,   ❶
  styles: ['.product {background: cyan}']
})
export class ProductDetailComponentParam {
  productID: string;


  constructor(route: ActivatedRoute) {   ❷
    this.productID = route.snapshot.params['id'];   ❸
  }
}
```

❶ Displays the received product ID using binding.

❷ The constructor of this component asks Angular to inject the ActivatedRoute object.

❸ Gets the value of the parameter named id and assigns it to the productID class variable, which is used in template via binding.

SIDEBAR **Subscribing to changing parameters**

In the previous code sample, we used the `snapshot` property of `ActivatedRoute` to get the values of the parameter passed to the route. The `snapshot` property represents a component loaded into the outlet at a particular moment in time.

Imagine that you have two links on the main window: one passes `1234` and another `6789` to the `product` route. After clicking on the first link, the `ProductDetailComponentParam` will be created and get 1234. Clicking on the second link won't change this value because the snapshot wouldn't be retaken.

The `ActivatedRoute` class has another property called `params` of type `Observable`, which allows a component that's loaded by the router to subscribe to incoming parameters that may change over time. We'll introduce working with observables in chapter 5, but the following code snippet shows how you can change the code of the `ProductDetailComponentParam` constructor to react to the changing parameters.

```
constructor(private route: ActivatedRoute) {
  //this.productID = route.snapshot.params['id'];

  this.route.params.subscribe(
      params => this.productID = params['id']
  );
}
```

The `ActivatedRoute` object will contain all the parameters that are being passed to the component. You just need to declare the constructor's argument, specifying its type, and Angular will know how to instantiate and inject this object. We'll cover dependency injection in detail in chapter 4.

In the next code sample we'll change the configuration of the `product` route and `routerLink` to ensure that the value of the product ID will be passed to the `ProductDetailComponentParam` component if the user choses to go this route. The new version of the app will be called main-param.ts:

```
import {Component} from '@angular/core';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
import { Routes, RouterModule } from '@angular/router';
import {HomeComponent} from "./components/home";
import {ProductDetailComponentParam} from "./components/product-param";

const routes: Routes = [
    {path: '',        component: HomeComponent},
    {path: 'product/:id', component: ProductDetailComponentParam}   ❶
];

@Component({
    selector: 'app',
    template: `
        <a [routerLink]="['/']">Home</a>
        <a [routerLink]="['/product', 1234]">Product Details</a>   ❷
        <router-outlet></router-outlet>
    `
})
class AppComponent {}

@NgModule({
    imports:      [ BrowserModule, RouterModule.forRoot(routes)],
    declarations: [ AppComponent, HomeComponent, ProductDetailComponentParam],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

❶ The path property has an additional URL segment, /:id.

❷ This time there are two elements in the array given to routerLink: the path that the route starts with, and the number that represents the product ID.

The `routerLink` property for the Product Details link is initialized with a two-element array. The elements of the array build up the path specified in the routes configuration given to the `RouterModule.forRoot()` method. The first element of the array represents the static part of the route's path: `product`. The second element represents the variable part of the path: `/:id`.

For simplicity we've hardcoded the ID to be `1234`, but if the `RootComponent` class had a `productID` variable pointing at the appropriate object, we could have written `{ productID}` instead of `1234`. For the Product Details route, Angular will construct the URL segment `/product/1234`. Figure 3.6 shows how the Product Details view will be rendered in the browser.

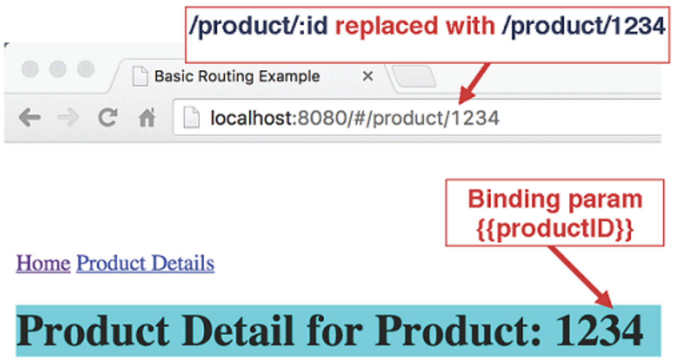


Figure 3.6 The Product Details route received the product ID 1234

Note the URL. The router replaced the `product/:id` path with `/product/1234`.

Let's review the steps that Angular performed under the hood to render the main page of the application:

1. Check the content of each `routerLink` to find the corresponding route configurations.
2. Parse the URLs and replace the parameter names with actual values where specified.
3. Build the `<a href="">` tags that the browser understands.

Figure 3.7 shows a snapshot of the home page of our application with the Chrome Developer Tools panel open.

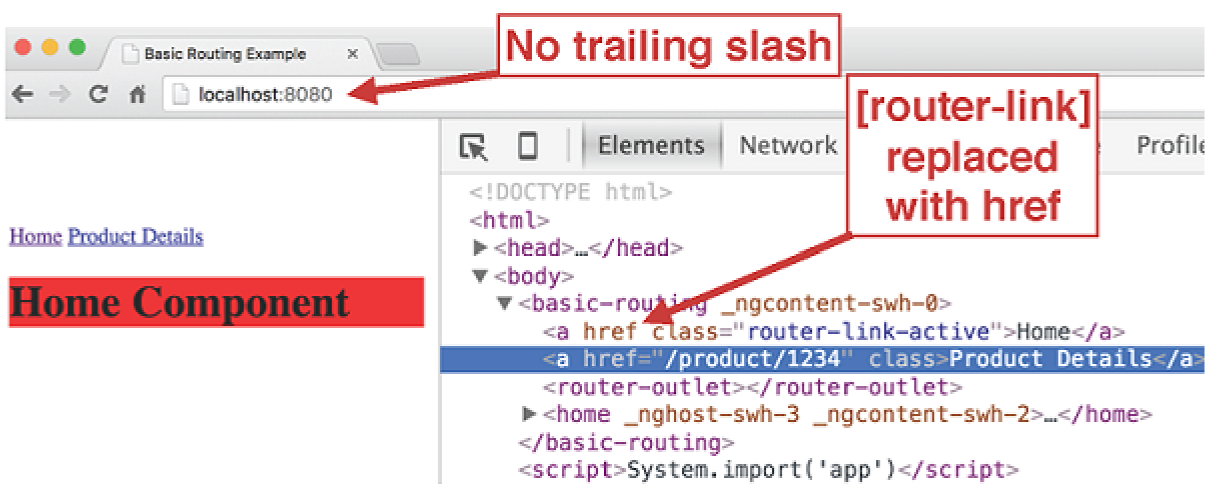


Figure 3.7 The Product Details anchor tag is ready

Because the `path` property of the configured Home route had an empty string, Angular didn't add anything to the base URL of the page. But the anchor under the Product Details link has already been converted into a regular HTML tag. When the user clicks on the Product Details link, the router will attach a hash sign and add `/product/1234` to the base URL so that the absolute URL of the Product Details view will become http://localhost:8080/#/product/1234.

3.2.2 Passing static data to a route

Parent components will usually pass data to their children, but Angular also offers a mechanism to pass arbitrary data to components at the time of route configuration. For example, besides dynamic data like a product ID, we may need to pass a flag indicating whether the application is running in a production environment or not. This can be done by using the `data` property of your route configuration.

The route for the product details can be configured as follows:

```
{path: 'product/:id', component: ProductDetailComponentParam , data: [{isProd: true}]}
```

The `data` property can contain an array of arbitrary key-value pairs. When the router opens `ProductDetailComponentParam`, the `data` value will be located in the data property of the `ActivatedRoute.snapshot`:

```
export class ProductDetailComponentParam {
  productID: string;
  isProdEnvironment: string;

  constructor(route: ActivatedRoute) {
    this.productID = route.snapshot.params['id'];

    this.isProdEnvironment = route.snapshot.data[0]['isProd'];
    console.log("this.isProdEnvironment = " + this.isProdEnvironment);
  }
}
```

Passing data to a route via the `data` property is not an alternative to configuring parameters in the `path` property, as in `path: 'product/:id'`, but it can come in handy when you need to pass some data to a route during the configuration phase, such as whether it's a production or QA environment. The application that implements this functionality is located in the main-param-data.ts file.

3.3 Child routes

An Angular application is a tree of components that have parent-child relations. Each component is well encapsulated, and you have full control over what you expose to the rest of the application's scripts and what you keep private within the component. Any component can have its own styles that won't mix with the parent's styles. A component can also have its own dependency injectors. A child component can have its own routes, but all routes are configured outside of any component.

In the previous section, we configured the routes to show either the content of `HomeComponent` or `ProductDetailComponent` in the `router-outlet` of `AppComponent`. Imagine now that we want to enable `ProductDetailComponent` (the child) to show either the product description or the seller's info.

This means that we want to add the configuration of child routes for `ProductDetailComponent`. We'll use the `children` property of the `Route` interface for this:

```
[ {path: '',            component: HomeComponent},
  {path: 'product/:id', component: ProductDetailComponent,
    children: [
      {path: '', component: ProductDescriptionComponent},
      {path: 'seller/:id', component: SellerInfoComponent}
    ]}
]
```

Figure 3.8 shows how the application will look once the user clicks on the Product Details link on the root component, which renders `ProductDetailComponent` (the child) showing `ProductDescription`. This is the default route of the child, because its `path` property has an empty string.

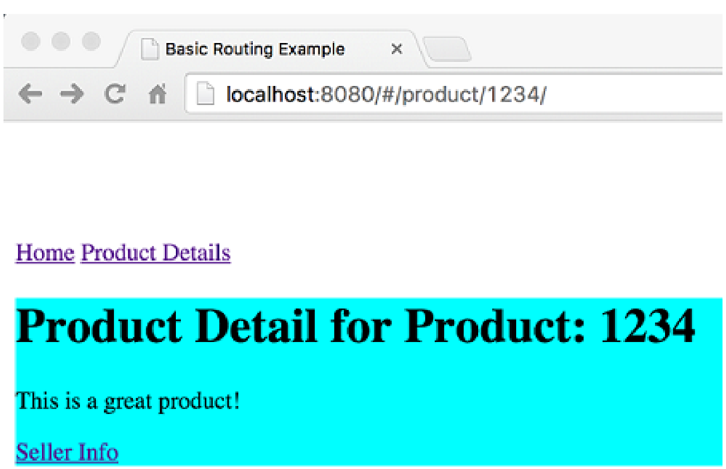


Figure 3.8 The Product Description route

Figure 3.9 shows the application after the user clicks on the Product Details link and then on Seller Info.

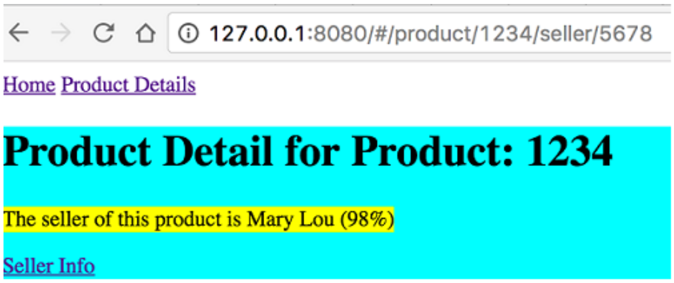


Figure 3.9 The child route renders SellerInfo

NOTE	**The seller’s info has a yellow background** If you read the electronic version of this book, you’ll see that the seller’s info is shown on a yellow background. We did this on purpose to discuss the styling of components a bit later in this chapter.

To implement the views shown in figures 3.8 and 3.9, we’ll modify `ProductDetailComponent` so it also has two children, `SellerInfoComponent` and `ProductDescriptionComponent`, and its own `<router-outlet>`. Figure 3.10 shows the hierarchy of components that we’re going to implement.

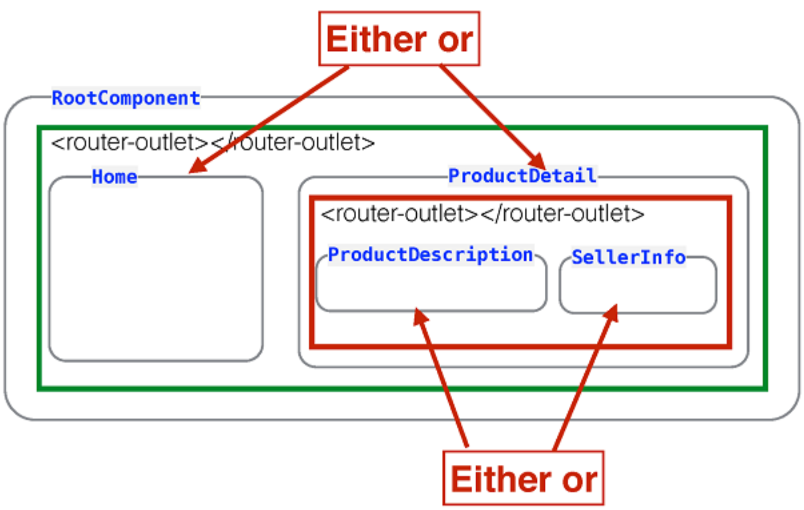


Figure 3.10 The routes hierarchy in the basic_routing app

The entire code of this example with the child routes is located in main-child.ts, shown next.

```
import {Component} from '@angular/core';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
import { Routes, RouterModule } from '@angular/router';
import {HomeComponent} from "./components/home";
import {ProductDetailComponent} from './components/product-child';
```

```
import {ProductDescriptionComponent} from './components/product-description';
import {SellerInfoComponent} from './components/seller';

const routes: Routes = [
    {path: '',           component: HomeComponent},
    {path: 'product/:id', component: ProductDetailComponent,
        children: [
          {path: '',           component: ProductDescriptionComponent},
          {path: 'seller/:id', component: SellerInfoComponent}
        ]}
];

@Component({
    selector: 'app',
    template: `
        <a [routerLink]="['/']">Home</a>
        <a [routerLink]="['/product', 1234]">Product Details</a>
        <router-outlet></router-outlet>
    `
})
class AppComponent {}

@NgModule({
    imports:      [ BrowserModule, RouterModule.forRoot(routes)],
    declarations: [ AppComponent, HomeComponent, ProductDetailComponent,
                    ProductDescriptionComponent, SellerInfoComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

Take another look at the URL in figure 3.9. When the user clicks on the Product Details link, the `product/1234` segment is added to the URL. The router finds a match to this path in the configuration object and renders `ProductDetailComponent` in the outlet.

The new version of `ProductDetailComponent` (product-child.ts) has its own outlet, where it can display either `ProductDescriptionComponent` (the default) or `SellerInfoComponent`:

```
import {Component} from '@angular/core';
import {ActivatedRoute} from '@angular/router';

@Component({
    selector: 'product',
    styles: ['.product {background: cyan}'],
    template: `
      <div class="product">
        <h1>Product Details for Product: {{productID}}</h1>

        <router-outlet></router-outlet>   ❶

        <p><a [routerLink]="['./seller', 5678]">Seller Info</a></p>   ❷
      </div>
    `
})
export class ProductDetailComponent {
  productID: string;

  constructor(route: ActivatedRoute) {
    this.productID = route.snapshot.params['id'];
```

```
  }
}
```

❶ ProductDetailComponent has its own router-outlet to render its child components one at a time.

❷ When the user clicks on this link, Angular adds the /seller/5678 segment to the existing URL and renders SellerInfoComponent.

> **NOTE** **Child components don't need to be imported**
> Neither `ProductDescriptionComponent` nor `SellerInfoComponent` are explicitly mentioned in the template of `ProductDetailComponent`, and there's no need to list them in the `directives` property. They're included in `AppModule`.

By looking at the route configuration for `SellerInfoComponent`, you'll see that it expects to receive the seller's ID as a parameter. We'll be passing a hard-coded value of `5678` as the seller's ID.

When the user clicks on the Seller Info link, the URL will include the product/1234/seller/5678 segment (see figure 3.9). The router will find a match in the configuration object and will display `SellerInfoComponent`.

> **NOTE** **Using the Back button**
> This version of `ProductDetailComponent` has only one link to open the seller's info. To navigate from the `seller` route back to /product, the user can just click on the web browser's Back button.

Our `ProductDescriptionComponent` is trivial:

```
import {Component} from '@angular/core';

@Component({
    selector: 'product-description',
    template: '<p>This is a great product!</p>'
})
export class ProductDescriptionComponent {}
```

Because `SellerInfoComponent` expects to receive the seller's ID, its constructor needs an argument of type `ActivatedRoute` to get the seller ID, like we did in `ProductDetailComponent`.

```
import {Component} from '@angular/core';
import {ActivatedRoute} from '@angular/router';

@Component({
    selector: 'seller',
    template: 'The seller of this product is Mary Lou (98%)',
```

```
    styles: [':host {background: yellow}']
})
export class SellerInfoComponent {
   sellerID: string;

   constructor(route: ActivatedRoute){
     this.sellerID = route.snapshot.params['id'];
     console.log(`The SellerInfoComponent got the seller id ${this.sellerID}`);
   }
}
```

In the preceding `SellerInfoComponent` we used a pseudoclass `:host` to display the content of this component on a yellow background. This will serve as a good segue to a brief discussion of the Shadow DOM.

The `:host` pseudoclass selector can be used with elements that are created using the Shadow DOM, which provides better encapsulation for components (see the "Shadow DOM Support in Angular" sidebar). Although not all web browsers support Shadow DOM yet, Angular emulates Shadow DOM by default and creates a shadow root. The HTML element associated with this shadow root is called shadow host.

In the preceding code we use `:host` to apply the yellow background color to `SellerInfoComponent`, which serves as a shadow host. Shadow DOM styles of the components are not merged with the styles of the global DOM and the IDs of the component's HTML tags won't overlap with the IDs of the DOM.

SIDEBAR **Shadow DOM support in Angular**

Shadow DOM is a part of the Web Components standards. Every web page is represented by a tree of DOM objects, but the Shadow DOM allows us to encapsulate a subtree of HTML elements to create a boundary between one component and another. Such a subtree is rendered as part of the HTML document, but its elements aren't attached to the main DOM tree. In other words, the Shadow DOM places a wall between the DOM content and the internals of the HTML component.

When you add a custom tag to a web page, it includes an HTML fragment, and with the Shadow DOM this fragment is scoped to the component without merging with the DOM of the web page. With the Shadow DOM, the CSS styles of the custom component won't be merged with the main DOM CSS, preventing possible conflicts in rendering styles.

Open any YouTube video in the Chrome browser, which natively supports Shadow DOM. The video player is represented by the tag `video`, which you can find by opening the Developer Tools and browsing the content under the Elements tab as shown in figure 3.11.

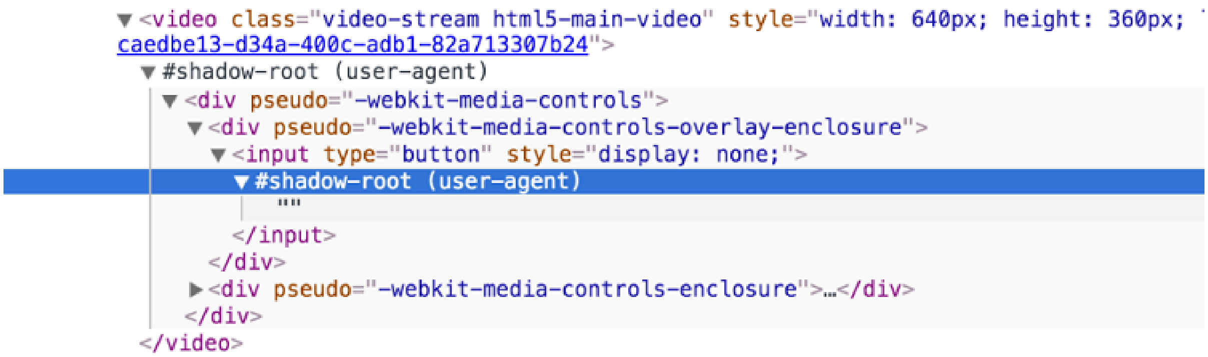


Figure 3.11 The <video> tag on a YouTube page

SIDEBAR

Although the video player consists of the content area and a toolbar with a dozen controls (the Play button, the audio slider, and so on) they're all encapsulated inside the shadow root. From the main DOM perspective, this page contains a "Lego block" `<video>`. To peek inside of this tag, you'd need to select the Show User Agent Shadow DOM option in the Developer Tools settings.

In Angular components, you specify the HTML markup in the `template` or `templateUrl` property of the `@Component` annotation. If a web browser supports the Shadow DOM natively, or you requested that Angular should emulate it, the component's HTML isn't merged with the global DOM object of the web page. In Angular, you can specify Shadow DOM mode by setting the `encapsulation` property in the `@Component` annotation to one of the following values:

- `ViewEncapsulation.Emulated`—Emulates encapsulation of the Shadow DOM (the default). This instructs Angular to generate unique attributes for the styles of the component and won't merge its styles with the styles of the web page's DOM. For example, if you open Developer Tools in Chrome while navigating to `SellerInfoComponent`, its HTML markup will look like this:

```
<head>
...
  <style>[_nghost-yls-7] {background: yellow;}</style>
</head>
...
<seller _nghost-yls-7="" _ngcontent-yls-6="">
  <p _ngcontent-yls-7=""></p>
  The seller of this product is Mary Lou (98% positive feedback)
</seller>
```

- `ViewEncapsulation.Native`—Uses the Shadow DOM that's natively supported by the browser. The HTML and styles aren't merged with the DOM of the web page. You should use this option only if you're sure that the user's browser supports Shadow DOM; otherwise an error is thrown. In this mode, the styles of `SellerInfoComponent` won't be added to the `<head>` section of the page, but all styles of the component and its parents will be encapsulated inside the component as seen in figure 3.12.

Figure 3.12 The shadow root encapsulates all styles

SIDEBAR

- `ViewEncapsulation.None`—Doesn't use Shadow DOM encapsulation. All the markup and styles will be integrated into the global web page DOM. The `:host` selector won't work in this mode, because there won't be any shadow host. You can still style the `SellerInfoComponent`, referring to the component by its selector:

```
import {Component, ViewEncapsulation} from '@angular/core';

@Component({
    selector: 'seller',
    template: 'The seller of this product is Mary Lou (98%)',
    styles: ['seller {background: yellow}'],
    encapsulation: ViewEncapsulation.None
})
export class SellerInfoComponent {}
```

  Angular won't generate any additional style attributes and will simply add the following line to the <head> section of the page:

```
<style>seller {background: yellow}</style>
```

In chapter 6, in the section "Changing templates at runtime with ngContent," you'll see how `ViewEncapsulation` affects the UI rendering with and without the Shadow DOM.

SIDEBAR **Deep linking**

Deep linking is the ability to create a link to specific content inside a web page rather than to the entire page. In our basic routing applications, you've seen examples of deep linking:

- The URL http://localhost:8080/#/product/1234 links not just to the Product Details page, but to a specific view representing the product with an ID of 1234.
- The URL http://localhost:8080/#/product/1234/seller/5678 links even deeper. It shows the information about the seller with an ID of 5678 who sells the product whose ID is 1234.

You can easily see deep linking in action by copying the link http://localhost:8080/#/product/1234/seller/5678 from the application running in Chrome and pasting it into Firefox or Safari.

3.4 Guarding routes

Now that you know how to arrange basic navigation using the router, let's consider some scenarios that require validation to be performed to decide if the user (or a program) is allowed to navigate to or leave the route:

- Open the route only if the user is authenticated and authorized to do so.
- Display a multipart form that consists of several components, and the user is allowed to navigate to the next section of the form only if the data entered in the current section is valid.
- Remind the user about unsaved changes if they try to navigate from the route.

The router has hooks that give you more control over the navigation to and from a route. You can use these hooks to implement any of preceding scenarios to *guard* the routes.

NOTE **Component lifecycle hooks**

Angular includes a number of component lifecycle hooks that allow you to handle important events in the life of a component. We'll cover them in chapter 6.

In section 3.1 we mentioned that the `Routes` type is an array of items that conforms to the `Route` interface, shown here:

```
export interface Route {
    path?: string;
    pathMatch?: string;
    component?: Type | string;
    redirectTo?: string;
    outlet?: string;
    canActivate?: any[];
```

```
    canActivateChild?: any[];
    canDeactivate?: any[];
    canLoad?: any[];
    data?: Data;
    resolve?: ResolveData;
    children?: Route[];
    loadChildren?: string;
}
```

While configuring our previous routes, we used three properties from this interface: `path`, `component`, and data. Now let's get familiar with the `canActivate` and `canDeactivate` properties, which allow you to hook up the routes with guards. Basically, you need to write a function implementing the validating logic that will return either `true` or `false`, and assign it to one of these properties. If `canActivate()` of the guard returns `true`, the user can navigate to the route. If `canDeactivate()` returns `true`, the user can navigate away from the route.

Because both the `canActivate` and `canDeactivate` properties of `Route` accept an array as a value, you can assign multiple functions (guards) if you need to check more than one condition to allow or forbid the navigation.

Let's update the first sample from this chapter (the one with the Home and Product Details links) to illustrate how you can protect the `product` route from users who aren't logged in. To keep the example simple, we won't use an actual login service but will generate the login status randomly.

We'll create a guard class that implements the interface `CanActivate`, which declares only one function to implement: `canActivate()`. This function should contain application logic that returns `true` or `false`. If the function returns `false` (the user isn't logged in), the application won't navigate to the route and will print an error message on the console.

```
import {CanActivate} from "@angular/router";
import {Injectable} from "@angular/core";

@Injectable()
export class LoginGuard implements CanActivate{

  canActivate() {
      return this.checkIfLoggedIn();
  }

  private checkIfLoggedIn(): boolean{

      // A call to the actual login service would go here
      // For now we'll just randomly return true or false

      let loggedIn:boolean = Math.random() <0.5;

      if(!loggedIn){
          console.log("LoginGuard: The user is not logged in and can't navigate product details");
      }
```

```
      return loggedIn;
  }
}
```

As you can see from the code, our implementation of the `canActivate()` function will randomly return `true` or `false`, emulating the user's logged in status.

The next step is to update the router configuration so it uses our guard. The following code snippet shows how the routes could be configured for an app that has Home and Product Details routes. The latter is protected by our `LoginGuard`:

```
[
  {path: '',        component: HomeComponent},
  {path: 'product', component: ProductDetailComponent, canActivate:[LoginGuard]}
]
```

Adding one or more guards to the array given to the `canActivate` property will automatically invoke all the guards, one after the other. If any of the guards returns `false`, navigating to the route will be prohibited.

But who will instantiate the `LoginGuard` class? Angular will do it for us using its dependency injection mechanism (described in chapter 4), but you have to mention this class in the list of providers that are needed for injection to work. We'll add the name `LoginGuard` to the list of providers in `@NgModule`:

```
@NgModule({
    imports:      [ BrowserModule, RouterModule.forRoot(routes)],
    declarations: [ AppComponent, HomeComponent, ProductDetailComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}
                LoginGuard],
    bootstrap:    [ AppComponent ]
})
```

The complete code of the main app script (main-with-guard.ts) follows.

```
import {Component} from '@angular/core';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
import { Routes, RouterModule } from '@angular/router';
import {HomeComponent} from "./components/home";
import {ProductDetailComponent} from "./components/product";
import {LoginGuard} from "./guards/login.guard";

const routes: Routes = [
    {path: '',        component: HomeComponent},
    {path: 'product', component: ProductDetailComponent,
        canActivate:[LoginGuard]}
];

@Component({
    selector: 'app',
    template: `
        <a [routerLink]="['/']">Home</a>
```

```
        <a [routerLink]="['/product']">Product Details</a>
        <router-outlet></router-outlet>
    `
})
class AppComponent {}

@NgModule({
    imports:      [ BrowserModule, RouterModule.forRoot(routes)],
    declarations: [ AppComponent, HomeComponent, ProductDetailComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy},
                LoginGuard],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

If you run this app and click on the Product Details link, it'll either navigate to this route or print the error message on the browser console, depending on the randomly generated value in `LoginGuard`. Figure 3.13 shows a screenshot taken after the user clicked on the Product Details link but `LoginGuards` decided that the user wasn't logged in.

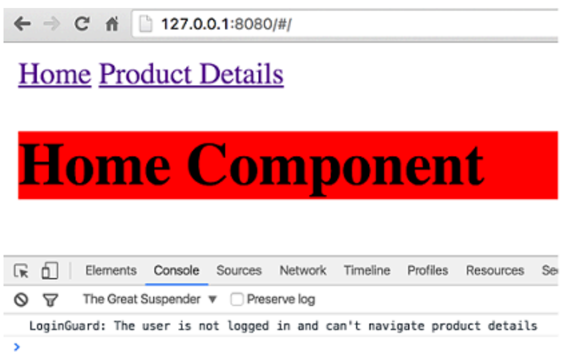


Figure 3.13 Clicking on the Product Details link is guarded

In the preceding example we implemented the `canActivate()` method without providing any arguments to it. But this method can be used with the following signature:

```
canActivate(destination: ActivatedRouteSnapshot, state: RouterStateSnapshot)
```

The values of `ActivatedRouteSnapshot` and `RouterStateSnapshot` will be injected by Angular automatically, and this may be quite handy if you want to analyze the current state of the router. For example, if you'd like to know the name of the route the user tried to navigate to, this is how you can do it:

```
canActivate(destination: ActivatedRouteSnapshot, state: RouterStateSnapshot) {
      console.log(destination.component.name);
   ...
}
```

NOTE **The `resolve` property**

If you want to wait for some async data to arrive before navigating to a route, use the `resolve` property while configuring the route. There you can specify a class that implements the `Resolve` interface with the function `resolve()`. The router won't instantiate the configured component until this function returns.

Implementing the `CanDeactivate` interface that controls the process of navigating from a route works similarly. Just create a guard class that implements the method `canDeactivate()`, like this:

```
import {CanDeactivate, Router} from "@angular/router";
import {Injectable} from "@angular/core";

@Injectable()
export class UnsavedChangesGuard implements CanDeactivate{

    constructor(private _router:Router){}

    canDeactivate(){
        return window.confirm("You have unsaved changes. Still want to leave?");

    }
}
```

Don't forget to add the `canDeactivate` property to the route configuration, and to include the new guard in the providers list in the module:

```
@NgModule({
    imports:      [ BrowserModule, RouterModule.forRoot(routes)],
    declarations: [ AppComponent, HomeComponent, ProductDetailComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy},
                LoginGuard, UnsavedChangesGuard],
    bootstrap:    [ AppComponent ]
})
```

NOTE **Displaying dialog boxes**

For a fancier way of displaying alerts and confirmation dialogs, use the `MdDialog` component from the Material Design 2 library (https://github.com/angular/material2).

For more details about the component lifecycle hooks applicable to navigation, refer to the `@angular/router` section in the Angular API documentation (https://angular.io/docs/ts/latest/api/). We'll discuss component lifecycles in chapter 6.

3.5 Developing a SPA with multiple router outlets

In the previous section you learned that a child route is represented by a URL consisting of parent and child segments. Our single-page app had a single tag, `<router-outlet>`, where Angular would render the component configured for either the parent or the child. Now we'll discuss how to configure and render sibling routes, meaning routes that are rendered in separate outlets at the same time. Let's see some use cases:

- Suppose a Gmail web client displays the list of emails in your inbox, and you decide to compose a new email. The new view will be displayed on the right side of the window and you'll be able to switch between the inbox and the draft of the new email without closing either view.
- Imagine a dashboard-like SPA that has several dedicated areas (outlets), and each area could render more than one component (but one at a time). Outlet A can display your stock portfolio either as a table or as a chart, while outlet B shows either the latest news or an advertisement.
- Say you want to add a chat area to a SPA so the user can communicate with a customer service representative while keeping the current route active as well. Basically, you want to add an independent chat route allowing the user to use both routes at the same time and to switch from one route to another.

In Angular you can implement any of these scenarios by having not only a *primary* outlet, but also named *auxiliary* outlets, which are displayed at the same time as the primary one.

To separate the rendering of components for primary and auxiliary routes, you'll need to add yet another `<router-outlet>` tag, but this outlet must have a name. For example, the following code snippet defines primary and chat outlets:

```
<router-outlet></router-outlet>
<router-outlet name="chat"></router-outlet>
```

Let's add a named route for a chat to our sample application. Figure 3.14 illustrates two routes opened at the same time after the user clicked on the Home and then the Open Chat links. The left side shows the rendering of `HomeComponent` in the primary outlet, and the right side shows `ChatComponent` rendered in a named outlet. Clicking on the Close Chat link will remove the content of the named outlet.

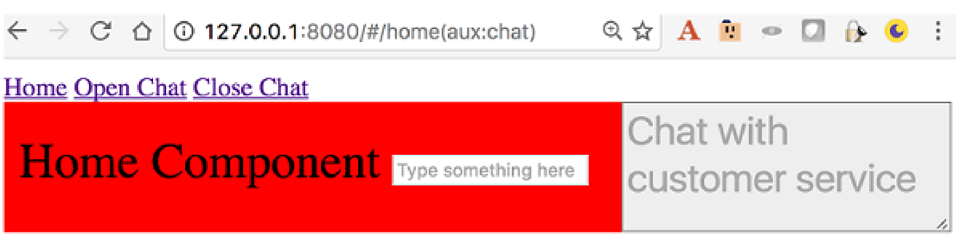


Figure 3.14 Rendering a chat view with an auxiliary route

We added an HTML `<input>` field to `HomeComponent` and a `<textarea>` to `ChatComponent` so it's easier to see which component has the focus when the user switches between the Home and Chat routes.

Note the parentheses in the URL of the auxiliary route, http://localhost:8080/#home/(chat). Whereas a child route is separated from the parent using the forward slash, an auxiliary route is represented as a URL segment in parentheses. This URL tells us that home and chat are sibling routes.

The code that implements this sample is located in the main_aux.ts file, and it's shown next. We've kept all the required components in the same file for simplicity. Both `HomeComponent` and `ChatComponent` have inlined styles to place them next to each other in the window. `HomeComponent` is styled to get 70% of the available viewport width, and `ChatComponent` will get the remaining 30%.

```
import {Component} from '@angular/core';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
import { Routes, RouterModule } from '@angular/router';

@Component({
    selector: 'home',
    template: `<div class="home">Home Component
               <input type="text" placeholder="Type something here"/> </div>`,
    styles: [`.home {background: red; padding: 15px 0 0 30px;  height: 80px; width:70%;
                    font-size: 30px; float:left; box-sizing:border-box;}`]})
export class HomeComponent {}

@Component({
    selector: 'chat',
    template: `<textarea placeholder="Chat with customer service"
                       class="chat"></textarea>`,
    styles: [`.chat {background: #eee; height: 80px;width:30%; font-size: 24px;
                     float:left; display:block; box-sizing:border-box;} `]})
export class ChatComponent {}

const routes: Routes = [
    {path: '',  redirectTo: 'home', pathMatch: 'full'},
    {path: 'home', component: HomeComponent},   ❶
    {path: 'chat', component: ChatComponent, outlet:"aux"}   ❷
];

@Component({
    selector: 'app',
    template: `
        <a [routerLink]="['']">Home</a>
        <a [routerLink]="[{outlets: {primary: 'home', aux: 'chat'}}]">Open Chat</a>   ❸
        <a [routerLink]="[{outlets: {aux: null}}]">Close Chat</a>   ❹
        <br/>
        <router-outlet></router-outlet>   ❺
        <router-outlet name="aux"></router-outlet>   ❻
    `
})
class AppComponent {}
```

```
@NgModule({
    imports:      [ BrowserModule, RouterModule.forRoot(routes)],
    declarations: [ AppComponent, HomeComponent, ChatComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

❶ Configures the route for the Home component. Because no outlet is specified, the component will be rendered in the primary one.

❷ Configures the route for the Chat component to be rendered in the outlet named aux.

❸ Renders the Home component in the primary outlet and Chat in the outlet called aux.

❹ To remove the named outlet with its content, give it a null value.

❺ Declares the primary outlet.

❻ Declares an additional named outlet, <router-outlet>. We named it aux.

NOTE **No hoisting for classes**
Because class declarations aren't hoisted (hoisting is explained in appendix A), make sure you declare your components before using them with `routerLink`.

If you want to navigate to (or close) the named outlets programmatically, use the `Router.navigate()` method, as it was explained in section 3.1.3. Here's an example:

```
navigate([{outlets: {aux: 'chat'}}]);
```

Let's take a breather and recap what we've covered so far in this chapter:

- Routes are configured on the module level.
- Each route has a path mapped to a component.
- The area where the route content is rendered is defined by the placement of the `<router-outlet>` area in the component's template.
- The `routerLink` can be used for navigating to a named route.
- The `navigate()` method can be used for navigating to a named route.
- If a route requires a parameter, you have to configure it in the `path` property of the route configuration and pass its value in `routerLink` or in the `navigate()` method.
- If a route expects a parameter, the underlying component must have a constructor with an argument of type `ActivatedRoute`.
- If a child component has its own route configuration, we call it a child route and it's configured using the `children` property defined in the `Route` interface.
- An application can show more than one route at the same time using named routes.

We're almost done covering the router. We'll cover one more topic: how to implement lazy-loading of components for rarely used routes. This is an important technique that will allow you to minimize the amount of code loaded for the landing page of your app. After that, you'll implement routing in the online auction.

3.6 Splitting an app into modules

Angular modules allow you to split an application into more than one module, where each module implements certain functionality. As a matter of fact, each of the code samples in this chapter already has more than one module, such as `AppModule`, `BrowserModule`, and `RouterModule`. `AppModule` is the root module of an application, but `BrowserModule` and `RouterModule` are feature modules. Note the main difference between them: the root module is bootstrapped, whereas feature modules are imported, as shown in the following code snippet:

```
@NgModule({
    imports:[ BrowserModule,
              RouterModule.forRoot(routes)],
    ...
})
class AppModule { }

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

Each module can expose and hide certain functionality, and all modules are executed in the same context, so they can share objects if need be. `RootModule` and `BrowserModule` were created by the Angular team, but you can split your application into modules too.

In a feature module, the `@NgModule` decorator has to import `CommonModule` instead of `BrowserModule`. Let's take our app with two links—Home and Product Details—and add one more: Luxury Items. Imagine that luxury items have to be processed differently than regular products, and we want to separate this functionality into a feature module called `LuxuryModule`, which will have one component called `LuxuryComponent`. It's recommended that a feature module and its supporting components, services, and other resources be placed in a separate directory. In our sample app, it'll be a directory named luxury.

The code of `LuxuryModule` is located in the luxury.module.ts file, shown next.

```
import { NgModule }      from '@angular/core';
import { CommonModule } from '@angular/common';
import {RouterModule} from '@angular/router';
import {LuxuryComponent} from "./luxury.component";

@NgModule({
    imports:      [ CommonModule,        1
        RouterModule.forChild([         2
```

```
        {path: 'luxury', component: LuxuryComponent}
    ]) ],
    declarations: [ LuxuryComponent ]
})

export class LuxuryModule { }
```

1. Imports CommonModule as required for feature modules.
2. Configures the route for this module using the forChild() method.
3. When the URL has the luxury segment, renders LuxuryComponent.
4. This module will have just one component.

When you configure the root module, use the `forRoot` method, and for feature modules use `forChild()`.

The code of the `LuxuryComponent` will just display the text "Luxury Component" on the yellow (for gold) background:

```
import {Component} from '@angular/core';

@Component({
    selector: 'luxury',
    template: `<h1 class="gold">Luxury Component</h1>`,
    styles: ['.gold {background: yellow}']
})
export class LuxuryComponent {}
```

Note that we're exporting `LuxuryComponent` to make it available to other members of the root module. The code of `AppComponent`, `AppModule`, and the bootstrap function is located in the main-luxury.ts file:

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component } from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
import {RouterModule} from "@angular/router";
import {HomeComponent} from "./components/home";
import {ProductDetailComponent} from "./components/product";
import {LuxuryModule} from "./components/luxury/luxury.module";

@Component({
    selector: 'app',
    template: `
        <a [routerLink]="['/']">Home</a>
        <a [routerLink]="['/product']">Product Details</a>
        <a [routerLink]="['/luxury']">Luxury Items</a>
        <router-outlet></router-outlet>
    `
})
export class AppComponent {}

@NgModule({
    imports: [ BrowserModule,
```

```
                LuxuryModule,
                RouterModule.forRoot([
                    {path: '',         component: HomeComponent},
                    {path: 'product', component: ProductDetailComponent}
                    ])
               ],
    declarations: [ AppComponent, HomeComponent, ProductDetailComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

1. Adds the link to the main app to navigate to the luxury path.
2. Declares our feature module.
3. Configures the route for the root module.

Note that the root module doesn't know about the internals of `LuxuryModule`, and it doesn't even mention `LuxuryComponent`. When the router parses the routes configuration from both root and feature modules, it'll properly map the `luxury` path to the `LuxuryComponent` that's exported by `LuxuryModule`.

If you run this application and click on the Luxury Items link, you'll see the window shown in figure 3.15.

Figure 3.15 Rendering LuxuryModule

This was an example of splitting a chunk of functionality into a module. Should you decide to stop selling luxury items, you'll only need to remove the references to `LuxuryModule` from the root module and one link from `AppComponent`. This is pretty easy refactoring, comparing to the process of removing functionality from a monolithic single-module app.

Moving a feature module from one app to another becomes easier as well. Not that every app needs to be able to sell luxury items, but many apps in a commercial portal may need, say, a payment module that can be reused across apps with minimal effort.

This is all good, but keep in mind that even though we encapsulated some functionality into a separate module, the code of this module is loaded on the application's launch. Do we really want to load the luxury module code into the browser when the application starts? Let’s discuss this next.

3.7 Lazy loading of modules

In large applications, we want to minimize the amount of code that needs to be downloaded to render the landing page of your application. The less code your app initially downloads, the faster the user will see it. This is especially important for mobile apps when they’re used in a poor connection area. If your application has modules that are rarely used, you can make them downloadable on demand, or lazy-loaded.

Angular allows you to easily split your app into modules: one root module and one or more feature modules. The latter can be loaded either eagerly, as we did in the previous section, or lazily.

After implementing the functionality for luxury items, we realized that most users rarely click on the Luxury Items link. Why load the code that handles luxury items on the initial bootstrap of the app? Let’s refactor the app to load the luxury module on demand.

In the next code sample, we implement lazy loading of the module. This sample will look a lot like the app from the previous section, but we’ll make a small change in the main module and change the way `LuxuryModule` is exported. This code is located in the main-luxury-lazy.ts file.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
import {RouterModule} from "@angular/router";
import {HomeComponent} from "./components/home";
import {ProductDetailComponent} from "./components/product";

@Component({
    selector: 'app',
    template: `
        <a [routerLink]="['/']">Home</a>
        <a [routerLink]="['/product']">Product Details</a>
        <a [routerLink]="['/luxury']">Luxury Items</a>
        <router-outlet></router-outlet>
    `
})
export class AppComponent {}

@NgModule({
    imports: [ BrowserModule,
               RouterModule.forRoot([
                   {path: '',        component: HomeComponent},
                   {path: 'product', component: ProductDetailComponent},
                   {path: 'luxury', loadChildren: 'app/components/luxury/luxury.lazy.module'}
                   ])
              ],
    declarations: [ AppComponent, HomeComponent, ProductDetailComponent],
    providers:[{provide: LocationStrategy, useClass: HashLocationStrategy}],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

Note that this time we aren't explicitly importing `LuxuryModule`. Also, we changed the route configuration for the `luxury` path, which now looks like this:

```
{path: 'luxury', loadChildren: 'app/components/luxury/luxury.lazy.module'}
```

Instead of mapping the `path` to a component, we use the `loadChildren` property, providing the path to the module to be loaded. Note that the value of `loadChildren` isn't a typed module name, but a string. Our root module doesn't know about the `LuxuryModule` type, but when the user clicks on the Luxury Items link, the module loader will parse this string and load `LuxuryModule` from the luxury.lazy.module.ts file, which looks a little different than the version presented in the previous section.

```
import { NgModule }      from '@angular/core';
import { CommonModule } from '@angular/common';
import {RouterModule} from '@angular/router';
import {LuxuryComponent} from "./luxury.component";

@NgModule({
    imports:      [ CommonModule,
        RouterModule.forChild([
        {path: '', component: LuxuryComponent}
    ]) ],
    declarations: [ LuxuryComponent ]
})

export default class LuxuryModule { }
```

Here we configured an empty path to be used as a default route.

Because this module will be lazy loaded, and we didn't declare the `LuxuryModule` type in the root module, we have to use the `default` keyword while exporting this class. When the user clicks on the Luxury Items link in the root module, the loader will load the content of the luxury.lazy.module.ts file and will figure out that `LuxuryModule` is a default entry point to the script from this file.

Now if you run the main-luxury-lazy application with the Developer Tools panel open to the Network tab, you won't see the luxury module in the list of downloaded files. Click on the Luxury Items link, and you'll see that the browser makes an additional request to the server to download `LuxuryModule` and `LuxuryComponent`.

In our super-simple example we reduced the size of the initial download only by 1 KB. But architecting large applications using lazy-loading techniques can lower the initial size of the downloadable code by hundreds of kilobytes or more, improving the perceived performance of your application. Perceived performance is what the user *thinks* of the performance of your application, and improving it is important, especially when the app is being loaded from a mobile device on a slow network.

3.8 Hands-on: Adding navigation to the online auction

This hands-on exercise starts where we left off in chapter 2. So far, we have just the home page of the auction (see figure 2.3), and the goal of this project is to add navigation so the user can click on the product name, which should replace the view that shows the carousel and product thumbnails with a `ProductItemComponent` view.

You won't see the final version of the Product Details view in this chapter. Even though the code from chapter 2 has `ProductService` with all the product details, we'll use it in chapter 4 to illustrate dependency injection. Figure 3.16 shows what our online auction will look like in this chapter, after the user clicks the First Product title on the home page.

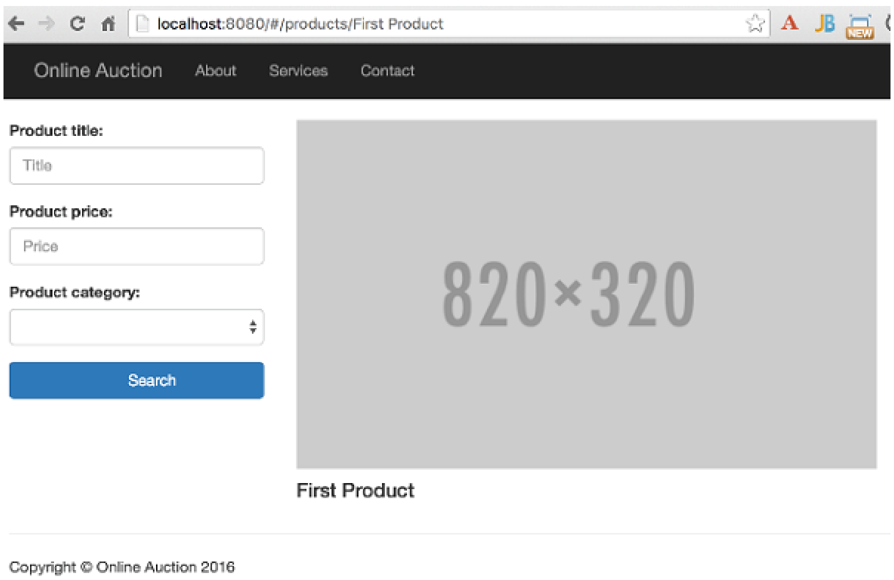


Figure 3.16 Navigating the Product Details route

In this hands-on section you'll need to perform the following steps:

1. Create a `ProductDetailComponent` that displays only the product title.
2. Refactor the code to introduce a `HomeComponent` that encapsulates the carousel and a grid with product items
3. Configure the route for the `products` path that takes a product title. This route has to navigate to `ProductDetailComponent`, which will receive the product title via the `ActivatedRoute` object.
4. Modify the `ApplicationComponent` code to render either `HomeComponent` or `ProductDetailComponent` depending on the selected route.
5. Add the `<route-outlet>` to the main application to render either `HomeComponent` or `ProductDetailComponent`.
6. Add a link with `[routerLink]` to the template of `ProductItemComponent` so when the user clicks on the product's title, the application will navigate to the Product Details route.

> **NOTE** **How to run the online auction**
> If you prefer skip ahead to see the final version of this project in action, open the command window in the auction folder and run `npm install` followed by `npm start`. Otherwise, copy the auction folder from chapter 2 to a separate location, and follow the instructions in the next subsections.

3.8.1 Creating ProductDetailComponent

Create a new app/components/product-detail folder and add a product-detail.ts file to that folder with the following content:

```
import {Component} from '@angular/core';
import {ActivatedRoute} from '@angular/router';

@Component({
  selector: 'auction-product-page',
  template: `
    <div>
      <img src="http://placehold.it/820x320">
      <h4>{{productTitle}}</h4>
    </div>
  `
})
export default class ProductDetailComponent {
  productTitle: string;

  constructor(route: ActivatedRoute){
    this.productTitle = route.snapshot.params['prodTitle'];
  }
}
```

3.8.2 Creating HomeComponent and code refactoring

In chapter 2 we created a main page for the auction that simply contained a number of components. You’ll need to refactor the code so the new version of the main page will use routing. We’ll define an area with the tag `<router-outlet>` where we’ll display either `HomeComponent` or `ProductDetailComponent`. `HomeComponent` will encapsulate the existing `CarouselComponent` and a grid with `ProductItemComponents`.

1. Create a new app/components/home folder, and in it add a home.ts file with the following content:

```
import {Component} from '@angular/core';

@Component({
  selector: 'auction-home-page',
  styleUrls: ['/home.css'],
  template: `
    <div class="row carousel-holder">
      <div class="col-md-12">
        <auction-carousel></auction-carousel>
      </div>
    </div>
    <div class="row">
```

```
      <div *ngFor="let product of products" class="col-sm-4 col-lg-4 col-md-4">
        <auction-product-item [product]="product"></auction-product-item>
      </div>
    </div>
  `
})
export default class HomeComponent {
  products: Product[] = [];

  constructor(private productService: ProductService) {
    this.products = this.productService.getProducts();
  }
}
```

Angular injects into this component the `ProductService`, and the provider for this service is declared in `AppModule`. You'll learn about providers in the next chapter.

In chapter 2 the preceding code was located in the application.ts file, but we want to encapsulate this code inside `HomeComponent`, and we'll configure a route for it in `AppModule`. In the next step, we'll remove the corresponding code from application.ts.

If you see styles that are not explicitly defined in the code, they come from the CSS that comes with the Bootstrap library. You can customize them as needed.

2. Create the home.css file to specify styles for placing the Bootstrap carousel component inside `HomeComponent`:

```
.slide-image {
    width: 100%;
}

.carousel-holder {
    margin-bottom: 30px;
}

.carousel-control,.item {
    border-radius: 4px;
}
```

3.8.3 Simplifying ApplicationComponent

Now that we've encapsulated a large portion of the code inside `HomeComponent`, the code of `ApplicationComponent` will become shorter.

1. Replace the content of the application.ts file with the following code:

```
import {Component, ViewEncapsulation} from '@angular/core';

@Component({
  selector: 'auction-application',
  templateUrl: 'app/components/application/application.html',
  styleUrls: ['app/components/application/application.css'],
  encapsulation:ViewEncapsulation.None
})
export default class ApplicationComponent {}
```

In the `templateUrl` and `styleUrls` properties, we use the full path to the HTML and CSS files. In chapter 10 in the section "Using relative paths in templates", you'll learn how to use a relative path while specifying HTML and CSS files.

In a book it's easier to describe shorter code snippets, so we'll place the markup of `ApplicationComponent` into a separate application.html file.

2. Modify the content of application.html to look like this:

```
<auction-navbar></auction-navbar>

<div class="container">
  <div class="row">
    <div class="col-md-3">
      <auction-search></auction-search>
    </div>

    <div class="col-md-9">
      <router-outlet></router-outlet>
    </div>
  </div>
</div>

<auction-footer></auction-footer>
```

The main change here is the replacement of the carousel and product item components with the tag `<router-outlet>`. When the router renders `HomeComponent`, the carousel and product item components will be rendered as well.

The top portion of the Auction window is taken up by the navigation bar, the bottom portion is the footer, and the area in the middle is split into two sections: the search component and the router outlet. According to Bootstrap's grid system, the entire width of our window is divided into 12 equal columns. We allocate 3 of them to `<auction-search>`, and 9 will go to `<router-outlet>`. In other words, 25% of the screen width is allocated for the search, and 75% is for the routes. We'll implement search in chapter 7, which covers working with forms.

3.8.4 Adding a RouterLink to ProductItemComponent

Our `HomeComponent` includes multiple instances of `ProductItemComponent`. Each of them should have a `routerLink` to navigate to the `ProductDetailComponent` passing the product title as a parameter.

1. Modify the code of the product-item.ts file to reference a CSS file, as shown here.

```
import {Component, Input} from '@angular/core';
import {Product} from '../../services/product-service';

@Component({
  selector: 'auction-product-item',
  styleUrls: ['app/components/product-item/product-item.css'],
  templateUrl: 'app/components/product-item/product-item.html',
})
export default class ProductItemComponent {
  @Input() product: Product;
}
```

The product-item.html file needs an anchor tag with the `routerLink` directive, which should navigate to the route mapped to the path `products/:prodTitle`. We'll configure it in `AppModule` a bit later.

2. Modify the content of product-item.html to look like this:

```
<div class="thumbnail">
  <img src="http://placehold.it/320x150">
  <div class="caption">
    <h4 class="pull-right">{{ product.price | currency }}</h4>
```

```
    <h4><a [routerLink]="['/products', product.title]">{{ product.title }}</a></h4>
    <p>{{ product.description }}</p>
  </div>
  <div class="ratings">
    <auction-stars [rating]="product.rating"></auction-stars>
  </div>
</div>
```

In the preceding code we use the `currency` pipe (a pipe is specified after the vertical bar) for formatting the product price. If this pipe doesn't work in your browser, read the workaround in the "Pipes" section in chapter 5.

3. Create a product-item.css file with the following content:

```
.caption {
  height: 130px;
  overflow: hidden;
}

.caption h4 { white-space: nowrap;}

.thumbnail { padding: 0;}

.thumbnail img { width: 100%;}

.thumbnail .caption-full {
  padding: 9px;
  color: #333;
}

.ratings {
  color: #d17581;
  padding-left: 10px;
  padding-right: 10px;
}
```

3.8.5 Modifying the root module to add routing

Finally, we need to update the app.module.ts file to add the `RouterModule` and location strategy, and to configure routes. Modify the content of app.module.ts to look like this:

```
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { RouterModule } from '@angular/router';
import {LocationStrategy, HashLocationStrategy} from '@angular/common';
import ApplicationComponent from './components/application/application';
import CarouselComponent from "./components/carousel/carousel";
import FooterComponent from "./components/footer/footer";
import NavbarComponent from "./components/navbar/navbar";
import ProductItemComponent from "./components/product-item/product-item";
import SearchComponent from "./components/search/search";
import StarsComponent from "./components/stars/stars";
import {ProductService} from "./services/product-service";
import HomeComponent from "./components/home/home";
import ProductDetailComponent from "./components/product-detail/product-detail";

@NgModule({
    imports:      [ BrowserModule,
                    RouterModule.forRoot([
                        {path: '',                    component: HomeComponent},
                        {path: 'products/:prodTitle', component: ProductDetailComponent}
    ]) ],
    declarations: [ ApplicationComponent,CarouselComponent,
                    FooterComponent, NavbarComponent,
```

```
                    HomeComponent, ProductDetailComponent,
                    ProductItemComponent,SearchComponent,StarsComponent],
    providers:    [ProductService,
                   {provide: LocationStrategy, useClass: HashLocationStrategy}],
    bootstrap:    [ ApplicationComponent ]
})
export class AppModule { }
```

Here we configure two routes: the base URL (the empty `path`) will navigate to `HomeComponent`, and the `products/:prodTitle path` is for rendering `ProductDetailComponent`, which will get the value of the product title as a parameter. The value for `prodTitle` will be provided in `ProductItemComponent`, where the `routerLink` was defined.

3.8.6 Running the auction

Switch to the auction_ directory in the command window, and start the server by entering `npm start` (the start script is configured in package.json, as explained in chapter 2). The browser will open the home page of the auction, which looks the same as in chapter 2. Now click on the title of any product, and you should see its simplified Product Details page as shown in figure 3.16. In chapter 4 we'll inject additional product details into this view.

SIDEBAR **Applying the spread operator**

As your application grows, the number of components that you declare in `AppModule` can make your code less readable. Using the ES6 spread operator (discussed in appendix A) may help. Consider creating a separate file where you list all your components, like this:

```
export const myComponents = [
    ApplicationComponent,
    CarouselComponent,
    FooterComponent,
    NavbarComponent,
    HomeComponent,
    ProductDetailComponent,
    ProductItemComponent,
    SearchComponent,
    StarsComponent];
```

Then your `@NgModule` decorator can use the spread operator as follows:

```
@NgModule({
    // other code goes here

    declarations: [ ...myComponents],

    // other code goes here
})
```

3.9 Summary

In this chapter you've learned how to implement navigation in a SPA using the Angular router. These are the main takeaways from this chapter:

- Configure routes for your application using `RouterModule`.
- By selecting a location strategy, you can control what the URL of each view looks like.
- While navigating an application, the router renders the underlying component in the content area defined by the `<router-outlet>` tags. There could be one or more such areas.
- To navigate to the route, add anchor tags to your application. The anchor tags should use the `routerLink` property instead of the `href` attribute. You can pass parameters to the route at this point.
- To minimize the initial size of your app, see if some of the modules can be loaded later on demand by implementing lazy-loading techniques.

4 Dependency injection

This chapter covers

- Introducing Dependency Injection (DI) as a design pattern
- Benefits of DI
- How Angular implements DI
- Registering object providers and the using injectors
- The hierarchy of injectors
- Applying DI in the online auction application

In the previous chapter we discussed the router, and now our online auction application knows how navigate from the Home view to an almost empty Product Details view. In this chapter we'll continue working on our online auction, but this time we'll concentrate on how to use Angular to automate the process of creating objects and assembling the application from its building blocks.

Any Angular application is a collection of components, directives, and classes that may depend on each other. Although each component can explicitly instantiate its dependencies, Angular can do this job using its Dependency Injection mechanism.

We'll start this chapter by identifying the problem that DI solves and reviewing the benefits of DI as a software engineering design pattern. Then we'll go over the specifics of how Angular implements the DI pattern using an example `ProductComponent` that depends on a `ProductService`. You'll see how to write an injectable service and how to inject it into another component.

Then you'll see a sample application that demonstrates how Angular DI allows you to easily replace one component dependency with another by changing just one line of code. After that we'll introduce a more advanced concept—a hierarchy of injectors.

At the end of the chapter we'll go through a hands-on exercise to build the next version of the online auction that uses the techniques covered in the chapter.

4.1 The Dependency Injection and Inversion of Control patterns

Design patterns are recommendations on how to solve certain common tasks. A given design pattern can be implemented differently depending on the software you use. In this section we'll briefly introduce two design patterns: Dependency Injection (DI) and Inversion of Control (IoC).

4.1.1 The Dependency Injection pattern

If you've ever written a function that takes an object as an argument, you could say that you wrote a program that instantiates this object and *injects* it into the function.

Imagine a fulfillment center that ships products. An application that keeps track of shipped products can create a product object and invoke a function that creates and saves a shipment record:

```
var product = new Product();
createShipment(product);
```

The `createShipment()` function depends on the existence of an instance of the `Product` object. In other words, the `createShipment()` function has a dependency: `Product`. But the function itself doesn't know how to create `Product`. The calling script should somehow create and give (think *inject*) this object as an argument to the function.

Technically, we're decoupling the creation of the `Product` object from its use, but both of the preceding lines of code are located in the same script, so it's not a real decoupling. If we need to replace a `Product` with `MockProduct`, it's a small code change in our simple example.

What if the `createShipment()` function had three dependencies (such as product, shipping company, and fulfillment center) and each of these dependencies had its own dependencies? Now creating a different set of objects for `createShipment()` would require many more manual code changes. Would it be possible to ask someone to create instances of dependencies (with their dependencies) for us?

This is what the Dependency Injection pattern is about: if object A depends on an object of type B, object A won't explicitly instantiate object B (as we did with the `new` operator above). Rather, it will get B *injected* from the operational environment. Object A just needs to declare, "I need an object of type B; could someone please give it to me?" The words *of type* are important here. Object A doesn't request a specific implementation of the object and will be happy as long as the injected object is of type B.

4.1.2 The Inversion of Control pattern

Inversion of Control (IoC) is a more general pattern than DI. Rather than making your application use some API from a framework (or a software container), the framework will create and supply the objects that the application needs. The IoC pattern can be implemented in different ways, and DI is one of the ways of providing the required objects. Angular plays the role of the IoC container and can provide the required objects, according to your component's declarations.

4.1.3 Benefits of Dependency Injection

Before we explore the syntax of Angular's implementation of DI, let's look at the benefits of getting objects injected vs. instantiating them with a `new` operator.

Angular offers a mechanism that helps with registering and instantiating component dependencies. In short, DI helps you write code in a loosely coupled way and makes your code more testable and reusable.

LOOSE COUPLING AND REUSABILITY

Say you have a `ProductComponent` that gets product details using the `ProductService` class. Without DI, your `ProductComponent` needs to know how to instantiate the `ProductService` class. It can be done in multiple ways, such as using `new`, calling `getInstance()` on a singleton object, or maybe invoking `createProductService()` on some factory class. In any case, `ProductComponent` becomes *tightly coupled* with `ProductService`.

If you need to reuse the `ProductComponent` in another application that uses a different service for getting product details, you'd need to modify the code (for example, `productService = new AnotherProductService()`). DI allows you to decouple application components by sparing them from the need to know how to create their dependencies.

Consider the following `ProductComponent` sample:

```
@Component({
  providers: [ProductService]
})
class ProductComponent {
  product: Product;

  constructor(productService: ProductService) {

    this.product = productService.getProduct();
  }
}
```

In Angular applications, we register objects for DI by specifying providers. A *provider* is an instruction to Angular on *how* to create an instance of an object for future injection into a target component or directive. In the preceding code snippet, the line `providers:[ProductService]` is shorthand for `providers:[{provide:ProductService, useClass:ProductService}]`.

NOTE	**Component-level providers** You already had a chance to see the `providers` property in chapter 3, but it was defined not on the component but on the module level.

Angular uses the concept of a *token*, which is an arbitrary name representing an object to be injected. Usually the token's name matches the type of the object to be injected, so in the preceding code snippet we're instructing Angular to provide a `ProductService` token using the class of the same name. Using an object with the property `provide`, you can map the same token to different values or objects (such as to emulate the functionality of the `ProductService` while someone else is developing a real service class).

NOTE	**Declaring tokens** In section 4.4.1 you'll see how to declare a token with an arbitrary name.

Now that we've added the `providers` property to the `@Component` annotation of the `ProductComponent`, Angular's DI module will know that it has to instantiate an object *of type* `ProductService`.

The `ProductComponent` doesn't need to know which concrete implementation of the `ProductService` type to use—it'll use whatever object is specified as a provider. The reference to the `ProductService` object will be injected via the constructor's argument, and there's no need to explicitly instantiate `ProductService` inside `ProductComponent`. Just use it as in the preceding code, which calls the service method `getProduct()` on the `ProductService` instance magically created by Angular.

If you need to reuse the same `ProductComponent` in a different application with a different implementation of the type `ProductService`, change the `providers` line, as in the following example:

```
providers: [{provide: ProductService, useClass: AnotherProductService}]
```

Now Angular will instantiate `AnotherProductService`, but your code that was using the type `ProductService` won't break. In this example, using DI increases the reusability of `ProductComponent` and eliminates its tight coupling with `ProductService`. If one object is tightly coupled with another, this may require substantial code modifications should you want to reuse just one of them in another application.

TESTABILITY

DI increases the testability of your components in isolation. You can easily inject mock objects if their real implementations aren't available or you want to unit-test your code.

Say you need to add a login feature to your application. You can create a `LoginComponent` (it would render ID and password fields) that uses a `LoginService` component, which should connect to a certain authorization server and check the user's privileges. The authorization server has to be provided by a different department, but it's not ready yet. You finished coding the `LoginComponent`, but you can't test it for reasons that are out of your control, such as a dependency on another component developed by someone else.

In testing, we often use mock objects that mimic the behavior of real objects. With a DI framework you can create a mock object, `MockLoginService`, that doesn't actually connect to an authorization server but rather has hard-coded access privileges assigned to the users with certain ID/password combinations. Using DI, you can write a single line that injects the `MockLoginService` into your application's Login view without needing to wait until the authorization server is ready. Later on, when that server is ready, you can modify the `providers` line so Angular will inject the real `LoginService` component, as shown in figure 4.1.

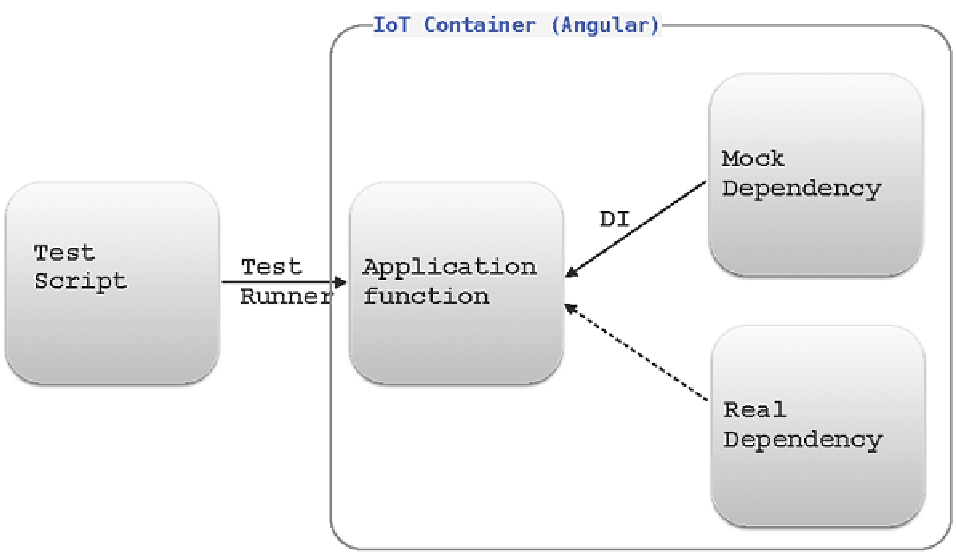


Figure 4.1 DI in testing

NOTE	**Unit-testing injectable services** In the hands-on section of chapter 9, you'll see how to unit-test injectable services.

4.2 Injectors and providers

Now that you've had a brief introduction to Dependency Injection as a general software engineering design pattern, let's go over the specifics of implementing DI in Angular. In particular, we'll go over such concepts as injectors and providers.

Each component can have an `Injector` instance capable of injecting objects or primitive values into a component or service. Any Angular application has a root injector available to all its modules. To let the injector know *what* to inject, you specify the provider. An injector will inject the object or value specified in the provider into the constructor of a component.

NOTE	**Lazy-loaded modules and injectors** Although eagerly loaded modules don't have their own injectors, a lazy-loaded module has its own sub-root injector that's a direct child of the application root injector.

NOTE	**Injection and constructors** In Angular you can inject data only via a constructor's arguments. If you see a class with a no-argument constructor, it's a guarantee that nothing is injected into this component.

Providers allow you to map a custom type (or a token) to a concrete implementation of this type (or value). You can specify the provider(s) either inside the component's `@Component` decorator or as a property of `@NgModule`, as we did in every code sample so far.

We'll be using `ProductComponent` and `ProductService` for all the code samples in this chapter. If your application has a class implementing a particular type (such as `ProductService`), you can specify a provider object for this class during the `AppModule` bootstrap, like this:

```
@NgModule({
  ...
  providers: [{provide:ProductService,useClass:ProductService}]
})
```

When the token name is the same as the class name, you can use the shorter notation to specify the provider in the module:

```
@NgModule({
  ...
  providers: [ProductService]
})
```

The `providers` property can be specified inside the `@Component` annotation. The short notation of the `ProductService` provider inside `@Component` will look like this:

```
providers:[ProductService]
```

No instance of the `ProductService` is created at this point. The `providers` line instructs the injector as follows: “When you need to construct an object that has an argument of type `ProductService`, create an instance of the registered class for injection into this object”.

> **NOTE** **The `viewProviders` property**
> Angular also has the `viewProviders` property, which is used when you don’t want the child components to use providers declared in the parent. You’ll see an example of using `viewProviders` in section 4.5.

If you need to inject a different implementation of a particular type, use the longer notation:

```
@NgModule({
  ...
  providers: [{provide:ProductService,useClass:MockProductService}]
})
```

Or, on the component level…

```
@Component({
   ...
   providers: [{provide:ProductService, useClass:MockProductService}]
})
```

Here we’re giving the following instruction to the injector: “When you need to inject an object of type `ProductService` into a component, create an instance of the class `MockProductService`”.

Thanks to the provider, the injector knows *what* to inject, and now we need to specify *where* to inject the object. In TypeScript it comes down to declaring a constructor argument specifying its type.

The following line shows how to inject an object of type `ProductService` into the constructor of some component.

```
constructor(productService: ProductService)
```

SIDEBAR

Injection with TypeScript vs. ES6

TypeScript simplifies the syntax of injection into a component as it doesn't require using any DI annotations with the constructor arguments. All you need to do is specify the type of the constructor's argument:

```
constructor(productService: ProductService)
```

This works because any component has an annotation `@Component`, and because the TypeScript compiler is configured with the option `"emitDecoratorMetadata": true`, Angular will automatically generate all required metadata for the object to be injected.

Because we use SystemJS for on-the-fly TypeScript transpiling, we can add the following TypeScript compiler option in systemjs.config.js:

```
typescriptOptions: {
  "emitDecoratorMetadata": true
}
```

If you're writing the class in ES6, add the `@Inject` annotation with an explicit type to the constructor's arguments:

```
constructor(@Inject(ProductService) productService)
```

The constructor will remain the same regardless of which concrete implementation of `ProductService` was specified as a provider. Figure 4.2 shows a sample sequence diagram of the injection process.

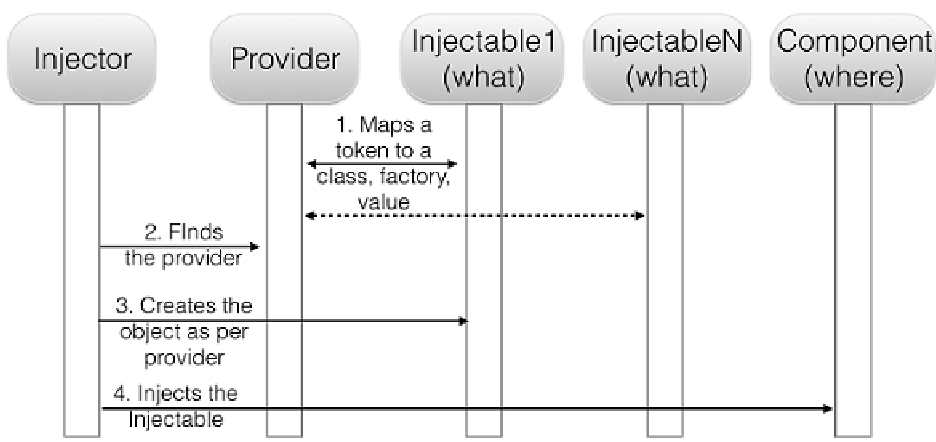


Figure 4.2 Injecting in time

4.2.1 How to declare a provider

You can declare custom providers as an array of objects that contain a `provide` property. Such an array can be specified in the `providers` property of the module or on the component level.

Here's an example of a single-element array that specifies the provider object for the `ProductService` token:

```
[{provide:ProductService, useClass:MockProductService}]
```

The `provide` property maps the token to the method of instantiating the injectable object. In the preceding example we instruct Angular to create an instance of the `MockProductService` class wherever the `ProductService` token is used as a dependency. But the object creator (Angular's injector) can use a class, a factory function, a string, or a special `OpaqueToken` class for instantiation and injection.

- To map a token to an implementation of a class, use the object with the `useClass` property, as shown in the preceding example.
- If you have a factory function that instantiates objects based on certain criteria, use an object with the `useFactory` property, which specifies a factory function (or a fat arrow expression) that knows how to instantiate required objects. The factory function can have an optional argument with dependencies, if any.
- To provide a `string` with a simple injectable value (such as the URL of a service) use the object with the `useValue` property.

In the next section we'll use the `useClass` property while reviewing a basic application. Section 4.4 will illustrate `useFactory` and `useValue`.

4.3 A sample application with Angular DI

Now that you've seen a number of code snippets related to Angular DI, we'll build a small application that will bring all the pieces together. We want to prepare you for using DI in the online auction application.

4.3.1 Injecting a product service

Let's create a simple application that will use a `ProductComponent` to render product details, and a `ProductService` to supply the data about the product. If you use the downloadable code that comes with the book, this app is located in the main-basic.ts file in di_samples directory. In this section we'll build an application that will produce the page shown in figure 4.3.

Basic Dependency Injection Sample

Product Details

Title: iPhone 7

Description: The latest iPhone, 7-inch screen

Price: $249.99

Figure 4.3 A sample DI application

The `ProductComponent` can request the injection of the `ProductService` object by declaring the constructor argument with a type:

```
constructor(productService: ProductService)
```

Figure 4.4 illustrates a sample application that uses these components.

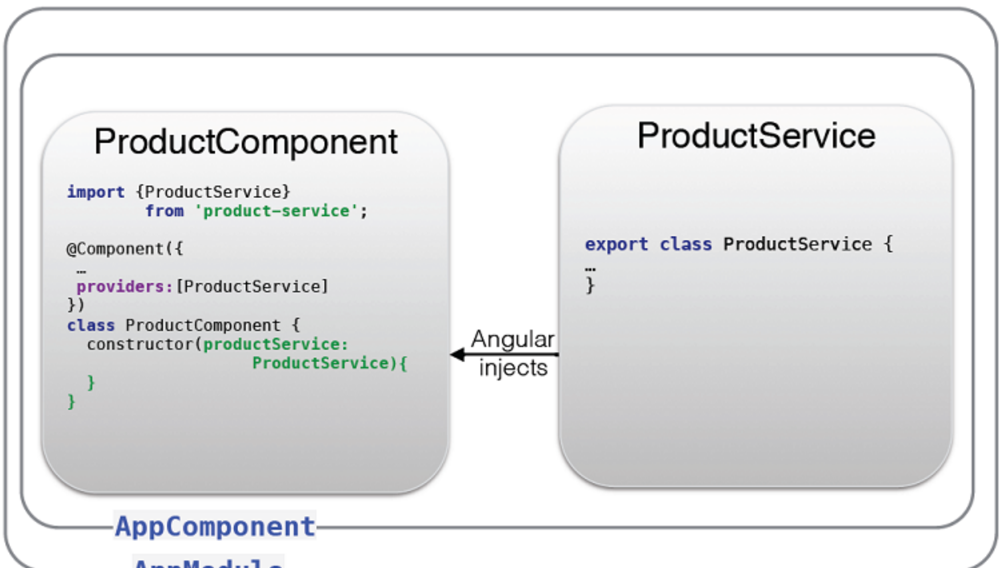


Figure 4.4 Injecting ProductService into ProductComponent

`AppModule` bootstraps `AppComponent`, which includes `ProductComponent`, which is dependent on `ProductService`.

Note the `import` and `export` statements. The class definition of `ProductService` starts with the `export` statement to enable other components to access its content. The `ProductComponent` includes the `import` statement providing the name of the class (`ProductService`) and the module being imported (located in the file product-service.ts).

The `providers` attribute defined on the component level instructs Angular to provide an instance of the `ProductService` class when requested.

The `ProductService` may communicate with some server, requesting details for the product selected on the web page, but we'll skip this part for now and concentrate on how this service can be injected into `ProductComponent`. Let's implement the components from figure 4.4.

Besides index.html, we'll be creating the following files:

- The file main-basic.ts will contain the code to load the `AppModule`, which includes `AppComponent`, which hosts `ProductComponent`.
- `ProductComponent` will be implemented in the product.ts file.
- `ProductService` will be implemented in a single product-service.ts file.

Each of these is pretty simple.

The main-basic.ts file contains the code of the module and root component, which hosts the `ProductComponent` child component. The module has to import and declare `ProductComponent`.

```
import {Component} from '@angular/core';
import ProductComponent from './components/product';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

@Component({
    selector: 'app',
    template: `<h1> Basic Dependency Injection Sample</h1>
             <di-product-page></di-product-page>`
})
class AppComponent {}

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

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

Based on the tag `<di-product-page>`, it's easy to guess that there's a component with the selector having this value. This selector is declared in `ProductComponent`, which will get its dependency (`ProductService`) injected via the constructor:

```
import {Component, bind} from '@angular/core';
import {ProductService, Product} from "../services/product-service";

@Component({
  selector: 'di-product-page',
  template: `<div>
  <h1>Product Details</h1>
  <h2>Title: {{product.title}}</h2>
  <h2>Description: {{product.description}}</h2>
  <h2>Price: \${{product.price}}</h2>
</div>`,

  providers:[ProductService]
})
```

```
export default class ProductComponent {
  product: Product;

  constructor( productService: ProductService) {   ❷

    this.product = productService.getProduct();
  }
}
```

❶ The short notation of the providers property tells the injector to instantiate the class ProductService.

❷ Angular instantiates ProductService and injects it here.

In this example, the name of the type is the same as the name of the class—`ProductService`—so we use a short notation without the need to explicitly map the `provide` and `useClass` properties.

While specifying providers, we separate the name (a token) of the injectable object from its implementation. In this case, the name of the token is the same as the name of the type: `ProductService`. The actual implementation of this service can be located in a class called `ProductService`, `OtherProductService`, or something else. Replacing one implementation with another comes down to changing the `providers` line.

The constructor of `ProductComponent` invokes `getProduct()` on the service and places a reference to the returned `Product` object into the `product` class variable, which is used in the HTML template.

By using double curly braces, the preceding markup allows us to bind the properties `title`, `description`, and `price` of the class `Product`. The product-service.ts file includes the declaration of two classes: `Product` and `ProductService`.

```
export class Product {   ❶
  constructor(
    public id: number,
    public title: string,
    public price: number,
    public description: string) {
  }
}

export class ProductService {

  getProduct(): Product {   ❷
    return new Product(0, "iPhone 7", 249.99, "The latest iPhone, 7-inch screen");
  }
}
```

❶ The Product class represents a product (a value object). It's used outside of this script, so we export it.

❷

For simplicity, the getProduct() method always returns the same product with hard-coded values.

In real-world applications, the `getProduct()` method would have to get the product information from some external data source, such as by making an HTTP request to a remote server.

To run this example, open a command window in the project folder and execute the command `npm start`. The live-server will open the window as shown earlier in figure 4.3.

The instance of `ProductService` was injected into `ProductComponent`, which rendered product details provided by the server.

In the next section you'll see a `ProductService` decorated with the `@Injectable` annotation, which can be used for generating DI metadata when the service itself has dependencies, as shown in the next section. The `@Injectable` annotation isn't needed here because our `ProductService` doesn't get any other service injected into it, and Angular doesn't need any additional metadata to inject `ProductService` into components.

4.3.2 Injecting the Http service

Often a service will need to make an HTTP request to get the requested data. The `ProductComponent` depends on `ProductService`, which will be injected using the Angular DI mechanism. If `ProductService` needs to make an HTTP request, it'll have an `Http` object as its own dependency. The `ProductService` will need to import the `Http` object for injection; the `@NgModule` has to import `HttpModule`, which defines `Http` providers. The `ProductService` class should have a constructor for injecting the `Http` object. Figure 4.5 shows `ProductComponent` depending on `ProductService`, which has its own dependency: `Http`.

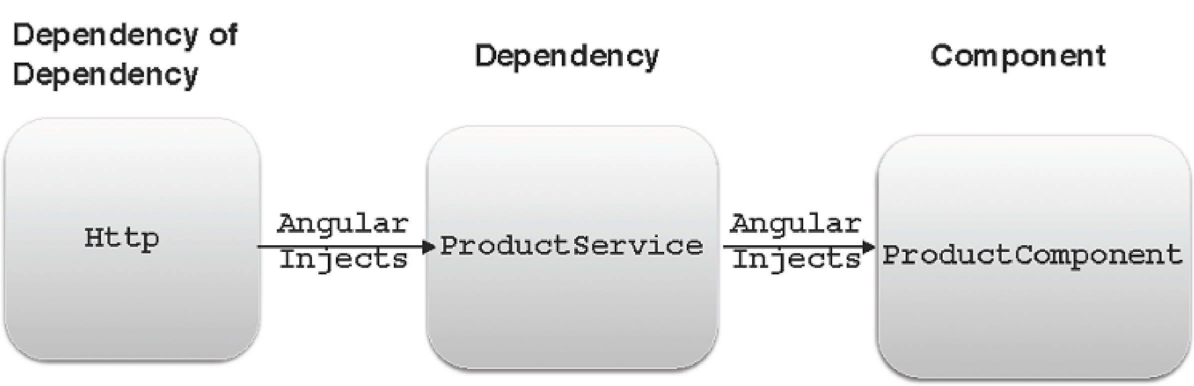


Figure 4.5 A dependency can have its own dependency

The following code snippet illustrates the `Http` object's injection into

`ProductService` and the retrieval of products from the products.json file:

```
import {Http} from '@angular/http';
import {Injectable} from "@angular/core";

@Injectable()
export class ProductService {
    constructor(private http:Http){
      let products = http.get('products.json');
    }
   // other app code goes here
}
```

The class constructor is the injection point, but where do we declare the provider for injecting the `Http` type object? All the providers required to inject various flavors of `Http` objects are declared in the `HttpModule`. You just need to add it to your `AppModule`, like this:

```
import { HttpModule} from '@angular/http';
...
@NgModule({
  imports: [
    BrowserModule,
    HttpModule
  ],
  declarations: [ AppComponent ],
  bootstrap: [ AppComponent ]
})
export class AppModule { }
```

NOTE	**Injecting a dependency into a dependency** In chapter 8, in the section “Injecting HTTP into a service”, we’ll write an application illustrating the architecture shown in figure 4.5.

Now that you’ve seen how to inject an object into a component, let’s see what it takes to replace one implementation of the service with another using Angular DI.

4.4 Switching injectables made easy

Earlier in this chapter, we stated that the DI pattern allows you to decouple components from their dependencies. In the previous section we decoupled `ProductComponent` from `ProductService`. Now let’s simulate another scenario.

Suppose you’ve started development with a `ProductService` that’s supposed to get data from a remote server, but the server’s feed isn’t ready. Rather than modifying the code in `ProductService` to introduce hard-coded data for testing, we’ll create another class, `MockProductService`.

Moreover, to illustrate how easy it is to switch from one service to another, we’ll create a small application that uses two instances of `ProductComponent`. Initially, the first one will use `MockProductService` and the second `ProductService`. Then, with a one-line change we'll have both of them use the same service. Figure 4.6 shows how the multiple_injectors application will render product components in the browser.

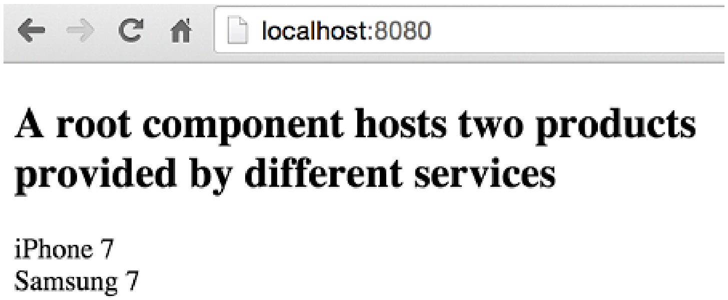


Figure 4.6 Rendering two products

The iPhone 7 product is rendered by `Product1Component`, and Samsung 7 is rendered by `Product2Component`. In this application we'll focus on switching product services using Angular DI, so we'll keep the components and services simple. To this end, the entire TypeScript code will be located in one main.ts file.

IMPORTANT	**A class playing the role of an interface** In appendix B we explain the TypeScript interfaces, which is a useful way to ensure that an object being passed to a function is valid, or that a class implementing an interface sticks to a declared contract. A class can implement an interface using the keyword `implements`, but there's more: in TypeScript all classes can be used as interfaces (though we don't encourage using this feature), so `ClassA` can implement `ClassB`. Even if the code isn't initially written with interfaces, you can still use a concrete class as if it were declared as an interface.

The content of main.ts is shown next. We'd like to draw your attention to the following line:

```
class MockProductService implements ProductService
```

This shows one class "implementing" another as if the latter was declared as an interface.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component } from '@angular/core';
import { BrowserModule } from '@angular/platform-browser'

class Product {
  constructor(public title: string) {}
}

class ProductService {    ❶
```

```
  getProduct(): Product {
    // Code making an HTTP request to get actual product details
    // would go here
    return new Product('iPhone 7');
  }
}

class MockProductService implements ProductService {    ❷
  getProduct(): Product {
    return new Product('Samsung 7');
  }
}

@Component({
  selector: 'product1',
  template: '{{product.title}}'})
class Product1Component {
  product: Product;

  constructor(private productService: ProductService) {    ❸
    this.product = productService.getProduct();
  }
}

@Component({
  selector: 'product2',
  template: '{{product.title}}',
  providers: [{provide:ProductService, useClass:MockProductService}]    ❹
})
class Product2Component {
  product: Product;

  constructor(private productService: ProductService) {    ❺
    this.product = productService.getProduct();
  }
}

@Component({
  selector: 'app',
  template: `
    <h2>A root component hosts two products<br> provided by different services</h2>
    <product1></product1>
    <br>
    <product2></product2>
  `
})
class AppComponent {}    ❻

@NgModule({
  imports:      [ BrowserModule],
  providers:    [ProductService],    ❼
  declarations: [ AppComponent, Product1Component, Product2Component],
  bootstrap:    [ AppComponent ]
})
class AppModule { }

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

❶ Initially we developed ProductService as a class.

❷ Then we introduced another service, MockProductService, that implements ProductService as an interface.

❸

3. The constructor of ProductComponent1 gets the instance of ProductService injected.
4. Declares a specific implementation of ProductService in the second component.
5. There's no need to change the constructor. ProductComponent2 will get MockProductService because its provider was specified at the component level.
6. AppComponent renders two child components, and each of them uses a different instance of ProductService.
7. Registers a provider with an application-level injector.

If a component doesn't need a specific `ProductService` implementation, there's no need to explicitly declare a provider for each component, as long as a provider was specified at the parent's level. In the preceding example, `Product1Component` doesn't declare its own providers, so Angular will find one on the application level. But each component is free to override the `providers` declaration made on the app or parent component level, as we did in `Product2Component`.

`ProductService` becomes a common token that both of our product components understand. `Product2Component` declares an explicit provider, which maps `MockProductService` to the common `ProductService` custom type. This component-level provider will override the parent's one.

If you decide that `Product1Component` should use the `MockProductService` as well, just add the `providers` line to its `@Component` annotation, as was done in `Product2Component`.

Running the preceding application will render product components in the browser, as shown earlier in figure 4.6.

This all is good, but suppose we've been notified by another team that the `ProductService` class (used as the app-level provider) won't be available for some time. How can we switch to using `MockProductService` exclusively for some time?

This requires a one-line change. Replacing the `providers` line in the module declaration will do the trick:

```
@NgModule({
...
providers: [{provide:ProductService, useClass:MockProductService}]
...
})
```

From now on, wherever the type `ProductService` needs to be injected and no `providers` is specified on the component level, Angular will instantiate and inject `MockProductService`. Running the application after making the preceding change will render our components as shown in figure 4.7.

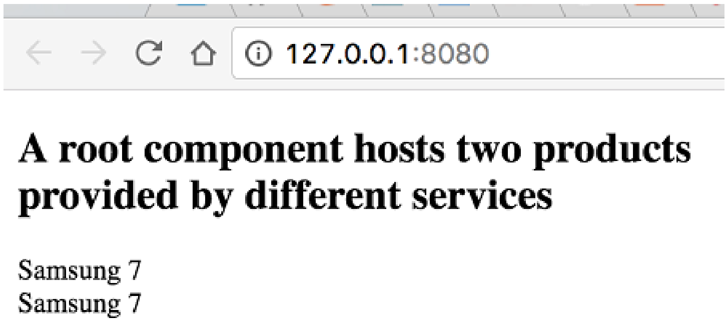


Figure 4.7 Rendering two products with MockProductService

Imagine that your application had dozens of components that were using `ProductService`. If each of them instantiated this service with a `new` operator or some factory class, you'd need to make dozens of code changes. With Angular DI, we were able to switch the service by changing one line in the `providers` declaration.

> **NOTE** **JavaScript hoisting and classes**
> Class declarations aren't hoisted (hoisting is explained in Appendix A). Typically, each class is declared in a separate file, and their declarations are imported on top of the script so all class declarations are available upfront. But if multiple classes are declared in one file, both `ProductService` and `MockProductService` must be declared before the components that use them. If you run into a situation where the objects are declared after the point of injection, consider using the function `forwardRef()` with the annotation `@Inject` (see the Angular documentation for `forwardRef()` at http://mng.bz/31YN).

4.4.1 Declaring providers with useFactory and useValue

Let's look at some examples that illustrate the factory and value providers.

In general, factory functions are used when you need to implement some application logic prior to instantiating an object. For example, you may need to decide which object to instantiate, or your object may have a constructor with arguments and you need to initialize them before creating an instance.

The following code snippet from the main-factory.ts file shows how you can specify a factory function as a provider. This factory function creates either `ProductService` or `MockProductService` based on a `boolean` flag.

```
const IS_DEV_ENVIRONMENT: boolean = true;

@Component({
  selector: 'product2',

  providers:[{
    provide: ProductService,
```

```
    useFactory: (isDev) => {
      if (isDev){
        return new MockProductService();
      } else{
        return new ProductService();
      }
    },
    deps: ["IS_DEV_ENVIRONMENT"]}],

  template: '{{product.title}}'
})
class Product2Component {
  product: Product;

  constructor(productService: ProductService) {
    this.product = productService.getProduct();
  }
}
```

First you declare a token with an arbitrary name (`IS_DEV_ENVIRONMENT` in this case) and set it to `true` to let the program know that you're operating in the development environment (that is, you want to work with the mock product service). The factory uses the arrow expression that will instantiate the `MockProductService`.

The constructor of `Product2Component` has an argument of type `ProductService`, and the service will be injected there. You could use such a factory for `Product1Component` as well, and changing the value of `IS_DEV_ENVIRONMENT` to `false` would inject the instance of `ProductService` into both components.

The preceding code sample isn't the best solution for switching environments, because it reaches out to `IS_DEV_ENVIRONMENT`, which was declared *outside* of the component, breaking the component's encapsulation. We want the component to be self-contained, so let's try to inject the value of `IS_DEV_ENVIRONMENT` into the component, so it doesn't need to reach out to the external code.

Simply declaring a constant (or a variable) isn't enough to make it injectable. We need to register the value of `IS_DEV_ENVIRONMENT` with the injector, using `provide` with `useValue`, which will allow us to use it as an injectable parameter in the arrow expression in the previous example.

NOTE **`useFactory` vs. `useValue`**

Both `useFactory` and `useValue` come from Angular core. `useValue` is a special case of `useFactory`, for when the factory is represented by a single expression and doesn't need any other dependencies.

For an easy switch between development and other environments, we can specify the environment's value provider on the root component level and then our service factory will know which service to construct. The value of the `useFactory` property is a function with two arguments: the factory function itself and its dependencies (`deps`).

NOTE **Using fat arrows**
The next and many other code samples use fat arrow function expressions described in appendix A. In essence, a fat arrow function expression is just a shorter notation for anonymous functions. For example, `(isDev)  {…}` is equivalent to `function(isDev) {…}`.

```
@Component({
  selector: 'product2',

  providers:[{
    provide: ProductService,
    useFactory: (isDev) => {
      if (isDev){
        return new MockProductService();
      } else{
        return new ProductService();
      }
    },   ❶
         deps:["IS_DEV_ENVIRONMENT"]})],   ❷
  template: '{{product.title}}'
 }
class Product2Component {...}
...

@NgModule({
  ...
  providers: [ ProductService,
               {provide: "IS_DEV_ENVIRONMENT", useValue:true}]   ❸
})
```

❶ The factory function has an isDev argument, which is a dependency that will be injected from outside.

❷ The second property, deps, defines the dependency of the factory function (an injectable value of IS_DEV_ENVIRONMENT in this case).

❸ To make the value of IS_DEV_ENVIRONMENT injectable, specify provide with useValue.

Because we injected the value into `IS_DEV_ENVIRONMENT` at the app level, any child component that uses this factory will be affected by a simple switch from `false` to `true`.

To recap, a provider maps the token to a class or a factory to let the injector know how to create objects. The class or factory may have its own dependencies, so the providers should specify all of them. Figure 4.8 illustrates the relationships between the providers and the injector from the previous example.

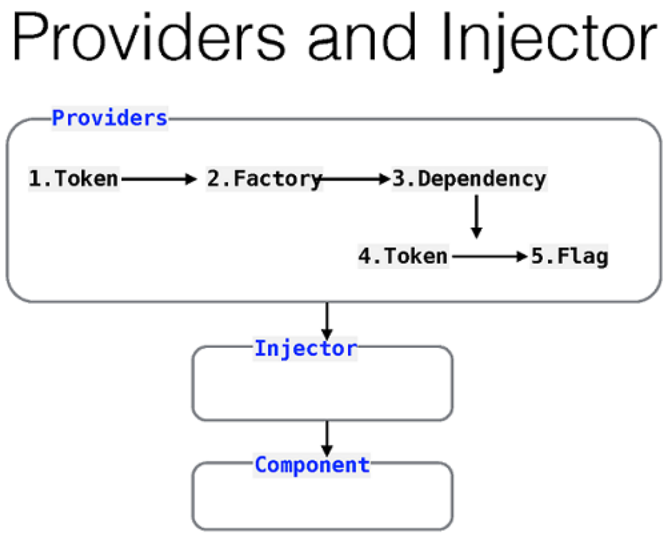


Figure 4.8 Binding a factory with dependencies

NOTE	Typesetter: The following numbered points are annotations to go with the numbered items in the preceding figure. I don't know if they'll work as labels in the figure, but cueballs in the figure with a matching list following it would probably be okay. Your call.

1. The first token is `ProductService`.
2. The factory is defined as an arrow function expression.
3. The factory has a dependency—`IS_DEV_ENVIRONMENT`.
4. The second token is `IS_DEV_ENVIRONMENT`.
5. The second token is mapped to the value `false`.

Angular prepares a tree of providers, finds the injector, and uses it for the `Product2Component` component. Angular will either use the component's injector or will use the parent's one. We'll discuss the hierarchy of injectors next.

4.4.2 Using OpaqueToken

Injecting into a hard-coded string (such as `IS_DEV_ENVIRONMENT`) may cause problems if your application has more than one provider that uses a string with the same value for a different purpose. Angular offers an `OpaqueToken` class that's preferable to using strings as tokens.

Imagine that you want to create a component that can get data from different servers (such as dev, prod, and QA). The following example illustrates how you could introduce an injectable value, `BackendUrl`, as an instance of `OpaqueToken` rather than as a string.

```
import {Component, OpaqueToken, Inject, NgModule} from '@angular/core';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { BrowserModule } from '@angular/platform-browser';

export const BackendUrl  = new OpaqueToken('BackendUrl');
```

```
@Component({
  selector: 'app',
  template: 'URL: {{url}}'
})
class AppComponent {
  constructor(@Inject(BackendUrl) public url: string) {}
}

@NgModule({
  imports:      [ BrowserModule],
  declarations: [ AppComponent],
  providers: [  {provide:BackendUrl, useValue: 'myQAserver.com'}],
  bootstrap:    [ AppComponent ]
})
class AppModule { }

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

You wrap the string “BackendUrl” into an instance of `OpaqueToken`. Then, in the constructor of this component, instead of injecting a vague `string` type, you inject a concrete `BACKEND_URL` type with the value provided in the module declaration.

4.5 The hierarchy of injectors

Any Angular application is a tree of nested components. When the web page loads, Angular creates an application object with its injector. It also creates a hierarchy of components with corresponding injectors, according to the application structure. For example, you may want a certain function to be executed when your application is initialized:

```
{provide:APP_INITIALIZER, useValue: myappInit}
```

The application’s root component hosts other components. If you include, for example, component B in the template of component A, the latter becomes a parent of the former. In other words, a root component is a parent to other child components, which in turn can have their own children.

Consider the following HTML document, which includes a root component represented by the tag `<app>`:

```
<html>
  <body>
    <app></app>
  </body>
</html>
```

From the following code, you can see that `app` is a selector of the `AppComponent`, which is a parent of the `<product1>` and `<product2>` components.

```
@Component({
  selector: 'app',
  template: `
```

```
    <product1></product1>
    <product2></product2>
  `
})
class AppComponent {}
```

The parent component’s injector creates an injector for each child component, so we have a hierarchy of components and a hierarchy of injectors. Also, the template markup of each component can have its own Shadow DOM with elements, and each element gets its own injector. Figure 4.9 shows the hierarchy of injectors.

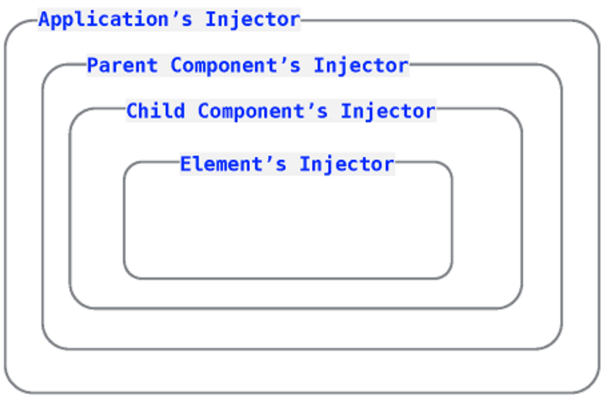


Figure 4.9 The hierarchy of injectors

When your code creates a component that requires a particular object to be injected, Angular looks for a provider of the requested object at the component level. If found, the component’s injector will be used. If it’s not found, Angular will check whether the provider exists on one of the parent components. If the provider for the requested object isn’t found at any level of the injectors hierarchy, Angular will throw an error.

NOTE	**Lazy-loaded modules and injectors** Angular creates an additional injector for a lazy-loaded module. Providers declared in the `@NgModule` of a lazy-loaded module are available inside the module, but not to the entire application.

Our sample application injects only a service, and it doesn’t illustrate the use of element injectors. In the browser, each component instance can be represented by a Shadow DOM, which has one or more elements depending on what’s defined in the component’s `template`. Each of the elements inside the Shadow DOM has an `ElementInjector` that follows the same parent-child hierarchy as the DOM elements themselves.

Say you want to add an autocomplete feature to the HTML `<input>` element component. To do that, you can define a directive as follows:

```
@Directive({
```

```
  selector: '[autocomplete]'
})
class AutoCompleter {
  constructor(element: ElementRef) {
    // Implement the autocomplete logic here
  }
}
```

The square brackets here mean that `autocomplete` can be used as an attribute of the HTML element. The reference to this element will be automatically injected into the constructor of the `AutoCompleter` class by the element injector.

Now take another look at the code from section 4.4. The `Product2Component` class had a provider of `MockProductService` at the component level. The `Product1Component` class didn't specify any providers for the type `ProductService`, so Angular performed the following actions:

- Checked its parent `AppComponent`—no providers there.
- Checked the `AppModule` and found `providers:[ProductService]` there.
- Used the app-level injector and created an instance of the `ProductService` on the app level.

If you remove the `providers` line from `Product2Component` and rerun the application, it'll still work using the app-level injector and the same instance of the `ProductService` for both components. If providers for the same token were specified on both parent and child components, and each of these components had a constructor requesting an object represented by the token, two separate instances of such an object would be created: one for the parent and another for the child.

VIEWPROVIDERS

If you want to ensure that a particular injectable service won't be visible to the component's children or other components, use the `viewProviders` property instead of `providers`. Say you're writing a reusable library that internally uses some service, which you don't want to be visible from the applications that use this library. Using `viewProviders` instead of `providers` will allow you to make such a service private for the library.

Here's another example. Imagine that we have the following hierarchy of components:

```
<root>
  <product2>
     <luxury-product></luxury-product>
  </product2>
</root>
```

Both `AppModule` and `Product2Component` have providers defined using the token

`ProductService`, but `Product2Component` uses a special class that we don't want to be visible by its children. In this case we'd use the `viewProviders` property with the `Product2Component` class, and when the injector of `LuxuryProductComponent` doesn't find a provider, it'll go up the hierarchy. It won't see the provider in `Product2Component`, and it will use the provider for `ProductService` defined in `RootComponent`.

NOTE **When the injectable instance is created**
An instance of the injectable object is created and destroyed at the same time as the component that defines the provider for this object.

4.6 Hands-on: Using DI in the online auction application

In chapter 3 we added routing to the online auction action so it can render a simplified Product Details view. In this hands-on exercise we'll implement the `ProductDetail` component to show actual product details.

The Home page of the auction is shown in figure 4.10:

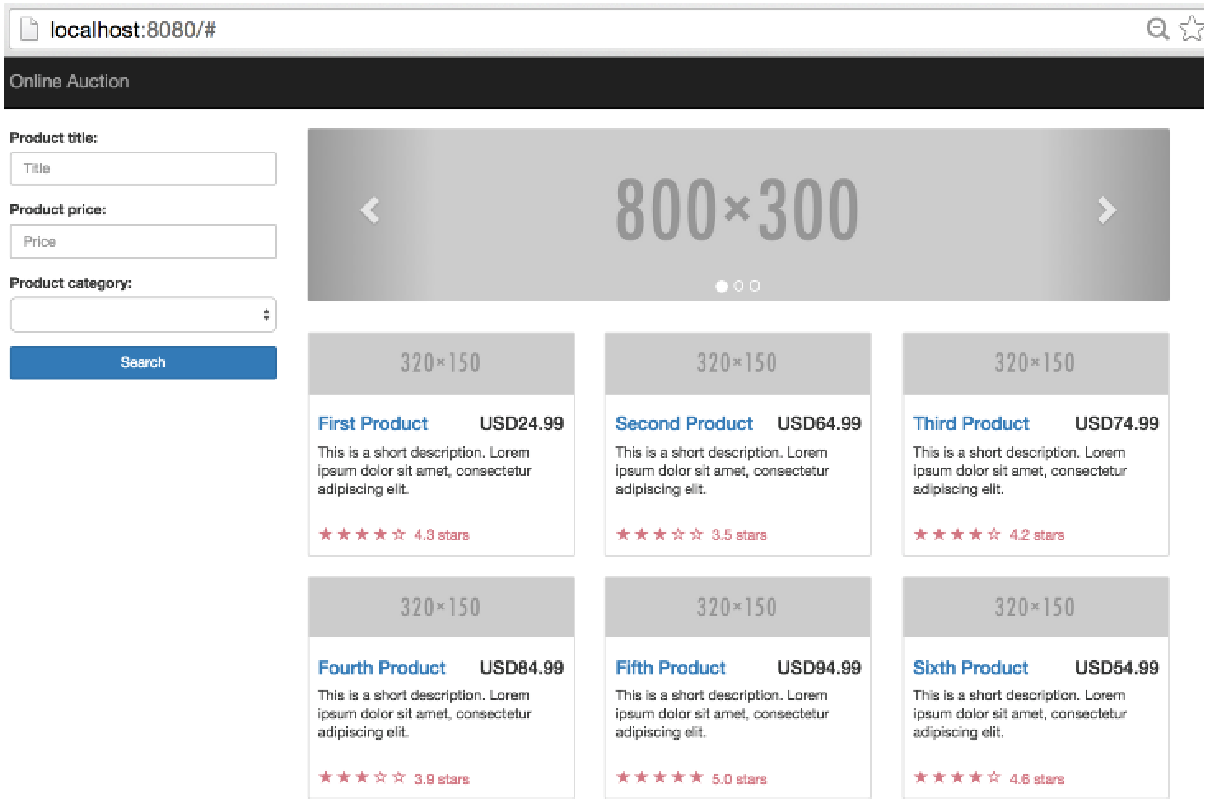


Figure 4.10 The auction Home page

If you click on any of the links, like First Product or Second Product, the app will show you a pretty basic detail view, as shown in figure 3.16 in the previous chapter. Now our goal is to render the details of the selected product, providing yet another illustration of DI in action. Figure 4.11 shows how the Product Details view will look at the end of this hands-on exercise when the First Product is selected.

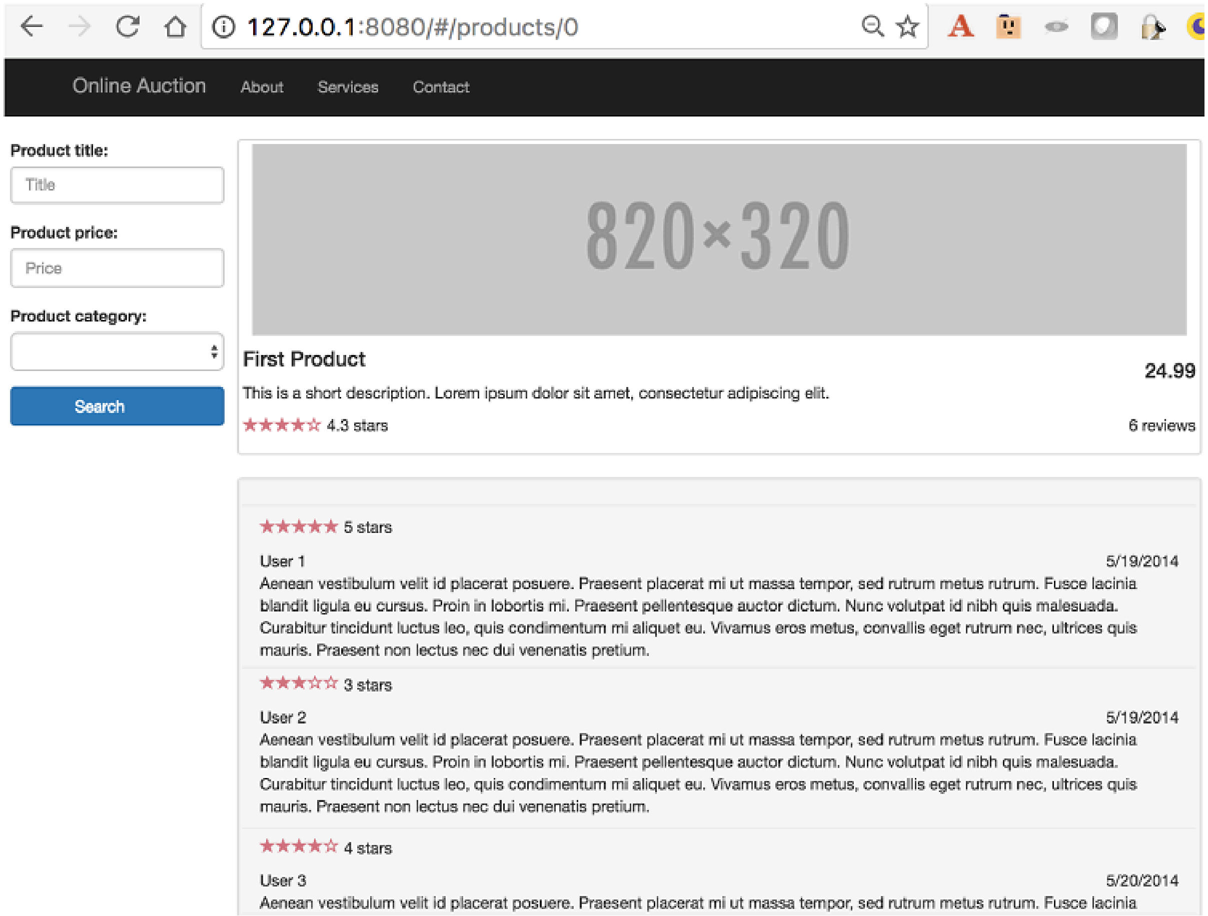


Figure 4.11 The auction Product Details view

> **NOTE** **How to work on the online auction app**
> We'll use the auction application developed in chapter 3 as a starting point for this exercise. If you prefer to see the final version of this project, browse the source code in the auction folder from chapter 4. Otherwise, copy the auction folder from chapter 3 to a separate location, run `npm install`, and follow the instructions below.

Now that you've learned about provider and dependency injection, let's quickly review some code fragments from the auction created in the previous chapter, focusing on the DI-related code.

The script in the app.module.ts file specified the app-level service providers, as shown here:

```
@NgModule({
    ...
    providers:    [ProductService,
                   {provide: LocationStrategy, useClass: HashLocationStrategy}],
    bootstrap:    [ ApplicationComponent ]
```

```
})
export class AppModule { }
```

Because the `ProductService` provider is specified in the module, it can be reused by all children of `ApplicationComponent`. The following fragment from `HomeComponent` (see home.ts) doesn't specify `providers` to be used for the injection of the `ProductService` via the constructor—it'll reuse the instance of `ProductService` created in its parent:

```
@Component({
  selector: 'auction-home-page',
  styleUrls: ['/home.css'],
  template: `...`
})
export default class HomeComponent {
  products: Product[] = [];

  constructor(private productService: ProductService) {
    this.products = this.productService.getProducts();
  }
}
```

As soon as the `HomeComponent` is instantiated, the `ProductService` is injected and its `getProducts()` method populates the `products` array, which is bound to the view.

The HTML fragment that displays the content of this array uses the `*ngFor` loop to display one `<auction-product-item>` template for each element of the array:

```
<div class="row">
  <div *ngFor="let product of products" class="col-sm-4 col-lg-4 col-md-4">
    <auction-product-item [product]="product"></auction-product-item>
  </div>
</div>
```

The template of the `<auction-product-item>` contained the following line:

```
<h4><a [routerLink]="['/products', product.title]">{{ product.title }}</a></h4>
```

Clicking on this link will instruct the router to render `ProductDetailComponent` and will provide the value of `product.title` as the route parameter. We want to modify this code to pass the product ID instead of the title.

This brief overview of the existing code was intended to remind you how the product details page was requested. Now let's implement the code to produce the view shown in figure 4.11.

CHANGING THE CODE TO PASS THE PRODUCT ID AS A PARAMETER

Open the product-item.html file and modify the line with `[routerLink]` so it looks like this:

```
<h4><a [routerLink]="['/products', product.id]">{{ product.title }}</a></h4>
```

The product-item.html file contains the template used for displaying products in the Home view, and now clicking on the product title will pass the `product.id` to the route configured for the path `products`.

MODIFYING THE PRODUCTDETAILCOMPONENT

Before we get to coding, let's look at figure 4.12, which shows the parent-child relationship between the components of the auction.

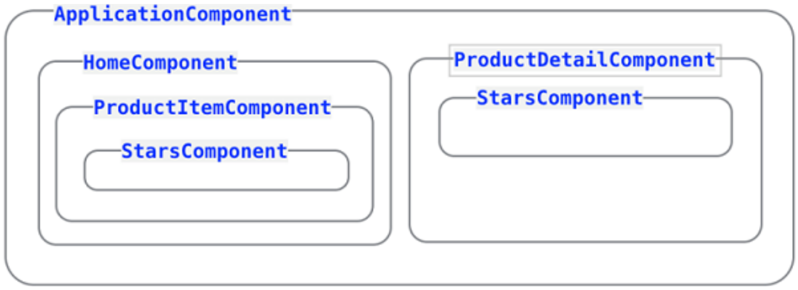


Figure 4.12 Parent-child relations in the auction

Understanding parent-child relations can help you make the decision about whether some of the parent injectors can be reused by their children. In chapter 3 we injected an instance of `ProductService` in `HomeComponent`, but we'll need it in the `ProductDetailComponent` as well. We can define the provider of `ProductService` during the bootstrap of the application to make it available in all children of `ApplicationComponent`. To do so, follow these steps:

1. Modify the code in app.module.ts to change the route configuration from `products/:prodTitle` to `products/:productId`. The first lines of the `@NgModule` decorator should look like this:

```
@NgModule({
    imports:[ BrowserModule,
              RouterModule.forRoot([
                {path: '',  component: HomeComponent},
                {path: 'products/:productId', component: ProductDetailComponent}
    ]) ],
```

   Because we're passing the product ID to `ProductDetailComponent`, its code should be modified accordingly.

2. Open the product-detail.ts file and modify its code to look like this:

```
import {Component} from '@angular/core';
import { ActivatedRoute} from '@angular/router';
import {Product, Review, ProductService} from '../../services/product-service';

@Component({
  selector: 'auction-product-page',
  templateUrl: 'app/components/product-detail/product-detail.html'
})
```

```
export default class ProductDetailComponent {
  product: Product;
  reviews: Review[];

  constructor(route: ActivatedRoute, productService: ProductService) {

    let prodId: number = parseInt(route.snapshot.params['productId']);
    this.product = productService.getProductById(prodId);

    this.reviews = productService.getReviewsForProduct(this.product.id);
  }
}
```

Angular will inject the `ProductService` instance into `ProductDetailComponent`. When `ProductDetailComponent` is created, it invokes the `getProductsById()` method, which returns one product with an `id` that matches the `productId` passed from the Home view via constructor's argument of type `ActivatedRoute`. This is how we populate the `product` variable.

Then the constructor calls the `getReviewsForProduct()` method to populate the `reviews` array. You'll see the declaration of this method as well as the `Review` class later in this section.

3. Create the product-detail.html file in the product-detail folder and modify it so it looks like this:

```
<div class="thumbnail">
    <img src="http://placehold.it/820x320">
    <div>
        <h4 class="pull-right">{{ product.price }}</h4>
        <h4>{{ product.title }}</h4>
        <p>{{ product.description }}</p>
    </div>
    <div class="ratings">
        <p class="pull-right">{{ reviews.length }} reviews</p>
        <p><auction-stars [rating]="product.rating"></auction-stars></p>
    </div>
</div>
<div class="well" id="reviews-anchor">
    <div class="row">
        <div class="col-md-12"></div>
    </div>
     <div class="row" *ngFor="let review of reviews">
        <hr>
        <div class="col-md-12">
            <auction-stars [rating]="review.rating"></auction-stars>
            <span>{{ review.user }}</span>
            <span class="pull-right">{{ review.timestamp | date: 'shortDate' }}</span>
            <p>{{ review.comment }}</p>
        </div>
    </div>
</div>
```

This HTML template uses local binding to the properties of the `product` variable. Note how we use the square brackets to pass the `rating` input to the `StarsComponent` (represented by `<auction-stars>`) introduced in chapter 2. In this version of the auction, the user can only see the reviews; we'll implement the Leave a Review functionality in chapter 6.

The pipe operator (|) allows you to create filters that can transform a value. The expression `review.timestamp | date: 'shortDate'` takes the timestamp from a `Review` object and displays it in a `shortDate` form. You can find other date formats in the Angular documentation at http://mng.bz/78lD. Angular comes with several classes that can be used with the pipe operator, and you can create custom filters (explained in chapter 5). In chapter 8 you'll see how to use the `async` pipe to automatically unwrap the server's responses.

4. Copy the product-service.ts file.

   To save you some typing, copy into your project the app/services/product-service.ts file provided with the code of the auction application for this chapter. This file contains three classes—`Product`, `Review`, `ProductService`—and hard-coded data for products and reviews.

   The HTML template from the previous step uses the classes `Product` and `Review`, shown below.

```
export class Product {
  constructor(
    public id: number,
    public title: string,
    public price: number,
    public rating: number,
    public description: string,
    public categories: string[]) {
  }
}

export class Review {
  constructor(
    public id: number,
    public productId: number,
    public timestamp: Date,
    public user: string,
    public rating: number,
    public comment: string) {
  }
}
```

   The `ProductService` class has three methods: `getProducts()`, which returns an array of `Product` objects, `getProductById()`, which returns one product, and `getReviewsForProduct()`, which returns an array of `Review` objects for the selected product. All the data for products and reviews is hard-coded in the `products` and `reviews` arrays respectively. For brevity we've just shown you fragments of these arrays. The `getReviewForProduct()` method filters the `reviews` array to find the reviews for the specified `productId`. Then it uses the `map()` function to turn an array of `Object` elements into a new array of `Review` objects.

```
export class ProductService {
  getProducts(): Product[] {
    return products.map(p => new Product(p.id, p.title, p.price, p.rating,
        p.description, p.categories));
  }

  getProductById(productId: number): Product {
    return products.find(p => p.id === productId);
  }

  getReviewsForProduct(productId: number): Review[] {
    return reviews
      .filter(r => r.productId === productId)
      .map(r => new Review(r.id, r.productId, Date.parse(r.timestamp), r.user,
        r.rating, r.comment));
  }
}

var products = [
```

```
  {
    "id": 0,
    "title": "First Product",
    "price": 24.99,
    "rating": 4.3,
    "description": "This is a short description."""" Lorem ipsum dolor sit amet,
        consectetur adipiscing elit.",
    "categories": ["electronics", "hardware"]},
  {
    "id": 1,
    "title": "Second Product",
    "price": 64.99,
    "rating": 3.5,
    "description": "This is a short description. Lorem ipsum dolor sit amet,
        consectetur adipiscing elit.",
    "categories": ["books"]}];

var reviews = [
  {
    "id": 0,
    "productId": 0,
    "timestamp": "2014-05-20T02:17:00+00:00",
    "user": "User 1",
    "rating": 5,
    "comment": "Aenean vestibulum velit id placerat posuere. Praesent..."},
  {
    "id": 1,
    "productId": 0,
    "timestamp": "2014-05-20T02:53:00+00:00",
    "user": "User 2",
    "rating": 3,
    "comment": "Aenean vestibulum velit id placerat posuere. Praesent... "
  }];
```

SIDEBAR **Using the ES6 API while compiling into ES5 syntax**

If your IDE shows the function `find()` in red, it's because your tsconfig.json specifies ES5 as a target for compilation, and the `find()` function wasn't supported in ES5 arrays. To remove the redness, you can install the type definition file for ES6 shim:

```
npm i @types/es6-shim --save-dev
```

For details, see the section "Installing type definition files" in appendix B.

5. Start the server in the auction directory by entering the command `npm start`. When you see the auction's home page, click on the product title to get the Product Details view shown in figure 4.11.

4.7 Summary

In this chapter you've learned what the Dependency Injection pattern is and how Angular implements it. Our online auction will continue using DI on every page. These are the main takeaways from this chapter:

- Providers register objects for future injection.
- You can create a provider not only for an object, but for a string value as well.
- Injectors form a hierarchy, and if Angular can't find the provider for the requested type at

the component level, it'll try to find it by traversing parent injectors.

- The value of the `providers` property is visible in the child components, whereas `viewProviders` is only visible at the component level.

5 Bindings, observables, and pipes

This chapter covers

- Various flavors of data binding
- The difference in binding to attributes vs. properties
- What observable data streams are
- How to treat events as observable data streams
- How to minimize the network load by canceling unwanted HTTP requests
- Minimizing manual coding with pipes

The goal of the the first four chapters was to jump-start application development with Angular. In those chapters we used property bindings, handled events, and applied directives without providing detailed explanations. In this chapter we want to take a breather and cover some of the techniques we used in more detail. We'll continue writing code in TypeScript, and you'll see an example of using destructuring syntax while handing events.

5.1 Data binding

Data binding allows you to connect the data from your application with the UI, and the data-binding syntax lowers the amount of manual coding. In chapter 2 we briefly introduced the data-binding syntax and we used it in almost every example in the previous chapters. In particular, you've seen the following examples:

```
<!-- Displaying a value or an expression as a string in a template -->

<h1>Hello {{ name }}!</h1>

<!-- Using square brackets to bind an HTML element's properties -->

<span [hidden]="isValid">This field is required</span>
```

```
<!-- Binding to events with parentheses -->

<button (click)="placeBid()">Place Bid</button>
```

In Angular, data binding is implemented in a unidirectional way (also known as one-way data binding). The "one way" could mean either applying data changes from the component's properties to the UI or binding UI events with the component's methods. For example, whenever a component's `productTitle` property is updated, the view (the template) is automatically updated by using the following syntax in the template: `{{productTitle}}`. Similarly, when a user types in an `<input>` field, the event binding (denoted by parentheses) invokes an event handler on the right side of the equal sign:

```
(input) = "onInput()"
```

NOTE	**Binding in templates** In templates, both double curly braces in the text and square brackets in HTML elements' attributes result in property binding. Angular binds the interpolated value (a string with injected expression values) to the `textContent` property of the corresponding DOM node. It's not just a one-time assignment—the text is constantly updated as the value of the corresponding expression changes.

NOTE	**What's wrong with AngularJS two-way binding** In AngularJS, data changes on the view automatically update the underlying data (one direction), which also triggers an update of the view (another direction). In other words, AngularJS uses two-way data binding under the hood. Although having two-way data binding in forms simplifies coding, using it to bind values in various application scripts may substantially slow performance in large applications. That's because AngularJS internally keeps a list of all data binding expressions on the page, and a browser event can result in AngularJS checking the list of the expressions over and over again until it ensures that everything is in sync. During this process, a single property can be updated multiple times.

Although Angular doesn't use two-way data binding by default, you can still implement it. Now it's your choice, not the framework's. In this section we'll go over several flavors of data binding:

- Event binding to invoke a function that handles this event
- Attribute binding to update the text value of an HTML element's attribute
- Property binding to update the value of the DOM element's property
- Template binding to transform the view template
- Two-way data binding with `ngModel`

5.1.1 Binding to events

To assign an event handler function to an event, you need to put the event name in parentheses in the component's template. The following code snippet shows how to bind the function `onClickEvent()` to the `click` event, and the function `onInputEvent()` to the `input` event.

```
<button (click)="onClickEvent()">Get Products</button>

<input placeholder= "Product name" (input)="onInputEvent()">
```

When the event specified in parentheses is triggered, the expression in the double quotes is re-evaluated. In the preceding examples, the expressions are functions, so they're invoked each time the corresponding event is triggered.

If you're interested in analyzing the properties of the event object, just add the `$event` argument to the handler function. In particular, the `target` property of the event object represents the DOM node where the event occurred. The instance of the event object will be available only within the binding scope (that is, in the event handler function). Figure 5.1 shows how to read the event-binding syntax.

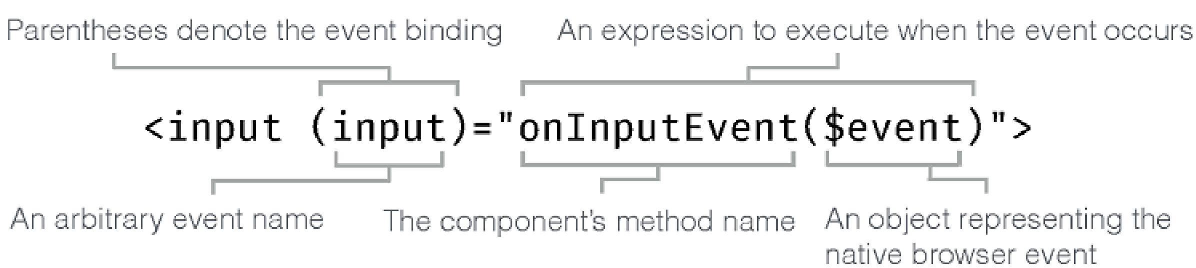


Figure 5.1 Event-binding syntax

The name of the event in parentheses is called *the target of binding*. You can bind functions to any standard DOM events that exist today (see the Mozilla Developer Network documentation for the "Event reference," http://mzl.la/1JcBR22) or that will be introduced in the future. You can also create custom events and bind function handlers to them in the same way (see the section in chapter 6 titled "Output properties and custom events").

5.1.2 Binding to properties and attributes

Each HTML element is represented by a tag with *attributes*, and the browser creates a DOM object with *properties* for each tag. The user sees DOM objects on the screen as they're rendered by the browser. You should have a good understanding of what exists at any given moment in the three distinct areas:

- The HTML document

- The DOM object
- The rendered UI

An *HTML document* consists of elements that are represented by tags with attributes, which are always strings. The browser instantiates HTML elements as *DOM objects* (nodes) that have properties and are rendered on the web page as a UI. Whenever the values of the DOM nodes' properties change, the page is re-rendered.

PROPERTIES

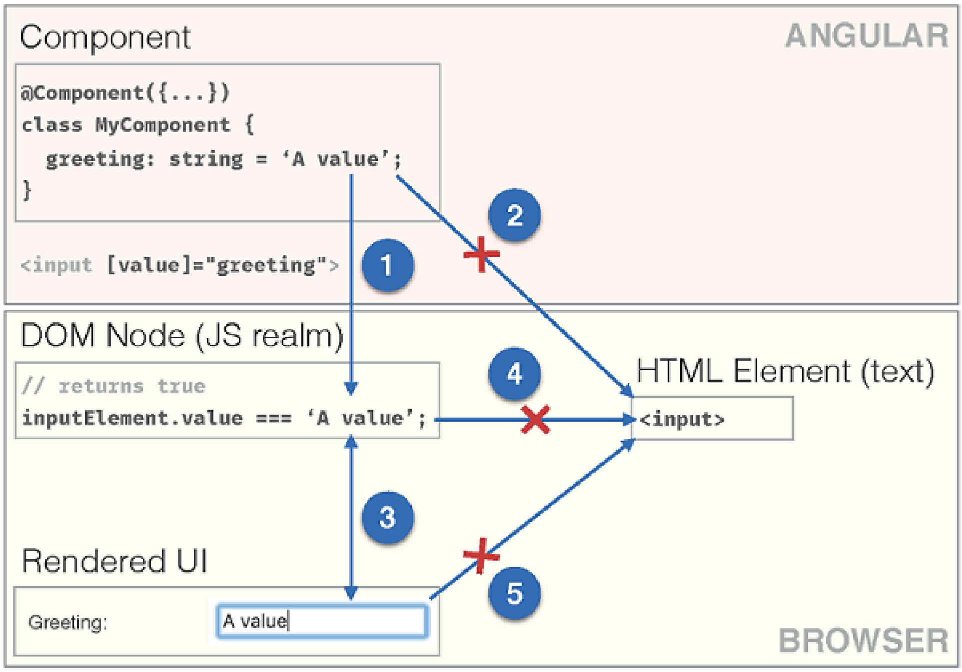
Consider the following `<input>` tag:

```
<input type="text" value="John" required>
```

The browser uses this string to create a node in the DOM tree, which is a JavaScript object of type `HTMLInputElement`. Each DOM object has an API in the form of methods and *properties* (see the Mozilla Developer Network documentation for "HTMLInputElement," http://mzl.la/1QqMBgQ). In particular, the `HTMLInputElement` object includes the properties `type` and `value` of type `DOMString`, and `required` of type `Boolean`. The browser renders this DOM node.

IMPORTANT	**DOM-UI synchronization** The browser will synchronize the rendered values with the values of the corresponding DOM object's properties, regardless of the synchronization features offered by a particular framework.

In Angular you denote property binding by enclosing the property name in square brackets and assigning an expression (or a class variable) to it. Figure 5.2 illustrates how Angular's property-binding mechanism works. Imagine a component, `MyComponent`, that has a class with a variable `greeting`. The template of this component includes an `<input>` tag with the class variable `greeting` bound to the property `value`.



1. Angular updates DOM through the *one-way* property binding.
2. Property binding does *not* update the HTML element.
3. DOM node's "value" property is displayed on UI. Browser keeps UI and DOM in sync.
4. DOM node's "value" property doesn't change the corresponding element's attribute.
5. Browser doesn't sync HTML element's attribute with UI when user types the text.

Figure 5.2 Property Binding

NOTE	Typesetter: The following numbered points go with the cueballs in the figure. They can be treated as labels to add to the figure, or as a list of cueballs following the figure—whatever works best.

1. Angular updates the DOM using the one-way property binding (from `greeting` to the DOM object's property). If a script assigns a reference to this `<input>` element to the variable `inputElement`, it's going to be equal to `A value`. Note that we use dot notation to access the value of the node's property.
2. Angular's property binding doesn't update the attribute of the HTML element after the value of `inputElement.value` changes.
3. The DOM node's `value` property is displayed on the UI. Angular updated the DOM node, and browser rendered the new value to keep the DOM and UI in sync.
4. The DOM node's `value` property doesn't change the attribute of the corresponding HTML element.
5. The browser doesn't sync the HTML element's attribute with the UI when the user types in the `<input>`. The user sees the new values coming from the DOM and not from the HTML document.

An application component may have a data structure that serves as a model. Application code may also change the model's property (such as a function that calculates something, or data coming from a server), which will trigger the property-binding mechanism, resulting in UI updates.

SIDEBAR **When property binding is used**

Property binding is used in two scenarios:

1. A component needs to reflect the state of the model in the view.
2. A parent component needs to update a property of its child (see the "Input Properties" section in chapter 6).

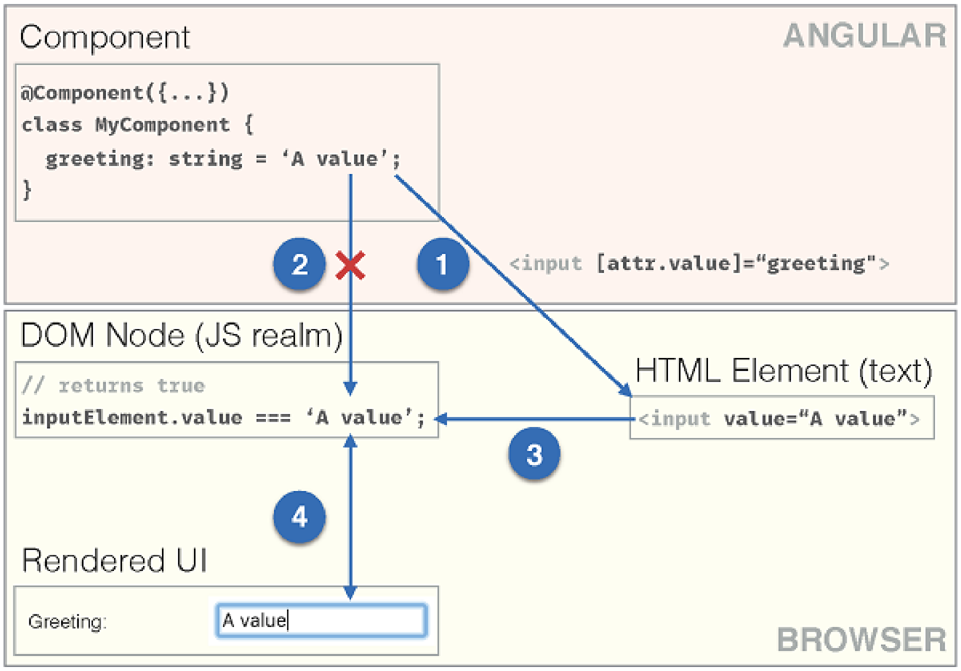
ATTRIBUTES

We use the word *attributes* in the context of the HTML document (not the DOM object). Attribute bindings are rarely used, because the browser uses HTML to build the DOM tree, and after that it works mainly with properties of the DOM object. But there are some cases when you may need to use attribute bindings. For example, the `hidden` attribute isn't supported in Internet Explorer 10, and it won't create a corresponding DOM attribute, so if you need to toggle the visibility of a component using CSS styles, attribute binding will help. Another example is integration with the Google Polymer framework—we could only do it via attribute binding.

Like property bindings, the attribute binding is denoted by placing an attribute name in square brackets. But to let Angular know that you want to bind to an attribute (and not the DOM property), you have to add the prefix `attr.`:

```
<input [attr.value]="greeting">
```

Figure 5.3 illustrates attribute binding.



1. Angular updates HTML element through the *one-way* attribute binding.
2. Attribute binding does *not* update the DOM node.
3. Browser syncs HTML input element's "value" attribute with the corresponding DOM node's property.
4. DOM node's "value" property is displayed on UI. Browser keeps UI and DOM in sync.

Figure 5.3 Attribute binding

NOTE	Typesetter: The following numbered points go with the cueballs in the figure. They can be treated as labels to add to the figure, or as a list of cueballs following the figure—whatever works best.

1. Angular updates the HTML element using the one-way attribute binding (from `greeting` to the HTML element's attribute). Note the `attr.` in the binding expression.
2. Angular's attribute binding doesn't update the DOM's node.
3. In this case, the DOM's object got `A value` because the browser synchronized the `value` attribute between the HTML element and the DOM.
4. The DOM node's `value` property is displayed on the UI because the browser keeps the UI and DOM in sync.

Let's see how the property and attribute bindings work in a simple example. The following code shows an `<input>` element that uses binding with the attribute `value` and the property `value`. This code sample is located in the attribute-vs-property.ts file:

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

@Component({
  selector: 'app',
  template: `
    <h3>Property vs attribute binding:</h3>

    <input [value]="greeting"   ❶
```

```
    [attr.value] = "greeting"  ❷

    (input)="onInputEvent($event)">  ❸
  `
})
class AppComponent {

  greeting: string = 'A value';

  onInputEvent(event: Event): void {

    let inputElement: HTMLInputElement = <HTMLInputElement> event.target;  ❹

    console.log(`The input property value = ${inputElement.value}`);

    console.log(`The input attribute value = ${inputElement.getAttribute('value')}`);  ❺
    console.log(`The greeting property value = ${this.greeting}`);
  }
}

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

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

❶ This is property binding.

❷ This is attribute binding.

❸ Binding a standard DOM input event, which is fired when the value of the <input> element is changed.

❹ The onInputEvent() event handler received the Event object, and its target property has a reference to the element where this event occurred.

❺ We use getAttribute() to get the attribute's value, while properties are accessible, using the dot notation.

If you run this program and start typing in the input field, it'll print on the browser console the content of the DOM's `value` property, the `value` attribute of the HTML `<input>` element, and the content of the `greeting` property of `MyComponent`. Figure 5.4 shows the console output after we started this program and typed "3" in the `<input>` field.

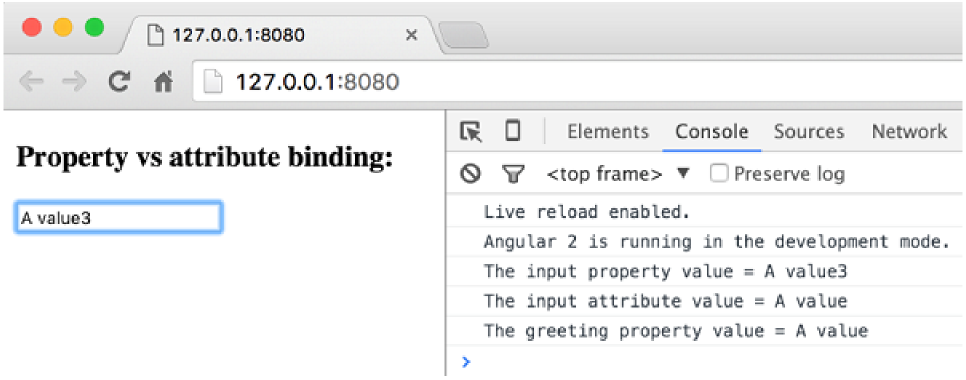


Figure 5.4 Running the properties-vs-attribute example

The value of the `value` attribute didn't change. The value of `greeting` isn't changed either, which proves that Angular doesn't use two-way data binding. In AngularJS, changing the model (`greeting`), would update the view, and if the user changed the data on the view, it would automatically update the model.

SIDEBAR **Simplifying code with destructuring**

In appendix A we cover the ES6 destructuring feature, which is supported by TypeScript as well. Destructuring could simplify the code of the event handler function `onInputEvent()` in the preceding code sample.

The `onInputEvent()` function receives the `Event` object, and then a line extracts the value from `target` property. With destructuring syntax, we could eliminate this line:

```
onInputEvent({target}): void {

  console.log(`The input property value = ${target.value}`);
  console.log(`The input attribute value = ${target.getAttribute('value')}`);
  console.log(`The greeting property value = ${this.greeting}`);
}
```

Using the curly braces in the argument of this function sends the following instruction to this function: "You'll get an object that has a `target` property. Just give me the value of this property."

5.1.3 Binding in templates

Say you need to conditionally hide or show a certain HTML element. You can do it by binding a Boolean flag to a `hidden` attribute or a `display` style of the element. Depending on the flag's value, this element will either be shown or hidden, but the object that represents this element remains in the DOM tree.

Angular offers *structural directives* (`NgIf`, `NgSwitch`, and `NgFor`) that change the DOM's structure by removing or adding elements to it. `NgIf` can conditionally remove an element from or add one to the DOM tree. `NgFor` loops through an array and adds an element to the DOM tree for each array element. `NgSwitch` adds one element to the DOM tree from a set of possible elements, based on some condition. Using template binding, you can instruct Angular to do this for you.

Removing elements can be better than hiding them if you want to ensure that your application won't waste time supporting the behavior of these elements (such as processing events or monitoring change detection).

> **NOTE** **HTML templates and Angular directives**
> The HTML `<template>` tag (see the Mozilla Developer Network documentation for "<template>," http://mzl.la/1OndeMV) is not a typical tag because the browser ignores its content unless the application includes a script to parse and add it to the DOM. Angular offers so-called *shortcut syntaxes* for directives—they start with an asterisk, such as `*ngIf` or `*ngFor`. When Angular's parser sees a directive that starts with an asterisk, it converts this directive into an HTML fragment that uses a `<template>` tag and is recognizable by browsers.

The following code sample (template-binding.ts) includes one `<span>` and one `<template>`, and it illustrates two flavors of template binding using the `NgIf` directive. Depending on the flag's value (which is toggled by the button click) the `<span>` elements either add to the DOM or remove from it.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

@Component({
    selector: 'app',
    template: `
    <button (click)="flag = !flag">Toggle flag's value</button>

    <p>
      Flag's value: {{flag}}
    </p>

    <p>
     1. span with *ngIf="flag": <span *ngIf="flag">Flag is true</span>
    </p>

    <p>
      2. template with [ngIf]="flag": <template [ngIf]="flag">Flag is true</template>
    </p>
  `
})
class AppComponent {
    flag: boolean = true;
}

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

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

Unlike other Angular bindings, the template binding transforms the view template. The preceding example conditionally adds or removes the message about the flag's value from the DOM tree. In this example we used both the shortcut syntax, `*ngIf="flag"`, to handle the `<span>` element and a fully expanded version, `[ngIf]="flag"`, to handle the content of the `<template>` tag.

Figure 5.5 shows that when the flag is `true`, the DOM tree includes the content of both `<span>` and `<template>`. Figure 5.6 shows that when the flag is `false`, the DOM tree doesn't include either `<span>` or `<template>`.

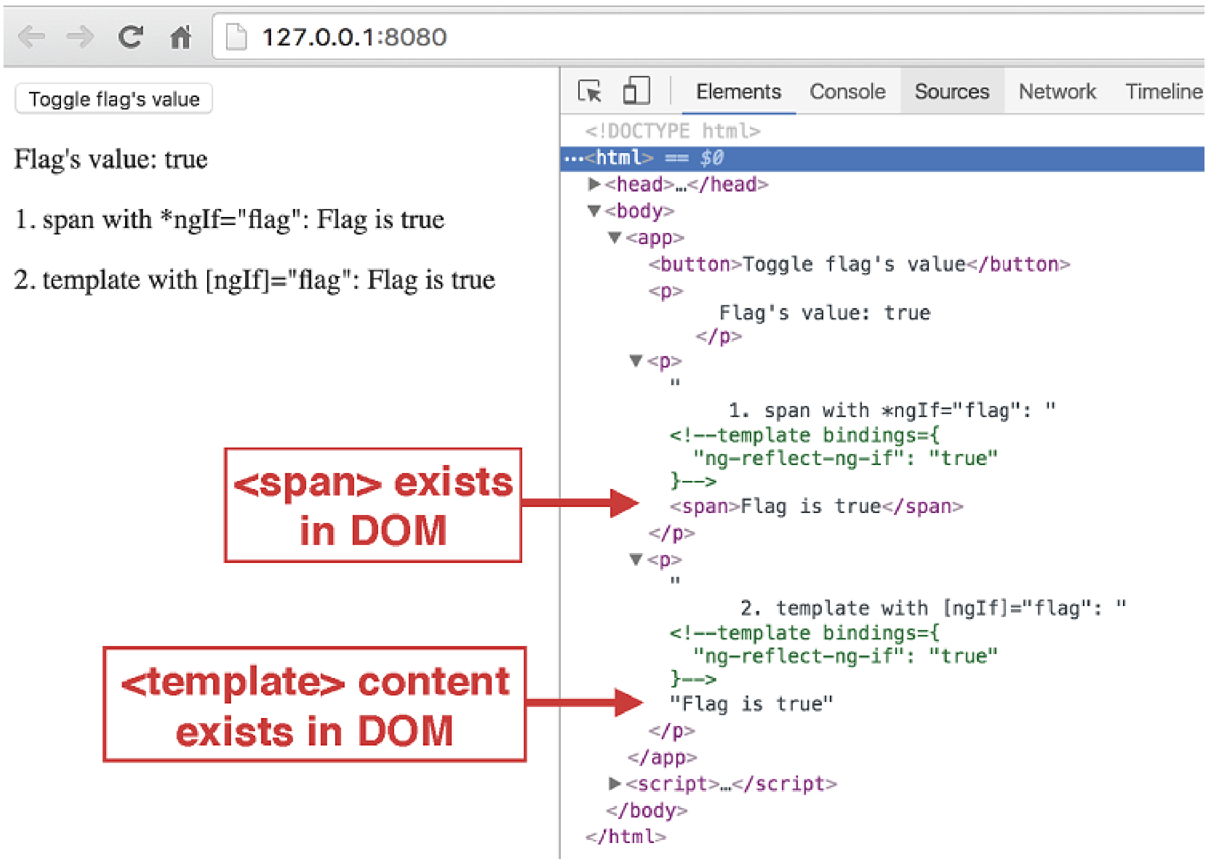


Figure 5.5 Template binding, flag is true

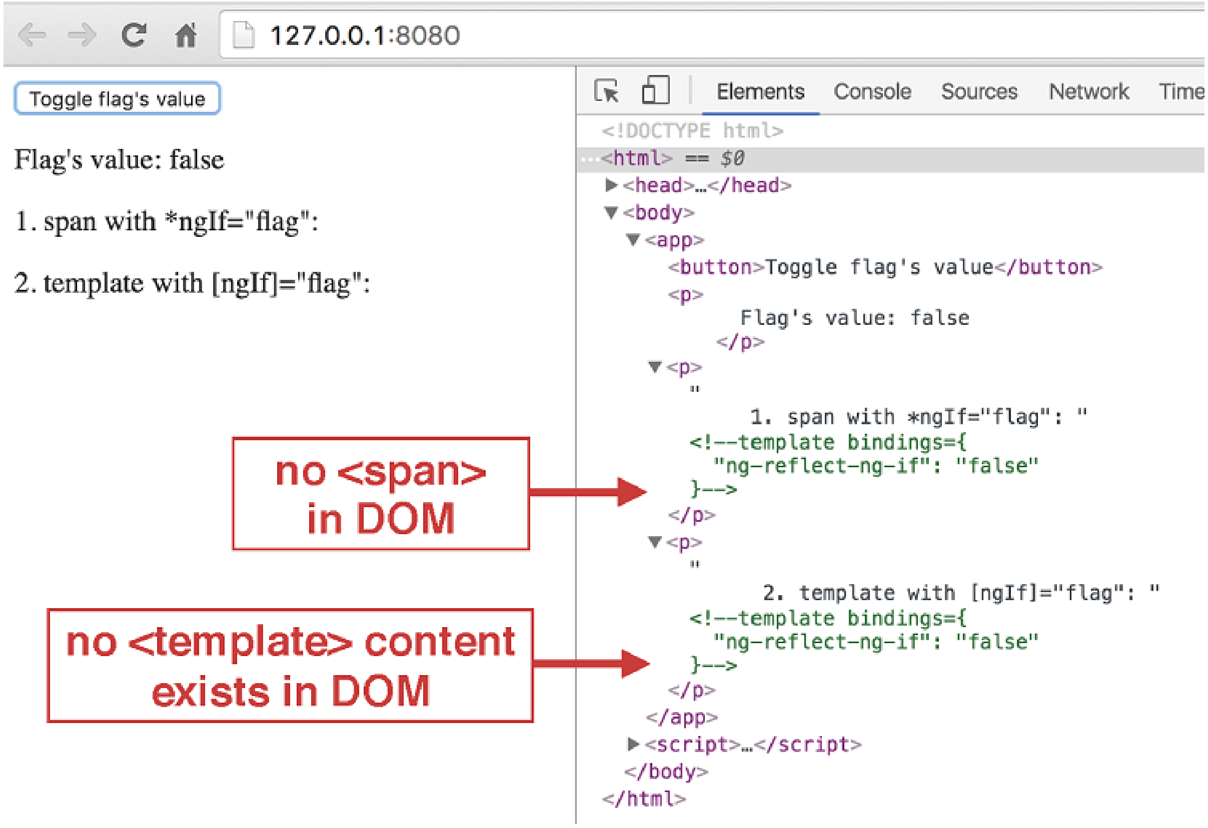


Figure 5.6 Template binding, flag is false

All of the binding examples you've seen so far illustrate binding in one direction: either from the UI to the application code, or from the code to the UI. But there's another scenario in which binding works in both directions, and we'll discuss it next.

5.1.4 Two-way data binding

Two-way data binding is a simple way to keep the view and the model in sync. Whether the view or the model change first, both are immediately synchronized.

You learned that the one-way binding from the UI to an Angular component is arranged by surrounding an event name with parentheses:

```
<input (input)="onInputEvent($event)">
```

One-way binding from a component to the UI is denoted by surrounding an HTML attribute with square brackets:

```
<input [value]="myComponentProperty" >
```

In some cases, you may still want to use two-way binding. The longer way of combining the two preceding code samples would be as follows:

```
<input [value]="myComponentProperty"
```

```
      (input)="onInputEvent($event)>
```

Angular also offers a shorter combined notation: `[()]`. In particular, Angular has a `NgModel` directive that you can use for two-way binding (note that when `NgModel` is used in templates, its name isn't capitalized):

```
<input [(ngModel)] = "myComponentProperty">
```

In this shorter notation example, you can still see `myComponentProperty`, but which event does it handle? In this example, the `NgModel` directive is used with the `<input>` element. This event is the default trigger for synchronizing the UI changes in the the HTML `<input>` element with the underlying model. But the driving event can be different, depending on the UI control being used with `ngModel`. This is controlled internally by a special `ControlValueAccessor` Angular interface, which serves as a bridge between a control and a native element. `ControlValueAccessor` is used for creating custom form controls.

Two-way binding was popular with forms where you needed to synchronize values from the form fields with the properties of underlying model object. In chapter 7 we'll cover the use of the `NgModel` directive in greater detail. You'll learn how to handle forms without the need to use `[(ngModel)]` for each form's control, but there are some cases where it can be handy, so let's get familiar with the syntax.

Say the landing page of a financial application allows the user to check the latest prices of a stock by entering its symbol in an input field. Users often enter the same stocks that they own or follow, such as `AAPL` for Apple. You could save the last-entered symbol as a cookie (or in HTML5 local storage), and the next time the user opens this page, the program could read the cookie and populate the input field. The user should still be able to type in this field, and the entered value should be synchronized with a `lastStockSymbol` variable, which plays the role of the model. The following code (two-way-binding.ts) implements this functionality.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { FormsModule } from '@angular/forms';

@Component({
    selector: 'stock-search',
    template: `<input type='text' placeholder= "Enter stock symbol"
                [(ngModel)] = "lastStockSymbol" />    ❶
               <br>The value of lastStockSymbol is {{lastStockSymbol}}`
})
class StockComponent {

    lastStockSymbol: string;    ❷
```

```
    constructor() {

        setTimeout(() => {
            // Code to get the last entered stock from
            // local history goes here (not implemented)

            this.lastStockSymbol="AAPL";
        }, 2000);
    }
}
@Component({
    selector: 'app',
    directives: [StockComponent],
    template:`<stock-search></stock-search>`

})
class AppComponent {}

@NgModule({

    imports:      [ BrowserModule, FormsModule],
    declarations: [ AppComponent],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

1. Requests the two-way binding to synchronize the changes with lastStockSymbol.
2. The lastStockSymbol is the model, and it can be modified either by the user typing in the input field or programmatically.
3. To emulate the scenario of reading the last stock symbol from a cookie, we arranged one-second delay after which the value of lastStockSymbol will be changed to AAPL and the <input> field will show it.
4. Imports FormsModule so we can use NgModel.

The `lastStockSymbol` variable and the value of the `<input>` field will always be in sync. You can see this in action by running the script in the two-way-binding.ts file.

NOTE **Two-way binding with application-specific properties**
In the preceding example, we used Angular's `NgModel` directive to implement two-way data binding, but you can use application-specific properties for this as well. You'll need to name the properties using a special suffix, `Change`. In the hands-on section of chapter 6, you'll see how to modify a product rating using two-way binding with the `[(rating)]` syntax.

In AngularJS, two-way binding was the default mode of operation, which seems like a simple and elegant solution for synchronizing a view and a model. But on a complex UI containing dozens of controls, changing the value in one place could cause a chain of binding updates, and performance could suffer.

With two-way binding, debugging could also be more difficult, as there could be many reasons why a particular value was changed. Was it because of the user's input or was it the result of a modified value in some variable?

Implementing change detection inside the Angular framework wasn't trivial either. With a unidirectional data flow, you always know where the change to a particular UI element or component property came from, because there is only one property in the component's code that could change a particular value on the UI.

5.2 Reactive programming and observables

Reactive programming is about creating responsive (fast) event-driven applications, where an observable event stream is pushed to the subscribers. In software engineering, Observer/Observable is a well-known pattern, and it's a good fit in any asynchronous processing scenario. But reactive programming is a lot more than just an implementation of the Observer/Observable pattern. The observable streams can be canceled, they can notify about the end of a stream, and the data pushed to the subscriber can be transformed on the way from the source to the subscriber by applying various operators (functions).

NOTE	**Push and pull** One of the most important characteristics of observables is that they implement the *push model* of data processing. In contrast, the *pull model* is implemented by looping through an array, by an `Iterable`, or by using ES6 generator functions.

Multiple libraries implement reactive extensions that support observable streams, and RxJS (https://github.com/Reactive-Extensions/RxJS) is one such library. The RxJS library is integrated in Angular.

5.2.1 What are observables and observers

The *observer* is an object that handles a data stream pushed by an *observable* function. There are two main types of observables: hot and cold. A *cold* observable starts streaming data when some code invokes a `subscribe()` function on it. A *hot* observable streams the data even if there's no subscriber interested in its data. In this book we'll use only cold observables.

A script that subscribes to an observable provides the observer object that knows what to do with the stream elements:

```
let mySubscription: Subscription = someObservable.subscribe(myObserver);
```

To cancel the stream subscription, invoke the `unsubscribe()` method.

```
mySubscription.unsubscribe();
```

An observable is an object that streams elements from some data source (a socket, an array, UI events) one element at a time. To be precise, an observable stream knows how to do three things:

- Emit the next element
- Throw an error
- Send a signal that the streaming is over (that the last element has been served)

Accordingly, an observer object provides up to three callbacks:

- The function to handle the next element emitted by the observable
- The function to handle errors in the observable
- The function to be invoked when the stream of data finishes

NOTE **`then()` and `subscribe()`**
In appendix A we discuss the use of the `Promise` object, which can invoke an event handler specified in the `then()` function only once. The `subscribe()` method is like a sequence of `then()` invocations: one invocation for each arriving data element.

The application code can apply a sequence of operators, transforming each element prior to supplying it to the handler function.

Figure 5.7 shows a sample data flow from an observable that emits data to a subscriber (which implements the observer). In this data flow, we apply two operators: `map()` and `filter()`. The emitter (the producer) creates an original stream of data (rectangles). The `map()` operator transfers each rectangle into a triangle, which is given to a `filter()` operator that filters out the stream to push only selected triangles to the subscriber.

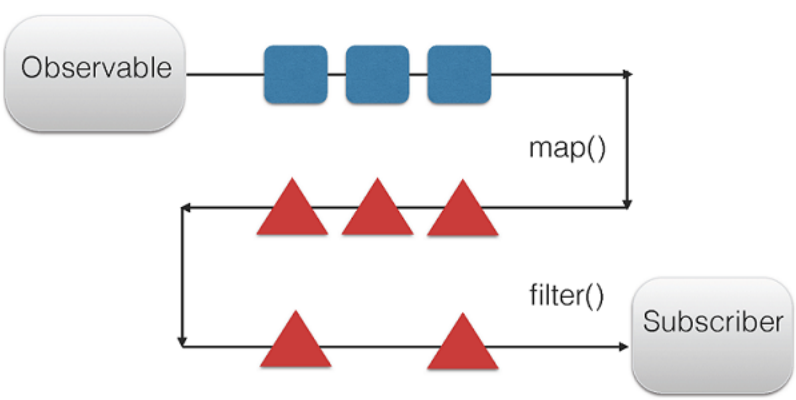


Figure 5.7 From observable to subscriber

A more realistic example would be a stream of `Customer` objects that's mapped to another stream containing only the `age` property of each customer. The first stream could be filtered to keep only those customer objects where `age < 50`.

IMPORTANT	**Chaining operators** Each operator accepts an observable object as an argument and returns an observable as well. This allows for chaining operators.

The documentation of reactive extensions (see the ReactiveX documentation for "Operators," http://reactivex.io/documentation/operators.html) uses *marble* diagrams to illustrate operators. For example, the `map()` operator is represented as the marble diagram shown in figure 5.8.

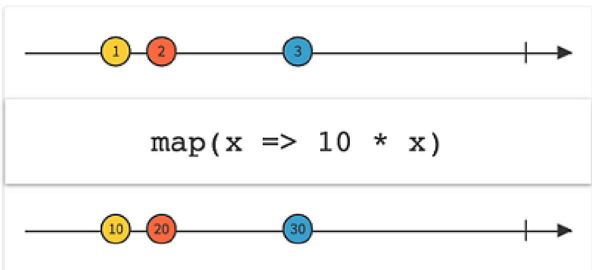


Figure 5.8 A marble diagram for map

This diagram illustrates a map operator that applies a function multiplying each element of the stream by ten. The vertical bars on the right represent the ends of the respective streams. On marble diagrams, errors are represented by red cross signs.

NOTE	**Interactive marble diagrams** Check out the RxMarbles website (http://rxmarbles.com), which offers interactive marble diagrams for a variety of Rx operators.

SIDEBAR **From arrays to iterables and observables**

JavaScript has a number of useful methods for working with arrays of data, such as these:

- `map()`—Allows you to apply a function to each element of the array. With `map()` you can transform one array into another without changing the number of its elements. For example, `myArray.map(convertToJSON)`.
- `filter()`—Allows you to apply a function to each element of an array, filtering out elements by applying some business logic; for example, `myArray.filter(priceIsLessThan100)`. The resulting array may have fewer elements than the original.
- `reduce()`—Allows you to produce an aggregate value from an array's elements; for example, `myArray.reduce((x,y)   x+y)`. The result of `reduce()` is always a single value.

A stream is a collection of data given to your application over time, and ES6 introduces the concept of *iterable* and *iterators* that allow you to treat an array as a data collection and iterate through its elements one at time.

The source of the iterable data doesn't have to be an array. You can write an ES6 generator function (see appendix A) that returns a reference to its iterator, and then you can start *pulling* the data (one at a time) from this iterator: `myIterator.next().value`. For each value, you can apply some business logic, and then reach out for the next element.

An observable object is a more advanced version of an iterator. Iterators use the pull model for retrieving the data, whereas observables push the data to subscribers.

It's probably easier to understand the concept of an observable stream by visualizing asynchronous data coming from the server. We'll see such an example later in this chapter, and more in chapter 8 while learning how to work with HTTP requests and websockets, but the concept of an observable stream can be applied to events as well. Is an event a one-time deal that just needs a handler function? Can you think of an event as a sequence of elements provided over time? We'll discuss event streams next.

NOTE **Turning a service into an observable**

You'll see how to turn any service into an observable in chapter 8.

5.2.2 Observable event streams

Earlier in this chapter, you learned about the syntax of event binding in templates. Now let's take a closer look at the event handling.

Each event is represented by the `Event` object (or a descendant) containing properties describing the event. Angular applications can handle standard DOM events and can create and *emit* (dispatch) custom events as well.

A handler function for an event can be declared with an optional `$event` parameter that contains a JavaScript object with properties describing the event. With standard DOM events, you can use any functions or properties of the browser's `Event` object (see the Mozilla Developer Network documentation for "Event," http://mzl.la/1EAG6iw).

In some cases, you won't be interested in reading the event object's properties, such as when the only button on a page is clicked, and this is all that matters. In other cases, you may want to know specific information, such as what character was entered in the `<input>` field when the `keyup` event was dispatched:

```
template:`<input (keyup)="onKey($event)">`
...

onKey(event:any) {
  console.log("You have entered " + event.target.value);
}
```

The preceding code snippet accesses the `value` property of the `<input>` element by using `event.target`, which points at the element that dispatched the event. But Angular allows you to get ahold of the HTML element (and its properties) right inside the template by declaring a *template local variable* that will always hold a reference to its HTML element.

The following code fragment declares a `mySearchField` local template variable (the name must start with a hash sign), extracts the value of the hosting HTML element (`<input>` in this case), and passes it to the event handler function rather than the reference to the `Event` object. Note that the hash sign is needed only to declare a local variable in the template; you don't need the hash when using this variable in the JavaScript portion of the code:

```
template:`<input #mySearchField (keyup)="onKey(mySearchField.value)">`
...

onKey(value: string) {
  console.log("You have entered " + value);
}
```

NOTE **Custom events**

If your code dispatches a custom event, it can carry application-specific data, and the event object can be strongly typed (not just be of the type `any`). You'll see how to do this in chapter 6, in the section titled "Output properties and custom events."

A traditional JavaScript application treats a dispatched event as a one-time deal; for example, one click results in one function invocation. Angular offers another approach where you consider events as observable streams of data happening over time. Handling observable streams is an important technique to master, so let's see what it's all about.

By subscribing to a stream, your code expresses an interest in receiving the stream's elements. During subscription, you specify the code to be invoked when the next element is emitted, and optionally the code for error processing and stream completion. Often you'll specify a number of chained operators and then invoke the `subscribe()` method.

How does all this apply to events coming from the UI? You could use event binding that handles multiple `keyup` events and handles the value of `lastStockSymbol`:

```
<input type='text' (keyup) = "getStockPrice($event)">
```

Isn't this technique good enough for handling multiple events? Imagine that the preceding code is used to get a price quote for the AAPL stock. After the user types the first A, the `getStockPrice()` function will make a `Promise`-based request to the server, which will return the price of A, if there is such a stock. Then the user enters the second A, which results in another server request for the AA price quote. The process repeats for AAP and AAPL.

This isn't what we want, and we can arrange a 500 millisecond delay so the user can have enough time to type several letters. The `setTimeout()` function comes to the rescue!

What if the user types slowly, and during the 500 millisecond interval manages only to enter AAP? The first request for AAP goes to the server, and 500 milliseconds later the second request for AAPL is sent. A program can't cancel the first HTTP request if the server returns a `Promise`, so we'll just keep our fingers crossed that our users type quickly and don't overload the server with unwanted requests.

With observable streams, there's a better solution to this problem, and some of the Angular UI components can generate them. For example, the `FormControl` class is one of the fundamental blocks of forms processing that represents form elements. Each form element has its own `FormControl` object. By default, whenever the value of the form element changes, `FormControl` emits the `valueChanges` event, which produces an observable stream you can subscribe to.

Let's write a small app that uses a simple form with one input field that generates an observable stream. To understand the next example, you just need to know that form elements are bound to Angular component properties via the `formControl` attribute.

> **NOTE** **Template-based vs. reactive forms**
> There's a way to program forms just by using directives in the component's template. These are *template-driven forms*. You can also program forms by creating form-related objects in the TypeScript code of your components. These are *reactive forms*. We'll cover Angular forms in chapter 7.

The following code sample (observable-events.ts) applies just one operator, `debounceTime()`, prior to invoking `subscribe()`. RxJS supports dozens of operators that you can use with `Observable` streams (see the RxJS documentation, http://bit.ly/1SuZzul), but Angular didn't reimplement all of them inside the framework. That's why we need to import additional operators from RxJS, which is a peer dependency of Angular. The `debounceTime()` operator allows us to specify a delay in emitting data elements of a stream.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { FormControl,  ReactiveFormsModule} from '@angular/forms';
//import 'rxjs/Rx'; // import all operators
import 'rxjs/add/operator/debounceTime';   ❶

@Component({
    selector: "app",
    template: `
       <h2>Observable events demo</h2>
      <input type="text" placeholder="Enter stock" [formControl]="searchInput">   ❷
    `
})
class AppComponent {

    searchInput: FormControl = new FormControl('');

    constructor(){

        this.searchInput.valueChanges
            .debounceTime(500)   ❸
            .subscribe(stock => this.getStockQuoteFromServer(stock));   ❹
    }

    getStockQuoteFromServer(stock: string) {

        console.log(`The price of ${stock} is ${100*Math.random().toFixed(4)}`);
    }
}

@NgModule({
    imports:      [ BrowserModule,  ReactiveFormsModule],   ❺
    declarations: [ AppComponent],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

1. You can either import the implementation of specific operators as here, or import all of them using import 'rxjs/Rx';.
2. This <input> element is represented by the ngFormControl named search.
3. Waits 500 milliseconds before emitting the next event with the content of the <input> element.
4. Subscribes to the observable stream.
5. Imports the module supporting reactive forms.

The `subscribe()` method will create the instance of the `Observer`, which in our example will pass each next value from the stream generated by the `searchInput` to the `getStockQuoteFromServer()` method. In a real-world scenario, this method would issue a request to the server, and you'll see such an app in the next section, but for now this function just generates a random number.

If we didn't use the `debounceTime()` operator, the `valueChanges` event would be emitted after each character typed by the user. To prevent processing each keystroke, we instruct `searchInput` to emit the data with a 500 millisecond delay, which allows the user to enter several characters before the content of the input field is emitted into the stream.

IMPORTANT	**When the operators are invoked** No matter how many operators you chain together, none of them will be invoked on the stream until you invoke `subscribe()`.

Figure 5.9 shows a screenshot taken after we started the preceding application and entered AAPL in the input field.

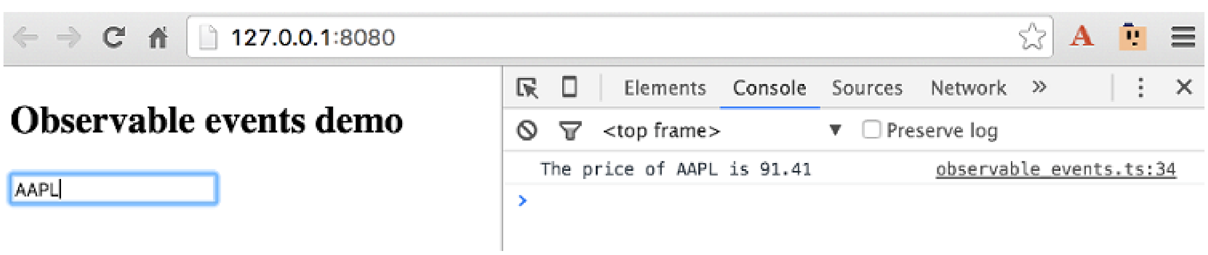


Figure 5.9 Getting the price for AAPL

> **NOTE** **Which event triggers the stream**
> In the previous code sample, we handled an observable stream that the `FormControl` object provided for us when the DOM object emitted the `change` event. If you prefer to generate an observable stream based on another event (such as on `keyup`), you can use the RxJS `Observable.fromEvent()` API (see the RxJS documentation on GitHub, http://bit.ly/1SkT7WL).

You may argue that you could have implemented the preceding example by simply handling the `input` event, which would be dispatched when the user finished entering the stock symbol and moved the focus out of the input field. This is true, but there are many scenarios where you'll want an immediate response from the server, such as retrieving and filtering a data collection as the user types.

The preceding example doesn't actually make any network requests to the server for price quotes—we simply generate random numbers on the user's computer. Even if the user enters a wrong stock symbol, this example will result in a local invocation of `Math.random()`, which has a negligible effect on the application's performance. In a real-world application, the user's typos may generate network requests that introduce delays while returning quotes for mistakenly entered stock symbols. In the next section we'll show you how to cancel pending server requests with observable streams.

5.2.3 How to cancel observables

One of the benefits of observables over promises is that the former can be canceled. In the previous section we offered one scenario in which a typo might result in useless server requests. Implementing master-detail views is another use case for a request cancellation. Say a user clicks on a row in a list of products to see the product details that must be retrieved from the server. Then they change their mind and click on another row, which will issue another server request, and the pending request should ideally be canceled.

Let's look at how you can cancel pending requests by creating an application that will issue HTTP requests as the user types in the input field. Now we'll handle two observable streams:

- The observable stream produced by the search field
- The observable stream produced by the HTTP requests issued while the user is typing in the search field

For this example (observable-events-http.ts) we'll use the free weather service at http://openweathermap.org, which provides an API for making weather requests for cities around the world. It returns the weather information as a JSON-formatted `string`. For example, to get the current temperature in London in Fahrenheit (`units=imperial`) the URL would look like this:

```
http://api.openweathermap.org/data/2.5/find?q=London&units=imperial&appid=12345
```

To use this service, we went to openweathermap.org and received from them an application ID (`appid`). The following example constructs the request URL by concatenating the base URL with the entered city name and the application ID. As the user enters the characters of the city name, the code subscribes to the event stream and issues HTTP requests. If a new request is issued before the response from the previous one comes back, the `switchMap()` operator cancels the previous request and sends the new one to this weather service. Canceling pending requests can't be done with promises. This example also uses the `FormControl` directive to generate an observable stream from the input field where the user enters the name of the city.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { FormControl,  ReactiveFormsModule} from '@angular/forms';
import {HttpModule, Http} from '@angular/http';

import {Observable} from 'rxjs/Rx';
import 'rxjs/add/operator/switchMap';
import 'rxjs/add/operator/map';
import 'rxjs/add/operator/debounceTime';

@Component({
    selector: "app",
    template: `
      <h2>Observable weather</h2>
      <input type="text" placeholder="Enter city" [formControl]="searchInput">
      <h3>{{temperature}}</h3>
    `
})
class AppComponent {
  private baseWeatherURL: string= 'http://api.openweathermap.org/data/2.5/find?q=';
  private urlSuffix: string = "&units=imperial&appid=ca3f6d6ca3973a518834983d0b318f73";

  searchInput: FormControl = new FormControl('');
  temperature: string;

  constructor(private http:Http){

      this.searchInput.valueChanges
        .debounceTime(200)
        .switchMap(city => this.getWeather(city))
        .subscribe(
            res => {
                if (res['cod'] === '404') return;
                if (!res.main) {
                        this.temperature ='City is not found';
                } else {

                        this.temperature =
                           `Current temperature is  ${res.main.temp}F, ` +
                            `humidity: ${res.main.humidity}%`;
```

```
            }
          },
          err => console.log(`Can't get weather. Error code: %s, URL: %s`, err.message, err.url),
  ❹
            () => console.log(`Weather is retrieved`)  ❺
        );
  }

  getWeather(city: string): Observable<Array<string>> {
    return this.http.get(this.baseWeatherURL + city + this.urlSuffix)  ❻
        .map(res => {
            console.log(res);
            return res.json()});  ❼
  }
}

@NgModule({
    imports:      [ BrowserModule,  ReactiveFormsModule,
                   HttpModule],  ❽
    declarations: [ AppComponent],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

❶ Imports the required HTTP support.

❷ The switchMap() operator takes the entered value from input field (the first observable) and passes it to the getWeather() method, which will issue the HTTP request to the weather service.

❸ The subscribe() method is needed to start the observable emitting its data, which in this case is emitted in 200-millisecond intervals.

❹ The second argument of subscribe() is a callback that will be invoked in the case of an error.

❺ The third argument of subscribe() is invoked after the stream is complete.

❻ The getWeather() method constructs the URL and defines the HTTP GET request.

❼ The map() operator takes the data that arrives in JSON form wrapped in the response object and converts it to an object.

❽ Adds HttpModule.

We'd like you to recognize two observables in the preceding app:

- The `FormControl` directive creates an `Observable` from the input field events (`this.searchInput.valueChanges`).
- `getWeather()` also returns an `Observable`.

We use the `switchMap()` operator instead of `subscribe` when the function that handles data generated by observable can also return an observable. Then we use `subscribe()` for the second observable:

Observable1 switchMap(function) Observable2 subscribe()

We're switching over from the first `Observable` to the second one. If Observable1 pushes the new value, but the function that creates Observable2 hasn't finished yet, it's killed and the `switchMap()` unsubscribes and resubscribes to Observable1 and starts handling the new value from this stream.

If the observable stream from the UI pushes the next value before `getWeather()` has returned its observable value, `switchMap()` kills the running `getWeather()`, gets the new value for the city from the UI, and invokes `getWeather()` again. While killing `getWeather()`, it also aborts the HTTP request that was slow and didn't complete in time.

The first argument of `subscribe()` contains a callback for handling data coming from the server. The code in this arrow expression is specific to the API provided by the weather service. We just extract the temperature and humidity from the returned JSON. The API offered by this particular weather service stores the error codes inside the response, so we had to manually handle the status 404 here and not in the error handler callback.

Now we'll show you that canceling the previous requests really works. Typing the word London takes more than the 200 milliseconds specified in `debounceTime()`, which means that the `valueChanges` event will emit the observable data more than once. To ensure that the request to the server takes more than 200 milliseconds we need a slow internet connection.

NOTE	**Code in constructors** In the preceding example, we put lots of code in the constructor, which may look like a red flag to developers who prefer using constructors just for initializing variables and not for executing any code that takes time to complete. If you take a closer look at the code, though, you'll notice that it just creates a subscription to two observable streams (UI events and HTTP service). No actual processing is done until the user starts entering the name of a city, which happens after the component is already rendered.

Let's run the preceding example and then turn on throttling in Chrome Developer Tools, emulating a slow GPRS connection. In our case, typing the word "London" resulted in four `getWeather()` invocations: for "Lo", "Lon", "Lond", and "London". Accordingly, four HTTP requests were sent over the slow connection, and three of them were automatically canceled by the `switchMap()` operator as seen in figure 5.10.

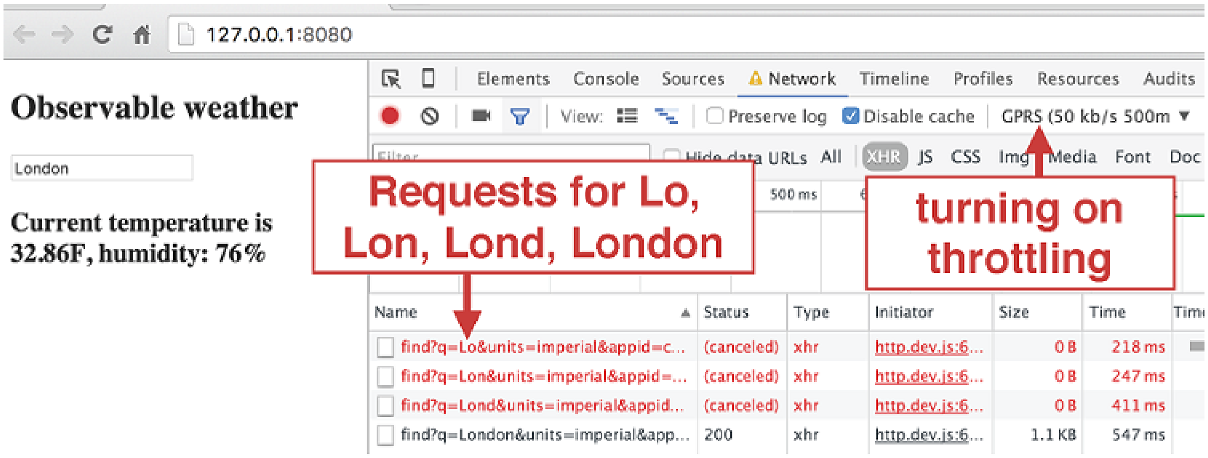


Figure 5.10 Running observable_events_http.ts

As you can see, with a very little programming we saved bandwidth by eliminating the need for the server to send us four HTTP responses for cities that we're not interested in and that may not even exist. As we stated in chapter 1, a good framework is one that allows you to write less code.

Pipes is yet another Angular feature that allows you to achieve more with less manual coding.

NOTE	**Another version of the weather app** Chapter 9 contains a refactored version of the weather application.

5.3 Pipes

A pipe is a template element that allows you to transform a value into a desired output. A pipe is specified by adding the vertical bar (`|`) and the pipe name right after the value to be transformed:

```
template: `<p>Your birthday is {{ birthday | date }}</p>`
```

Angular comes with a number of predefined pipes, and each pipe has a class that implements its functionality (such as `DatePipe`) as well as the name that you can use in the template (such as `date`):

- `UpperCasePipe` allows you to convert an input string into uppercase by using `| uppercase` in the template.
- `DatePipe` allows you to display a date in different formats by using `| date`.
- `CurrencyPipe` transforms a number into a desired currency by using `| currency`.
- `AsyncPipe` will unwrap the data from the provided `Observable` stream by using `| async`. You'll see a code sample that uses `async` in chapter 8.

Some pipes don't require input parameters (such as `uppercase`), and some do (such as `date:'medium'`). You can chain as many pipes as you want. The next code snippet shows how you can display the value of the `birthday` variable in a medium date format and in the uppercase (for example, JUN 15, 2001, 9:43:11 PM):

```
template=
   `<p>
      {{ birthday | date:'medium' | uppercase}}
   </p>`
```

As you can see, with literally no coding you can convert a date into the required format as well as show it in uppercase (see the date formats in the Angular DatePipes documentation, http://mng.bz/78lD).

SIDEBAR **A workaround for broken pipes**

At the time of writing, such pipes as `date`, `number`, and `currency` don't work in all browsers. There are two workarounds for this issue:

- Add the polyfill service to your index.html:
  <script
  src="https://cdn.polyfill.io/v2/polyfill.min.js?features=Intl.~locale.en"></script>
  This service will polyfill just what your browser needs.
- If you don't want (or aren't allowed) to load scripts from CDNs, add the internationalization package to your project:

  ```
  npm install intl@1.1.0 --save
  ```

  Then add the following lines to your index.html:

  ```
  <script src="node_modules/intl/dist/Intl.min.js"></script>
  <script src="node_modules/intl/locale-data/jsonp/en.js"></script>
  ```

The second solution will increase the size of your application by 33 KB.

You can read more about pipes in the Angular documentation at http://bit.ly/236vyVx , which includes the name of the class implementing a particular pipe as well as examples of its use.

5.3.1 Custom pipes

In addition to predefined pipes, Angular offers a simple way to create custom pipes, which can include code specific to your application. You need to create a `@Pipe` annotated class that implements the `PipeTransform` interface. The `PipeTransform` interface has the following signature:

```
export interface PipeTransform {
  transform(value: any, ...args: any[]): any;
}
```

This tells us that a custom pipe class must implement just one method with the preceding signature. The first parameter of `transform` takes a value to be transformed, and the second defines zero or more parameters required for your transformation algorithm. The `@Pipe` annotation is where you specify the name of the pipe to be used in the template.

If your component uses custom pipes, they have to be explicitly listed in its `@Component` annotation in the `pipes` property.

In the previous section, our weather example displayed the temperature in London in Fahrenheit. But most countries use the metric system and show temperature in Celsius. Let's create a custom pipe that can convert the temperature from Fahrenheit to Celsius and back.

The code of our custom `TemperaturePipe` pipe (see temperature-pipe.ts) can be used in a template as `temperature`.

```
import {Pipe, PipeTransform} from '@angular/core';

@Pipe({name: 'temperature'})   ❶
export class TemperaturePipe implements PipeTransform {

    transform(value: any[], fromTo: string): any {   ❷

        if (!fromTo) {   ❸
          throw "Temperature pipe requires parameter FtoC or CtoF ";
        }

        return (fromTo == 'FtoC') ?
                  (value - 32) * 5.0/9.0:  // F to C
                   value * 9.0 / 5.0 + 32;  // C to F
    }
}
```

❶ The name of our pipe is temperature, and it can be used in the component's template.

❷ A custom pipe implements the PipeTransform interface, so we must add the transform method.

❸ If this pipe is used without providing a format, we throw an error. An alternative approach would be to return the provided value without transformation.

Next comes the code of the component (pipe-tester.ts) that uses our `temperature` pipe. Initially this program will convert the temperature from Fahrenheit to Celsius (the `FtoC` format). By clicking the toggle button, you can change the direction of the temperature conversion.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
```

```
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { FormsModule } from '@angular/forms';
import {TemperaturePipe} from './temperature-pipe';

@Component({
  selector: 'app',
  pipes:[TemperaturePipe],   ❶

  template:`<input type='text' value="0"
            placeholder= "Enter temperature" [(ngModel)] = "temp">
            <button (click)="toggleFormat()">Toggle Format</button>
            <br>In {{targetFormat}} this temperature is
                {{temp | temperature: format | number:'1.1-2'}}`   ❷

})
class AppComponent {

    temp: number;
    toCelsius: boolean=true;
    targetFormat: string ='Celsius';
    format: string='FtoC';   ❸

    toggleFormat(){   ❹

        this.toCelsius = !this.toCelsius;
        this.format = this.toCelsius? 'FtoC': 'CtoF';

        this.targetFormat = this.toCelsius?'Celsius':'Fahrenheit';
    }
}
@NgModule({
    imports:      [ BrowserModule, FormsModule],   ❺
    declarations: [ AppComponent],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

❶ Explicitly lists our custom pipe in the @Component annotation.

❷ Chains our temperature pipe with Angular's number pipe to display the resulting temperature as a number having at least one digit before the decimal point and up to two digits after.

❸ The initial value, FtoC, will be passed as a parameter to our temperature pipe.

❹ When the user clicks on the toggle button, switch the conversion direction and change the output text accordingly.

❺ Imports FormsModule required for ngModel support.

In the hands-on section, we'll create yet another custom pipe for filtering auctioned products.

5.4 Hands-on: Filtering products in the online auction

In this exercise we'll use observable event streams to filter featured products on the home page of the online auction. An auction (or any online store) may display many products, which complicates the finding of a specific product.

For example, auction users may remember just a couple of letters in a product title, and to spare them from scrolling through pages of products, we'll let them start typing the product title to filter out products that don't match. Most importantly, the rendered product list must change as the user types.

This is a good use case for applying reactive observable event streams. The user types a letter, which emits the next element of the stream that represents the current content of the search field. The subscriber of this stream provides immediate filtering and re-rendering of the products on the UI. In this scenario, we won't make any requests to the server.

> **NOTE** **How to work on the online auction app**
> We'll use the auction application developed in chapter 4 as a starting point for this exercise. If you prefer to see the final version of this project, just browse the source code in the auction folder for chapter 5. Otherwise, copy the auction folder from chapter 4 to a separate location, run `npm install`, and follow the instructions below.

1. Create a custom pipe `FilterPipe`. To do so, create a new pipes subdirectory under app, and in pipes create the filter-pipe.ts file, implementing the custom pipe `FilterPipe`. This file should have the following content:

```
import { Pipe, PipeTransform} from '@angular/core';

@Pipe({name: 'filter'})
export class FilterPipe implements PipeTransform {

  transform(list: any[], filterByField: string, filterValue: string): any {


     if (!filterByField || !filterValue) { ❶
         return list;
     }


     return list.filter(item => { ❷
         const field = item[filterByField].toLowerCase();
         const filter = filterValue.toLocaleLowerCase();
         return field.indexOf(filter) >= 0;
     });
  }
}
```

❶ If either the field name or the filter's value aren't provided, don't filter.

❷ Filters the array of Product objects by the property passed in the filterByField parameter. It returns true only for those array elements that have characters provided as a filterValue.

2. Modify `HomeComponent` to use `FilterPipe`. `HomeComponent` is the parent of `<auction-product-item> components`, and it also has a variable `products` that stores an array of products provided by the `ProductService`. Our `FilterPipe` will filter out the elements of this array.

   We need to add an `<input>` element where the user can enter a filter criterion. `HomeComponent` will subscribe to the observable stream of events from this input field to get the value for the pipe.

   Finally, we need to use our custom pipe, which requires the following:

   1. Import the `FilterPipe`.
   2. Include `FilterPipe` in the `pipes` property of the `@Component` annotation.
   3. Apply the filter in the `*ngFor` loop to each array element.

      Modify the code of the home.ts file so it looks like this:

```
import {Component} from '@angular/core';
import {FormControl} from '@angular/forms';
import {Product, ProductService} from '../../services/product-service';
import CarouselComponent from '../carousel/carousel';
import ProductItemComponent from '../product-item/product-item';
import {FilterPipe} from '../pipes/filter-pipe' ❶
import 'rxjs/add/operator/debounceTime';

@Component({
  selector: 'auction-home-page',
  pipes: [FilterPipe], ❷
  styleUrls: ['app/components/home/home.css'],
  template: `
    <div class="row carousel-holder">
      <div class="col-md-12">
        <auction-carousel></auction-carousel>
      </div>
    </div>
    <div class="row">
      <div class="col-md-12">
        <div class="form-group">
          <input placeholder="Filter products by title"
                 class="form-control" type="text"
                 [formControl]="titleFilter"> ❸
        </div>
      </div>
    </div>
    <div class="row">
      <div *ngFor="let product of products | filter:'title':filterCriteria" class="col-sm-4
❹
        <auction-product-item [product]="product"></auction-product-item>
      </div>
    </div>
  `
})
export default class HomeComponent {
  products: Product[] = [];
  titleFilter: FormControl = new FormControl();
  filterCriteria: string;

  constructor(private productService: ProductService) {
    this.products = this.productService.getProducts();
    this.titleFilter.valueChanges
      .debounceTime(100)
      .subscribe( ❺
```

```
            value => this.filterCriteria = value,
            error => console.error(error));
    }
}
```

❶ Import the pipe.

❷ Add the pipe to the @Component annotation.

❸ Add the input element where the user can type.

❹ Apply the filter pipe. filter is the name of our custom pipe, title is the product property to filter by, and filterCriteria is the name of the property that holds the current filter criteria entered by the user.

❺ Subscribe to the input's events stream and assign the filter value to match the current value of the <input> element.

3. Run the application by entering `npm start` in the Command window. Start typing any letters from the product title in the filter field, and you'll see that only the products that meet the filter criteria are rendered by the browser.

For reference, we ran the auction application and paused it in the debugger after typing the letter `f` in the filter field. Figure 5.11 shows a screenshot illustrating the input received by our `FilterPipe` before the filtering is complete.

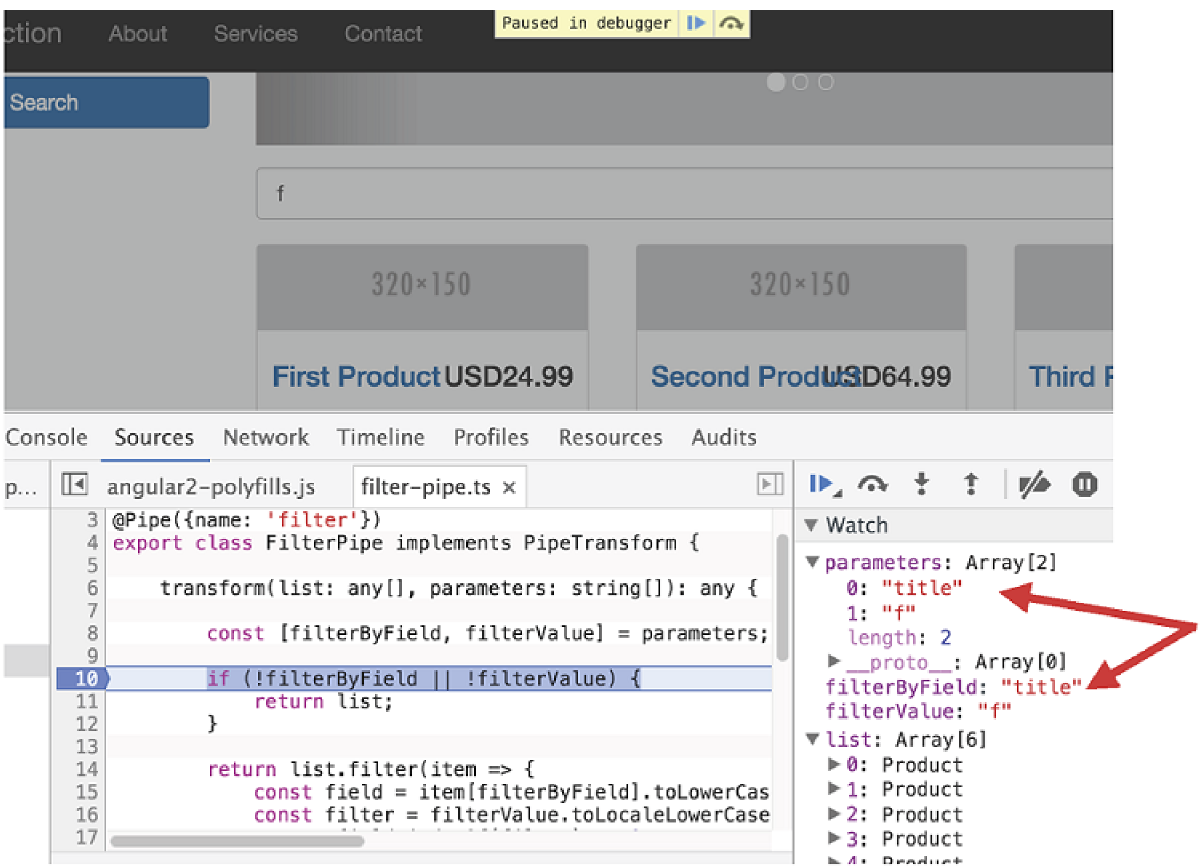


Figure 5.11 FilterPipe receives the values

In the Watch panel, you can see the values received by the `FilterPipe` as parameters. The arrows illustrate TypeScript destructuring in action. After the filtering is complete, this window shows only the products that have “f” in their titles.

In this hands-on exercise, we implemented the event observable stream and the custom pipe.

5.5 Summary

From a binding perspective, there’s a separation of responsibilities between a software developer and Angular. The developer is responsible for providing bindings between the component’s template and the supporting code. Angular applies its change-detection mechanism to ensure that bindings are immediately updated to reflect the current state of the application.

Observable streams is a fundamental concept of the *reactive* programming style, which is being practiced by developers in multiple programming languages. RxJS 5, the JavaScript library of reactive extensions, is integrated into the Angular framework.

These are the main takeaways from this chapter:

- Binding to a component’s properties propagates the data in one direction: from DOM to UI.
- Binding to events propagates actions from the UI to the component.
- Two-way binding is denoted with the `[()]` notation.
- A structural directive, `ngIf`, is used for adding nodes to and removing nodes from the browser’s DOM.
- Using observable data streams simplifies asynchronous programming. You can subscribe to and unsubscribe from a stream as well as cancel pending requests for data.

6 Implementing component communications

This chapter covers

- Creating loosely coupled components
- How a parent component should pass data to its child, and vice versa
- Implementing the Mediator design pattern to create reusable components
- A component lifecycle
- How change detection works

We’ve established that any Angular application is a tree of components. While designing components, we need to ensure that they’re reusable and self-contained, and at the same time have some means for communicating with each other. In this chapter we’ll focus on how components can pass data to each other in a loosely coupled manner.

First, we’ll show you how a parent component can pass data to its child by binding to the input properties of the child. Then you’ll see how a child component can send data to its parent by emitting events via its output properties.

We’ll continue with an example that applies the Mediator design pattern for arranging data exchange between components that don’t have parent-child relationships. The Mediator pattern is probably the most important pattern in any component-based framework.

Finally, we’ll discuss the lifecycle of an Angular component and the hooks that you can use to provide application-specific code that intercepts important events during a component’s creation, its lifespan, and its destruction.

6.1 Inter-component communication

Figure 6.1 depicts a view that consists of a number of components that are numbered and have different shapes for easier reference. Some of the components contain other components (let's call the outer ones *containers*), and others are peers. To abstract this from any particular UI framework we avoided using HTML elements like input fields, drop-downs, and buttons, but you can extrapolate this into a view of your real-world application.

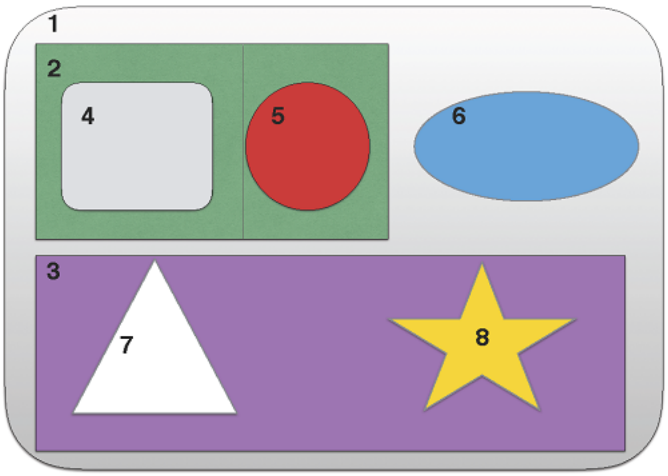


Figure 6.1 A view consists of components

When you design a view that consists of multiple components, the less they know about each other the better. Say a user clicks on the button inside component 4, which has to initiate some actions in component 5. Is it possible to implement this scenario without component 4 knowing that component 5 even exists? Yes, it is.

You've seen already examples of loosely coupling components by using dependency injection. Now we'll show you a different technique for achieving the same goal, using bindings and events.

6.1.1 Input and output properties

Think of an Angular component as a black box with outlets. Some of them are marked as `@Input()`, and others are marked as `@Output()`. You can create a component with as many inputs and outputs as you want.

If an Angular component needs to receive some values from the outside world, you can bind the producers of these values to the corresponding inputs of the component. Who are they received from? The component doesn't have to know. The component just needs to know *what* to do with these values when they're provided.

If a component needs to communicate some values to the outside world, it can *emit events* through its outputs. Who are they emitted to? The component doesn't have to know. Whoever is interested can listen to the events that a component emits.

Let's implement these principles. First we'll create an `OrderComponent` that can receive order requests from the outside world.

INPUT PROPERTIES

The input properties of a component are decorated with `@Input` and are used for getting data from the parent component. Imagine that we want to create a UI component for placing orders to buy stocks. It will know how to connect to the stock exchange, but that's irrelevant in the context of this discussion of input properties. We want to ensure that the `OrderComponent` receives data from other components via its properties marked with `@Input` annotations.

The following code sample (see input_property_binding.ts) includes two components: `AppComponent` (the parent) and `OrderComponent` (the child). The latter has two properties, `stockSymbol` and `quantity`, marked with `@Input` annotations. The `AppComponent` allows users to enter a stock symbol, which is passed to the `OrderComponent` via bindings.

We'll also pass `quantity` to the `OrderComponent`, but we won't use binding with `quantity` to illustrate the case when a parent needs to pass to the child a value that won't be changing. We'll leave the binding mechanism off by not surrounding the `quantity` attribute in the `<order-processor>` tag with square brackets.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component, Input } from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

@Component({
    selector: 'order-processor',
    template: `
    Buying {{quantity}} shares of {{stockSymbol}}
   `,
    styles:[`:host {background: cyan;}`]
})
class OrderComponent {


    @Input() stockSymbol: string;     ❶

    @Input() quantity: number;     ❷
}
@Component({
    selector: 'app',
    template: `
    <input type="text" placeholder="Enter stock (e.g. IBM)" (change)="onInputEvent($event)">
    <br/>

    <order-processor [stockSymbol]="stock"     ❸

            quantity="100"></order-processor>     ❹
   `
})
class AppComponent {
    stock: string;

    onInputEvent({target}):void{

        this.stock=target.value;     ❺
```

```
    }
}

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

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

1. Declares two input properties.
2. Binds the value of the stock property of AppComponent to the input property of OrderComponent.
3. Assigns the value 100 to the input property of OrderComponent. There's no binding here.
4. As soon as the user moves the focus from the AppComponent input field, the change event is dispatched, and OrderComponent will get a new stock symbol for processing.

NOTE **Losing types without binding**
Because we didn't use binding for the `quantity` attribute, the value `100` will arrive in the `OrderComponent` as a `string` (all values in HTML attributes are strings). If you want to preserve the types, use bindings, like this: `[quantity]="100"`.

NOTE **Binding is unidirectional**
If you change the values of `stockSymbol` or `quantity` in the `OrderComponent`, these changes won't affect the property values of the parent component. Property binding is unidirectional: from parent to child.

Figure 6.2 shows the browser's window after the user types IBM in the input field. The `OrderComponent` received the input values.

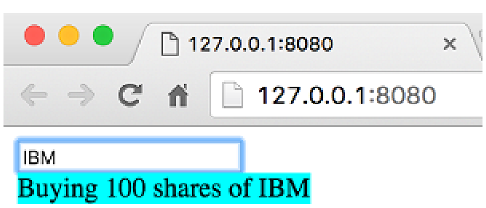


Figure 6.2 The OrderComponent got the values

The next question is how can a component intercept the moment when one of its input properties changes? A simple way is to change the input property to a setter. We use `stockSymbol` in the template of the component, so we need the getter as well.

Because we have a public setter, we renamed the variable to `_stockSymbol` and made it private.

```
private _stockSymbol: string;

@Input()
set stockSymbol(value: string) {
    this._stockSymbol = value;
    if (this._stockSymbol != undefined) {
      console.log(`Sending a Buy order to NASDAQ: ${this.stockSymbol} ${this.quantity}`);
    }
}

get stockSymbol(): string {
    return this._stockSymbol;
}
```

When this application starts, all input variables are initialized with default values, and the change-detection mechanism will qualify the initialization as a change of the bound variable `stockSymbol`. The setter will be invoked, and to avoid sending an order for the `undefined` `stockSymbol`, we check its value in the setter.

NOTE	**Intercepting changes in input properties** In section 6.2.1 we'll show you how to intercept the changes in input properties without using setters.

In chapter 3 we showed you how to pass parameters to a component using `ActivatedRoute`. In this scenario, parameters are being passed via constructor. Binding to `@Input()` parameters is a solution for passing data from parent to child, and it works only for components located within the same route.

OUTPUT PROPERTIES AND CUSTOM EVENTS

Angular components can dispatch custom events using the `EventEmitter` object. These events can be handled either inside the component or by its parents. `EventEmitter` is a subclass of `Subject` (implemented in RxJS), which can serve as both observable and observer. In other words, `EventEmitter` can dispatch custom events using its `emit()` method as well as consume observables using its `subscribe()` method. Because this section is about sending data from a component to the outside world, we'll be focusing on dispatching custom events here.

Let's say we need to write a UI component that's connected to a stock exchange and displays changing stock prices. This component may be used in a financial dashboard application in a brokerage firm. Besides displaying prices, this component should also send events with the latest prices to the outside world so other components can apply some business logic to the changing prices.

Let's create a `PriceQuoterComponent` that implements such functionality. For this example, we won’t connect to any servers but will rather emulate the changing prices using a random number generator. Displaying changing prices inside `PriceQuoterComponent` is pretty straightforward—we’ll bind the `stockSymbol` and `lastPrice` properties to the component’s template.

We’ll notify the outside world by emitting custom events via the `@Output` property of the component. Not only will we be firing the event as soon as the price changes, but this event will also carry a payload: an object with the stock symbol and the latest price. The following script (see output-property-binding.ts) implements this functionality.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component, Output, EventEmitter }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';


interface IPriceQuote {   ❶
    stockSymbol: string;
    lastPrice: number;
}

@Component({
    selector: 'price-quoter',
    template: `<strong>Inside PriceQuoterComponent: {{stockSymbol}}

        {{price | currency:'USD':true:'1.2-2'}}</strong>`,   ❷
    styles:[`:host {background: pink;}`]
})
class PriceQuoterComponent {

    @Output() lastPrice: EventEmitter <IPriceQuote> = new EventEmitter();   ❸

    stockSymbol: string = "IBM";   ❹
    price:number;

    constructor() {
      setInterval(() => {
          let priceQuote: IPriceQuote = {
              stockSymbol: this.stockSymbol,

              lastPrice: 100*Math.random()   ❺
          };

          this.price = priceQuote.lastPrice;


          this.lastPrice.emit(priceQuote)   ❻
      }, 1000);
    }
}
@Component({
   selector: 'app',
   template: `

   <price-quoter (lastPrice)="priceQuoteHandler($event)"></price-quoter><br>   ❼

   AppComponent received: {{stockSymbol}} {{price | currency:'USD':true:'1.2-2'}}`   ❽
})
@NgModule({
    imports:      [ BrowserModule],

    declarations: [ AppComponent, PriceQuoterComponent],   ❾
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

1. Declares a TypeScript interface to represent a price quote. This will help your IDE with error checking and type-ahead prompts.
2. Displays the stock symbol and price in the component's UI. We use CurrencyPipe for currency formatting.
3. The output property, lastPrice, is represented by the EventEmitter object, which will emit lastPrice events to the parents of this component.
4. In this example, we used a hard-coded value, IBM, as a stock symbol.
5. Emulates changing prices by invoking a function that generates a random number every second and populates the priceQuote object.
6. Sends each new price to whomever is interested via the output property by emitting an event, which carries the priceQuote object as a payload.
7. This tag represents the PriceQuoterComponent child component, which internally updates the price quotes in its template. On the application level, the event handler for the last-price event is invoked to display the price quote that arrives with the event object.
8. Displays the price quotes in the application's template as well.
9. The event handler receives the object of type IPriceQuote, and we extract the values of stockSymbol and lastPrice from it.

If you run this code sample, you'll see the prices update every second in both the `PriceQuoterComponent` (pink background) as well the `AppComponent` (white background) as shown in figure 6.3.

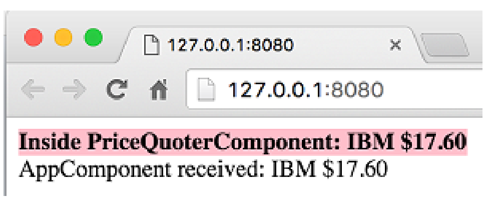


Figure 6.3 Running the output properties example

> **NOTE** **Changing the name of the custom event**
> By default, the name of a custom event is the same as the name of the output property, which is `lastPrice` in our case. If you want to emit an event with a different name, specify the name of the event as an argument to the `@Output` annotation. For example, to emit an event called `last-price`, declare the output property as `@Output('last-price') lastPrice;`.

In the preceding example, we created the `PriceQuoterComponent` as an Angular component because it includes the UI. But the business may require the functionality for price quote retrieval without the UI, so they can reuse it both on trader's applications as well as on large dashboards. We could implement the same functionality as an injectable service, as we did with `ProductService` in our online auction project.

SIDEBAR **Event bubbling**

As we write this, Angular doesn't offer a syntax to support event bubbling. For the `PriceQuoterComponent`, this means that if you try to listen to the `last-price` event not on this component but on its parent, the event won't bubble up there. In the following code snippet, the `last-price` event won't reach the `<div>` because it's the parent of `<price-quoter>`:

```
<div (last-price)="priceQuoteHandler($event)">
  <price-quoter ></price-quoter>
</div>
```

SIDEBAR If event bubbling is important to your application, don't use `EventEmitter`; use native DOM events instead. The following example is another version of the `PriceQuoterComponent` that handles event bubbling without using Angular's `EventEmitter`:

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component, ElementRef }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

interface IPriceQuote {
  stockSymbol: string,
  lastPrice: number
}

@Component({
  selector: 'price-quoter',
  template: `PriceQuoter: {{stockSymbol}} \${{price}}`,
  styles:[`:host {background: pink;}`]
})
class PriceQuoterComponent {
  stockSymbol: string = "IBM";
  price:number;

  constructor(element: ElementRef) {
    setInterval(() => {

      let priceQuote: IPriceQuote = {
        stockSymbol: this.stockSymbol,
        lastPrice: (100*Math.random()).toFixed(2)
      };

      this.price = priceQuote.lastPrice;

      element.nativeElement
          .dispatchEvent(new CustomEvent('last-price', {
            detail: priceQuote,
            bubbles: true
          }));
    }, 1000);
  }
}
```

```
@Component({
  selector: 'app',
  template: `
    <div (last-price)="priceQuoteHandler($event)">
      <price-quoter></price-quoter>
    </div>
    <br>
    AppComponent received: {{stockSymbol}} \${{price}}
  `
})
class AppComponent {

  stockSymbol: string;
  price:number;

  priceQuoteHandler(event: CustomEvent) {
    this.stockSymbol = event.detail.stockSymbol;
    this.price = event.detail.lastPrice;
  }
}
@NgModule({
  imports:      [ BrowserModule],
  declarations: [ AppComponent, PriceQuoterComponent],
  bootstrap:    [ AppComponent ]
})
class AppModule { }

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

SIDEBAR In the preceding application, Angular injects a reference to the DOM element that represents `<price-quoter>` using `ElementRef`, and then the custom event is dispatched by invoking `element.nativeElement.dispatchEvent()`. Event bubbling will work here, but keep in mind that this code becomes browser-specific and won't work with non-HTML renderers.

6.1.2 The Mediator pattern

When you design a component-based UI, each component should be self-contained, and they shouldn't rely on the existence of other UI components. Such loosely coupled components can be implemented using the Mediator design pattern, which according to Wikipedia "defines how a set of objects interact" (https://en.wikipedia.org/wiki/Mediator_pattern). We'll explain what this means by analogy with Lego toys.

Imagine a boy playing with Lego building blocks (think *components*) that "don't know" about each other. Today this boy (the *mediator*) can use some blocks to build a house, and tomorrow he'll construct a boat from the same components.

IMPORTANT **The role of the mediator**
The role of the mediator is to ensure that components properly fit together according to the task at hand, while remaining loosely coupled.

Let's revisit figure 6.1. Each component except number 1 has a parent (a container) that can play the role of mediator. The top-level mediator is container 1, which is responsible for making sure that components 2, 3, and 6 can communicate if need be. On the other hand, component 2 is a mediator for 4 and 5. Component 3 is the mediator for 7 and 8.

The mediator needs to receive data from one component and pass it to another. Let's go back to examples of monitoring stock prices.

Imagine a trader monitoring the prices of several stocks. At some point she clicks on the Buy button next to a stock symbol to place a purchase order with the stock exchange. We can easily add a Buy button to `PriceQuoterComponent` from the previous section, but this component doesn't know how to place orders to buy stocks. `PriceQuoterComponent` will notify the mediator (`AppComponent`) that the trader wants to purchase a particular stock at that very moment.

The mediator should know which component can place purchase orders and how to pass the stock symbol and quantity to it. Figure 6.4 shows how an `AppComponent` can mediate the communication between `PriceQuoterComponent` and `OrderComponent`.

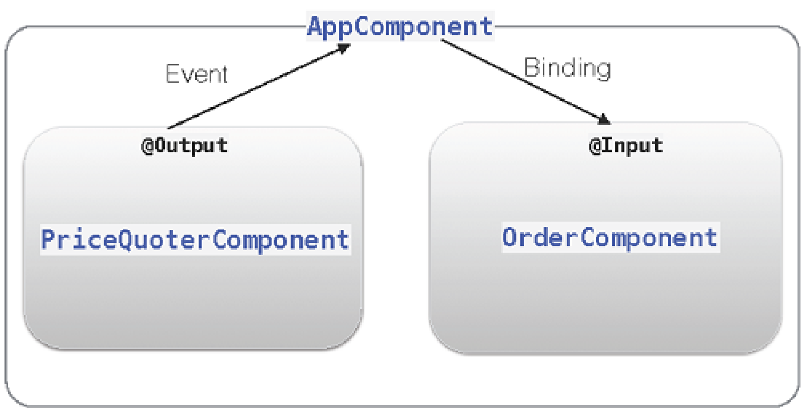


Figure 6.4 Mediating communications

IMPORTANT	**Emitting events works like broadcasting** `PriceQuoterComponent` emits events via the `@Output` property without knowing who will receive the events. `OrderComponent` just waits for the value of the `@Input` property to change as a signal for placing an order.

To demonstrate the Mediator pattern in action, let's write a small application that consists of the two components shown in figure 6.4. You can find this application in the mediator directory, which has the following files:

- stock.ts—The interface defining a value object that represents a stock
- price-quoter.ts—The `PriceQuoterComponent`
- order.ts—The `OrderComponent`
- mediator.ts—Hosts both `PriceQuoterComponent` and `OrderComponent`

We’ll use the `Stock` interface in two scenarios:

- To represent the payload of the event emitted by `PriceQuoteComponent`.
- To represent the data given to the `OrderComponent` via binding.

The content of the stock.ts file is shown here:

```
export interface Stock {
  stockSymbol: string;
  bidPrice: number;
}
```

We use SystemJS for transpiling the TypeScript on the fly. By default, SystemJS would turn the content of our stock.ts file into an empty `stock.js` module, and we’d get an error when the SystemJS loader tried to import it. We need to let SystemJS know that it has to treat `Stock` as a module. This can be done while configuring SystemJS by using the `meta` annotation, as shown in the following code extract from systemjs.config.js:

```
packages: {...},
meta: {
  'app/mediator/stock.ts': {
    format: 'es6'
  }
}
```

The `PriceQuoteComponent` shown next will have a Buy button and the `buy` output property. It will emit the `buy` event only when the user clicks on the Buy button.

```
import {Component, Output, Directive, EventEmitter} from '@angular/core';
import {Stock} from './stock';

@Component({
    selector: 'price-quoter',
    template: `<strong><input type="button" value="Buy" (click)="buyStocks($event)">
        {{stockSymbol}} \${{lastPrice | currency:'USD':true:'1.2-2'}}</strong>
              `,
    styles:[`:host {background: pink; padding: 5px 15px 15px 15px;}`]
})
export class PriceQuoterComponent {
    @Output() buy: EventEmitter <Stock> = new EventEmitter();

    stockSymbol: string = "IBM";
    lastPrice:number;

    constructor() {
        setInterval(() => {
            this.lastPrice = 100*Math.random();
        }, 2000);
    }

    buyStocks(): void{

        let stockToBuy: Stock = {
            stockSymbol: this.stockSymbol,
            bidPrice: this.lastPrice
        };
```

```
        this.buy.emit(stockToBuy);
    }
}
```

When the mediator (the `AppComponent` below) receives the `buy` event from `<price-quoter>`, it'll extract the payload from this event and assign it to the `stock` variable, which is bound to the input parameter of `<order-processor>`. The code of the mediator.ts is shown next.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component} from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

import {OrderComponent} from './order';
import {PriceQuoterComponent} from './price-quoter';
import {Stock} from './stock';

@Component({
    selector: 'app',
    template: `
    <price-quoter (buy)="priceQuoteHandler($event)"></price-quoter><br>
    <br/>
    <order-processor [stock]="stock"></order-processor>
  `
})
class AppComponent {
    stock: Stock;

    priceQuoteHandler(event:Stock) {
        this.stock = event;
    }
}
@NgModule({
    imports:      [ BrowserModule],
    declarations: [ AppComponent, OrderComponent,
                    PriceQuoterComponent],
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

When the value of the `buy` input property on `OrderComponent` changes, its setter will display the message "Placed order …", showing the `stockSymbol` and the `bidPrice`.

```
import {Component, Input} from '@angular/core';
import {Stock} from './stock';

@Component({
    selector: 'order-processor',
    template: `{{message}}`,
    styles:[`:host {background: cyan;}`]
})
export class OrderComponent {

    message:string = "Waiting for the orders...";

    private _stock: Stock;
```

```
    @Input() set stock(value: Stock ){
        if (value && value.bidPrice != undefined) {
            this.message = `Placed order to buy 100 shares of ${value.stockSymbol}
                at \$${value.bidPrice.toFixed(2)}`;
        }
    }

    get stock(): Stock{
        return this._stock;
    }
}
```

The screenshot in figure 6.5 was taken after the user clicked on the Buy button when the price of the IBM stock was $12.17.

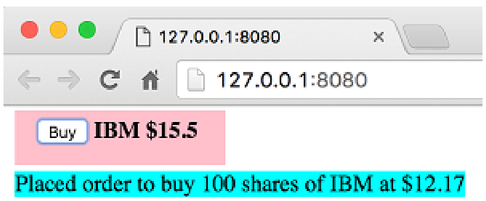


Figure 6.5 Running the mediator example

`PriceQuoteComponent` is rendered on top, and `OrderComponent` is at the bottom. They're self-contained and loosely coupled.

IMPORTANT	**Think of mediators early** Don't start implementing the UI components of your application until you've identified your mediators, the custom reusable components, and the means of communication between them.

The Mediator design pattern is a good fit for our online auction as well. Imagine the last minutes of a bidding war for a hot item. Users monitor frequently updated bids and click the button to increase their bids.

SIDEBAR **An alternative implementation of Mediator**

In this section you saw how sibling components use their parent as a mediator. If components don't have the same parent or aren't displayed at the same time (the router may not display the required component at the moment), you can use an injectable service as a mediator. Whenever the component is created, the mediator service is injected, and the component can subscribe to events emitted by the service (as opposed to using `@Input()` parameters like `OrderComponent` did).

If you'd like to see this in action, read the "Providing Search Results to HomeComponent" section in the hands-on exercise in chapter 8. Check the code of the `ProductService` that plays the role of the mediator. This service defines the `searchEvent: EventEmitter` variable, which is used by the `SearchComponent` to emit the data entered by the user. The `HomeComponent` subscribes to the `searchEvent` variable to receive the text entered by the user in the search form.

6.1.3 Changing templates at runtime with ngContent

In some cases you'll want to be able to dynamically change the content of a component's `template` at runtime. In AngularJS, this was known as *transclusion*, but the new term for it is *projection*. In Angular you can project a fragment of the parent component's template onto its child by using the `ngContent` directive. The syntax is pretty simple and requires two steps:

1. In the child component's template, include the tags `<ng-content></ng-content>` (the *insertion point*).
2. In the parent component, include the HTML fragment that you want to project into the child's insertion point between tags representing the child component (such as `<my-child>`):

```
template: `
  ...
  <my-child>
    <div>Passing this div to the child</div>
  </my-child>
  ...
`
```

In this example, the parent component won't render the content placed between `<my-child>` and `</my-child>`.

The following example (located in the basic-ng-content.ts file) illustrates this technique.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component, ViewEncapsulation}      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
```

```
@Component({
  selector: 'child',
  styles: ['.wrapper {background: lightgreen;}'],
  template: `
    <div class="wrapper">
     <h2>Child</h2>
      <div>This div is defined in the child's template</div>

      <ng-content></ng-content>    ❶
    </div>
  `,

  encapsulation: ViewEncapsulation.Native    ❷
})
class ChildComponent {}

@Component({
  selector: 'app',
  styles: ['.wrapper {background: cyan;}'],
  template: `
    <div class="wrapper">
     <h2>Parent</h2>
      <div>This div is defined in the Parent's template</div>
      <child>

        <div>Parent projects this div onto the child </div>    ❸
      </child>
    </div>
  `,
  encapsulation: ViewEncapsulation.Native
})
class AppComponent {}

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

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

❶ The content that comes from the parent is displayed here.

❷ By default, Angular uses the ViewEncapsulation.Emulated mode (see the Shadow DOM sidebar in chapter 3). We'll start with Native, and then we'll rerun this program in Emulated and None modes.

❸ This content won't be rendered by the AppComponent, but will be passed to ChildComponent instead.

We'll also use this example to illustrate how the Shadow DOM and Angular's `ViewEncapsulation` work. Have you noticed that both parent and child components use the `.wrapper` style in their outermost `<div>` elements? In a regular HTML page, this would mean that both parent and child would be rendered with the same style. We'll show that it's possible to encapsulate styles inside child components so they don't conflict with parent styles if their names are the same.

Figure 6.6 shows the running application in `ViewEncapsulation.Native` mode with the Developer Tools panel open. The `ChildComponent` got the HTML content from

AppComponent and created Shadow DOM nodes for parent and child (see #shadow-root on the right). Note that the .wrapper style from the parent's <div> (the cyan background) wasn't applied to the child's <div> also using the .wrapper style, which is rendered in the light green background. The child's #shadow-root acts as a wall protecting the child's styles from inheriting the parent's styles.

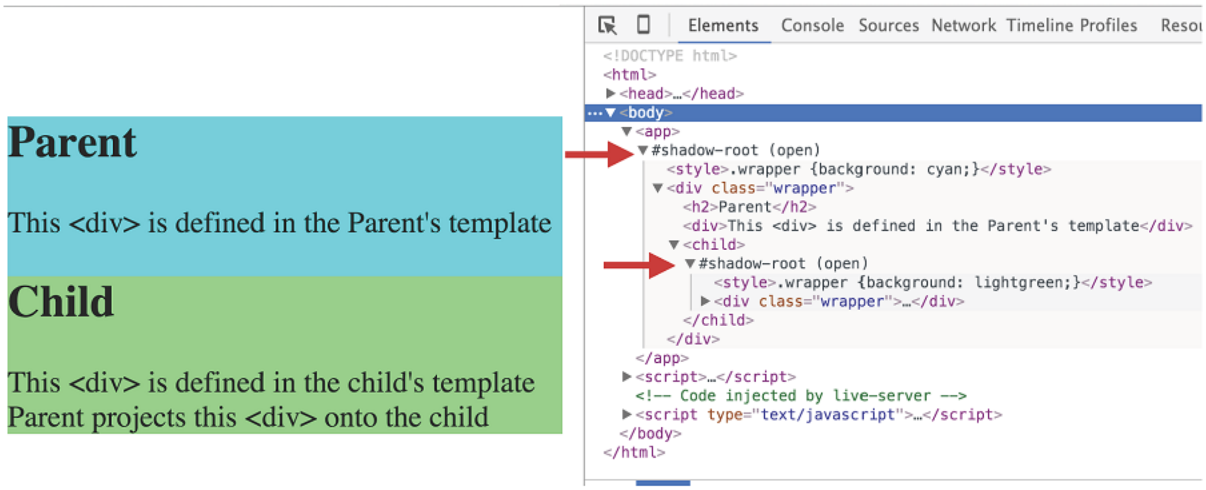


Figure 6.6 Running basic-ng-content.ts with ViewEncapsulation.Native

The screen shot in figure 6.7 was taken after changing encapsulation to ViewEncapsulation.Emulated. The DOM structure is different, and there are no #shadow-root nodes any longer. Angular generated additional attributes for the parent's and child's elements to implement encapsulation, but the UI is rendered the same way.

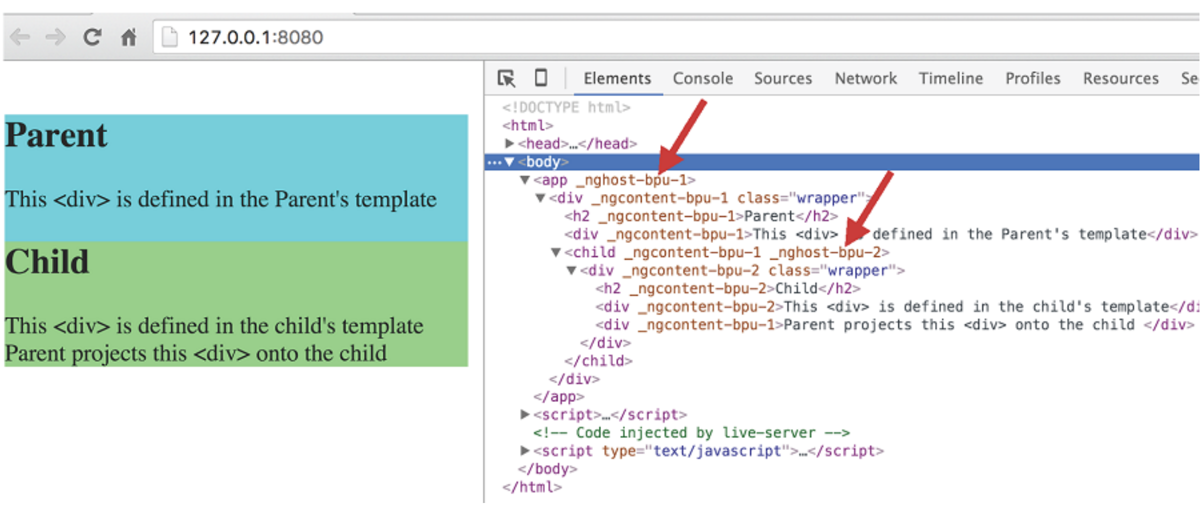


Figure 6.7 Running basic-ng-content.ts with ViewEncapsulation.Emulated

Figure 6.8 shows the same example running with encapsulation set to ViewEncapsulation.None. In this case, all the parent's and child's elements were merged into the main DOM tree, and the styles weren't encapsulated—the entire window is shown with the parent's light green background.

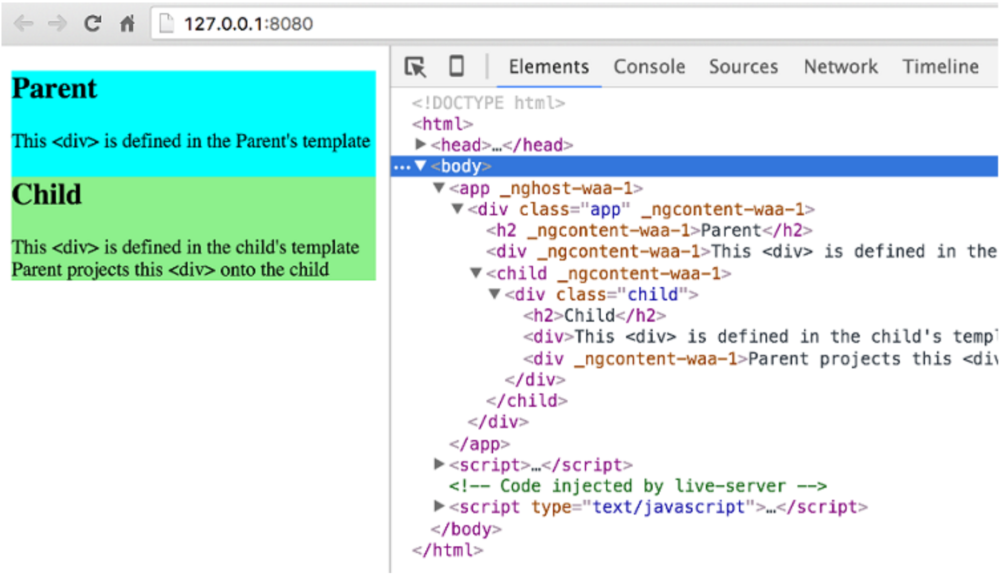


Figure 6.8 Running basic-ng-content.ts with ViewEncapsulation.None

PROJECTING INTO MULTIPLE AREAS

A component can have more than one `<ng-content>` tag in its template. Let's consider an example where a child component's template is split into three areas: header, content, and footer. The HTML markup for the header and footer could be projected by the parent component, and the content area could be defined in the child component. To implement this, the child component will need to include two separate pairs of `<ng-content></ng-content>` populated by the parent (header and footer).

To ensure that the header and footer content will be rendered in the proper `<ng-content>` areas, we'll use the `select` attribute, which can be any valid selector (a CSS class, a tag name, and so on). The child's template could look like this:

```
<ng-content select=".header"></ng-content>
<div>This content is defined in child</div>
<ng-content select=".footer"></ng-content>
```

The content that arrives from the parent will be matched by the selector and be rendered in the corresponding area. Here's the complete code that implements this (the ng-content-selector.ts file).

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component}      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

@Component({
  selector: 'child',
  styles: ['.child {background: lightgreen;}'],
  template: `
    <div class="child">
```

```
      <h2>Child</h2>
       <ng-content select=".header" ></ng-content>
       <div>This content is defined in child</div>
       <ng-content select=".footer"></ng-content>
     </div>
   `
})
class ChildComponent {}

@Component({
  selector: 'app',
  styles: ['.app {background: cyan;}'],
  template: `
    <div class="app">
     <h2>Parent</h2>
      <div>This div is defined in the Parent's template</div>
      <child>
        <div class="header" >Child got this header from parent {{todaysDate}}</div>
        <div class="footer">Child got this footer from parent</div>
      </child>
    </div>
  `
})
class AppComponent {
  todaysDate: string = new Date().toLocaleDateString();
}

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

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

Note that we use property binding in `AppComponent` to include today's date in the header. The projected HTML can only bind the properties visible in the parent's scope, so you can't use the child's properties in the parent's binding expression. Running this example will render the page shown in figure 6.9.

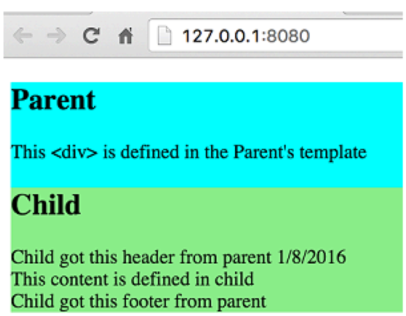


Figure 6.9 Running ng-content-select.ts

The `ngContent` directive with the `select` attribute allows you to create a universal component with a view divided into several areas that get their markup from the outside.

SIDEBAR

Direct binding to `innerHTML`

You can bind a component property with HTML content directly to `template`, as in this example:

```
<p [innerHTML]="myComponentProperty"></p>
```

But using `ngContent` is preferable to binding to `innerHTML` for the following reasons:

- `innerHTML` is a browser-specific API, whereas `ngContent` is platform independent.
- With `ng-content` you can define multiple slots where the HTML fragments will be inserted.
- `ngContent` allows you to bind the parent component's properties into projected HTML.

6.2 Component lifecycle

Various events happen during the lifecycle of an Angular component. When a component is created, the change-detection mechanism (which will be explained in the next section) starts monitoring the component. The component is initialized, added to the DOM, and rendered so the user can see it. After that, the state of the component (the values of its properties) may change, causing re-rendering of the UI, and finally the component is destroyed.

Figure 6.10 shows the lifecycle hooks (callbacks) where you can add custom code if need be. The callbacks shown on the light gray background will be invoked only once, and those on the darker blue background multiple times.

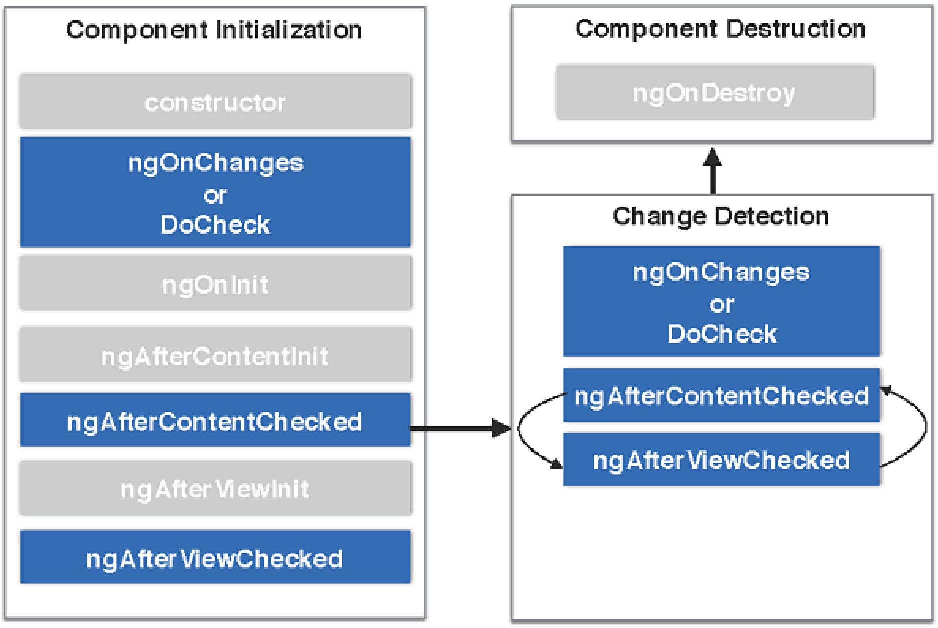


Figure 6.10 A component's lifecycle

The user sees the component after the initialization phase is complete. Then the change-detection mechanism ensures that the component's properties stay in sync with its UI. If the component is removed from the DOM tree as a result of the router's navigation or a structural directive (such as `ngIf`), Angular initiates the destroy phase.

The constructor is invoked first when the instance of the component is being created, but the component's properties aren't initialized yet in the constructor. After the constructor's code is complete, Angular will invoke the following callbacks *if you implemented them*:

- `ngOnChanges()`—Called when a parent component modifies (or initializes) the values bound to the input properties of a child. If the component has no input properties, `ngOnChanges()` isn't invoked. If a developer wishes to implement a custom change-detection algorithm, it has to be placed in `DoCheck()`. You shouldn't use both `ngOnChanges()` and `DoCheck()` in the same component.
- `ngOnInit()`—Invoked after the first invocation of `ngOnChanges()`, if any. Although you might initialize some component variables in the constructor, the properties of the component aren't ready yet. By the time `ngOnInit()` is invoked, the component's properties will have been initialized.
- `ngAfterContentInit()`—Invoked when the child component's state is initialized if you used the `ngContent` directive to pass some HTML code to it.
- `ngAfterContentChecked()`—Invoked on the child component that used `ngContent` after it gets the content from the parent (or during the change-detection phase) if the bindings used in `ngContent` change.
- `ngAfterViewInit()`—Invoked when the binding on the component's template is complete. The parent component is initialized first, and if it has children, this callback is invoked after all children are ready.
- `ngAfterViewChecked()`—Invoked when the change-detection mechanism checks if there are any changes in the component template's bindings. This callback may be called

more than once as the result of modifications in this or other components.

Whenever you see the word `Content` in the name of the lifecycle callback method, that method is applied if some content is projected using <ng-content>. When you see the word `View` in the name of the callback method, it applies to the template of the component. The word `Checked` means that the component's changes are applied and the component is synchronized with the DOM.

NOTE	**When not to write code in constructors** In our online auction application, we inject `ProductService` in the constructor of `HomeComponent` and invoke the method `getProducts()` right there. If the `getProducts()` method needed to use some values of the component's properties, we'd move the invocation of this method to `ngOnInit()` to ensure that all properties are initialized by the time we call `getProducts()`. The other reason to move code from the constructor to `ngInit()` is to keep the constructor's code light without starting any long-running synchronous functions from there.

Some applications may need to invoke specific business logic whenever the value of a property changes. For example, financial applications need to log each of a trader's steps, so if a trader placed a buy order at $101 and then immediately changed the price to $100, this must be tracked in a log file. This could be a good use case for adding logging in the `DoCheck()` callback.

During the destruction phase, your application may clean up system resources. Say your component is subscribed to some application-level service that keeps track of the application state (such as an application store offered by the Redux library). When Angular destroys this component, it should unsubscribe from the state service inside the `ngOnDestroy()` callback.

NOTE	**Naming conventions of lifecycle callbacks** Each of the lifecycle callbacks is declared in the interface with a name that matches the name of the callback without the prefix `ng`. For example, if you're planning to implement some functionality in the `ngOnChanges()` callback, add `implements OnChanges` to your class declaration.

For more information about the component lifecycle, read the Angular documentation on lifecycle hooks at http://mng.bz/6huZ. In the next section you'll see a code sample that uses one of the lifecycle hooks.

6.2.1 Using ngOnChanges

We'd like to illustrate component lifecycle hooks using `ngOnChanges()` as an example. Our example will include parent and child components, and the latter will have two input properties: `greeting` and `user`. The first property is a `string` and the second is an `Object` with one property, `name`. To understand why the `ngOnChanges()` callback may or may not be invoked, you need to be familiar with the concept of mutable vs. immutable objects.

SIDEBAR

Mutable vs. immutable

JavaScript strings are immutable, which means that when a string value is created in memory, it'll never change. Consider the following code snippet:

```
var greeting = "Hello";
greeting = "Hello Mary";
```

The first line creates the value `Hello` at a certain memory location, such as `@287651`. The second line doesn't change the value at that address but creates the new string `Hello Mary` at a different location, such as `@286777`. Now we have two strings in memory, and each of them is immutable.

What happens to the variable `greeting`? Its value changed, because initially it pointed at one memory location, and then to another.

JavaScript objects are mutable, which means that after the object instance is created at a certain memory location, it stays there even if the values of its properties change. Consider the following code:

```
var user = {name: "John"};
user.name = "Mary";
```

After the first line, the object is created and the `user` variable points at a certain memory location, such as `@277500`. The string `John` has been created at another memory location, such as `@287600`, and the `user.name` variable stores the reference to this address.

After the second line is executed, the new string `Mary` is created at another location, such as `@287700`, and the `user.name` variable stores the reference to this new address. But the variable `user` still stores the memory address `@277500`. In other words, we mutated the content of the object `@277500`.

Let's add the hook `ngOnChanges()` to the child component to demonstrate how it intercepts modifications of the input properties (see ng-onchanges-with-param.ts). This application has parent and child components. The child has two input properties (

`greetings` and `user`) and one regular property (`message`). The user will be able to modify the values of the input properties of the child. Let's demonstrate what property values will be given to the `ngChanges()` method if it's invoked.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component, Input,  OnChanges, SimpleChange, enableProdMode }
         from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {FormsModule} from '@angular/forms';

interface IChanges {[key: string]: SimpleChange};   ❶

@Component({
  selector: 'child',
  styles: ['.child{background:lightgreen}'],
  template: `
     <div class="child">
      <h2>Child</h2>
      <div>Greeting: {{greeting}}</div>
      <div>User name: {{user.name}}</div>
      <div>Message: <input [(ngModel)]="message"></div>
    </div>
  `
})
class ChildComponent implements OnChanges {
  @Input() greeting: string;   ❷
  @Input() user: {name: string};   ❸
  message: string = 'Initial message';   ❹

  ngOnChanges(changes: IChanges) {   ❺
    console.log(JSON.stringify(changes, null, 2));
  }
}

@Component({
  selector: 'app',
  styles: ['.parent {background: lightblue}'],
  template: `
     <div class="parent">
       <h2>Parent</h2>
      <div>Greeting: <input type="text" [value]="greeting"   ❻
      (change)="greeting = $event.target.value"></div> //
      <div>User name: <input type="text" [value]="user.name"   ❼
      (change)="user.name = $event.target.value"></div>

      <child [greeting]="greeting" [user]="user"></child>   ❽
    </div>
  `
})
class AppComponent {
  greeting: string = 'Hello';
  user: {name: string} = {name: 'John'};
}

enableProdMode();   ❼

@NgModule({
  imports:      [ BrowserModule, FormsModule],
  declarations: [ AppComponent, ChildComponent],
  bootstrap:    [ AppComponent ]
```

```
})
class AppModule { }

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

1. Declares a structural type for the object to store changes. It’s used in ngOnChanges().
2. The input properties of ChildComponent will get their values from AppComponent.
3. The message property doesn’t have the @Input annotation. We’ve added it to show that modifying its value won’t result in an invocation of the ngOnChanges callback.
4. Angular invokes ngOnChanges() when the bindings to input properties change.
5. In the parent component, we modify the values of greeting and user.name on the change event, which is dispatched when these fields lose focus.
6. The values of the parent’s greeting and user are bound to the child’s input properties.
7. Enables production mode (see the following note about “Enabling production mode”).

When Angular invokes `ngOnChanges()`, it provides the values of each modified input property. Each modified value is represented by an instance of the `SimpleChange` object that contains the current and previous values of the modified input property. The `Simple.change.isFirstChange()` method allows you to determine whether the value was set for the first time or if it’s just being updated. We use `JSON.stringify()` for pretty printing of the received values.

> **NOTE** **Using TypeScript structural types**
> TypeScript has a structural type system, so the type of the argument `changes` of `ngOnChanges()` is specified by including a description of the expected data. As an alternative, we could have declared an interface (such as `interface IChanges {[key: string]: SimpleChange};`), and the function signature would look like `ngOnChanges(changes: IChanges)`. The preceding declaration of the `user` property in `AppComponent` is yet another example of using the structural type.

Let’s see if changing `greeting` and `user.name` in the UI will result in the invocation of `ngOnChanges()` on the child component.

Figure 6.11 shows a screenshot after we ran the preceding example (on-changes-with-param.ts) with the Chrome Developer Tools open.

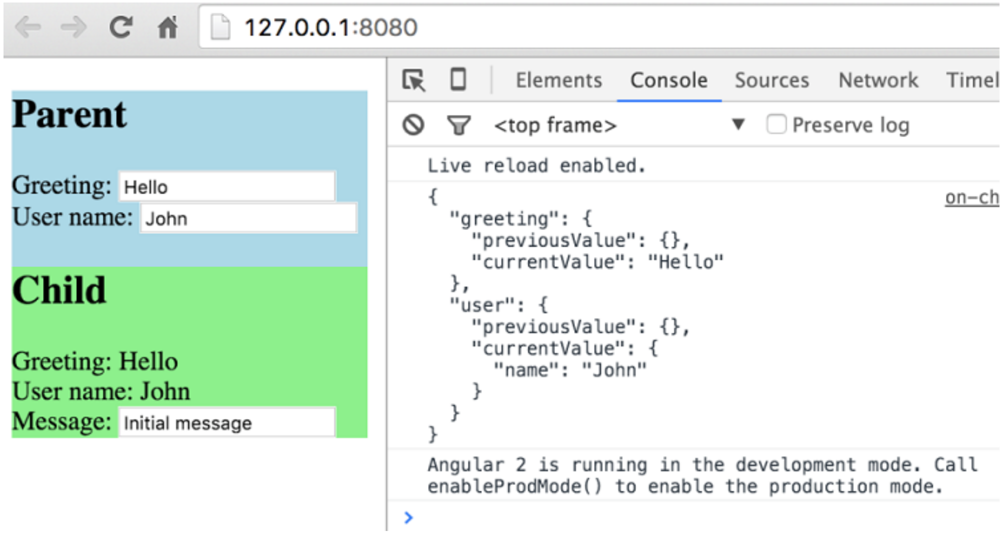


Figure 6.11 Initial invocation of ngOnChanges()

Initially, when the application applied the binding to the child component's input properties, they had no values. The `ngOnChanges()` callback was invoked, and the previous values of both `greeting` and `user` were changed from `{}` to `Hello` and `{name: "John"}` respectively.

NOTE	**Enabling production mode** In figure 6.11 you can see a message stating that Angular 2 is running in development mode, which performs assertions and other checks within the framework. One such assertion verifies that a change-detection pass doesn't result in additional changes to any bindings (for example, your code doesn't modify the UI in lifecycle callbacks). To enable production mode, invoke `enableProdMode()` in your application before invoking the `bootstrap()` method. Enabling production mode will result in better performance in the browser.

Let's have the user change the values in all the input fields. After adding the word `dear` to the Greeting field and moving the focus away, Angular's change-detection mechanism refreshes the binding to the child's *immutable* input property, `greeting`, invokes the `ngOnChanges()` callback, and our code prints the previous value as `Hello` and the current one as `Hello dear`, as shown in figure 6.12.

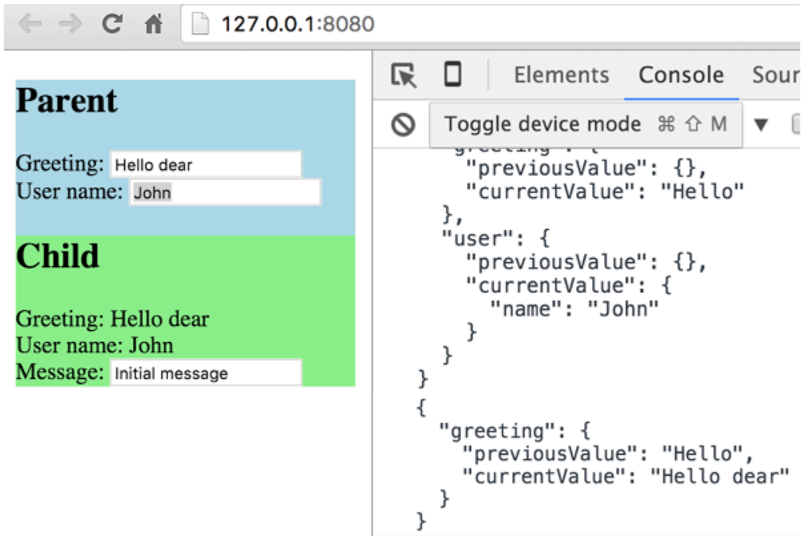


Figure 6.12 Invocation of ngOnChanges() after the greeting is changed

Now suppose the user adds the word Smith in the User Name field and moves the focus from this field: no new messages are printed on the console, as seen in figure 6.13. That's because the user changed only the `name` property of the *mutable* `user` object; the reference to the `user` object itself didn't change. This explains why `ngOnChanges()` wasn't invoked. Changing the value in the `message` property of the `ChildComponent` didn't invoke `ngOnChanges()` either, because this property wasn't annotated with `@Input`.

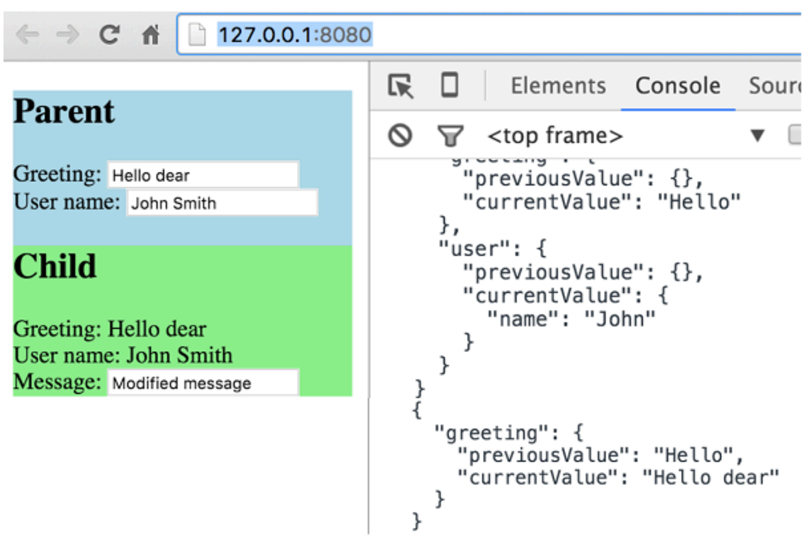


Figure 6.13 ngOnChanges() wasn't invoked this time

> **NOTE** **Bindings and change detection**
> Although Angular doesn't update bindings to input properties if the object reference hasn't changed, the change-detection mechanism still catches property updates on each object property. This is why John Smith, the new value of the User Name in the child component, has been rendered.

Earlier, in section 6.1.1, we used a setter to intercept the moment when the value of the input parameter changed. We could have used `ngOnChanges()` instead of the setters there. There are use cases when using `ngOnChanges()` instead of a setter isn't an option, and you'll see why in the hands-on section of this chapter.

6.3 A high-level overview of change detection

Angular's change-detection (CD) mechanism is implemented in zone.js (a.k.a. the Zone), and its main purpose is to keep the changes in the component properties (the model) and the UI in sync. CD is initiated by any asynchronous event that happens in the browser (the user clicked on a button, data is received from a server, a script invoked the `setTimeout()` function, and so on).

When CD runs its cycle, it checks all the bindings in the component's template. Why might binding expressions need to be updated? Because one of the component's properties changed.

> **NOTE** **Unidirectional change detection**
> The CD mechanism applies changes from a component's property to the UI. CD never changes the value of the component's property.

You can think of an application as a tree of components with the root component on the top of this tree. When Angular compiles component templates, each component gets its own change detector. When CD is initiated by the Zone, it makes one pass starting from the root down to the leaf components, trying to see if the UI of each component needs to be updated.

Angular implements two CD strategies: `Default` and `OnPush`. If all components use the `Default` strategy, the Zone checks the entire component tree regardless of where the change happened. If a particular component declares the `OnPush` strategy, the Zone will check this component and its children only if the bindings to the component's input properties have changed. To declare the `OnPush` strategy, you just need to add the following line to the component's template:

```
changeDetection: ChangeDetectionStrategy.OnPush
```

Let's get familiar with these strategies using three components, the parent, child, and grandchild depicted in figure 6.14.

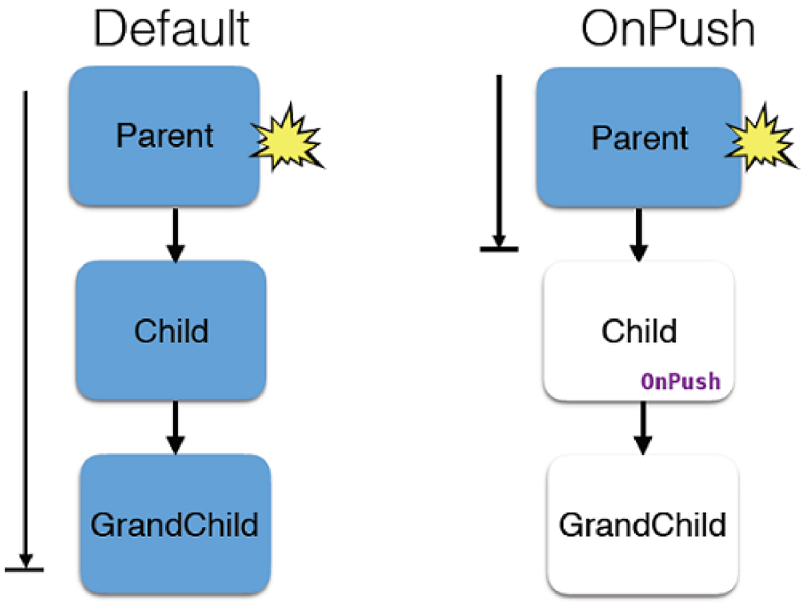


Figure 6.14 Change-detection strategies

Let's say a property of the parent was modified. CD will start checking the component and all its descendants. The left side of figure 6.14 illustrates the default CD strategy: all three components will be checked for changes.

The right side of figure 6.14 illustrates what happens when the child component has the `OnPush` CD strategy. CD starts from the top, but it sees that the child component has declared the `OnPush` strategy. If no bindings to the input properties of the child component have changed, CD won't check either the child or the grandchild.

Figure 6.14 shows a rather small application with only three components, but real-world apps can have hundreds of components, and with the `OnPush` strategy you can opt out of CD for specific branches of the tree.

Figure 6.15 depicts a CD cycle caused by an event in the GrandChild1 component. Even though this event happened in the leaf component, the CD cycle will start from the top and will be performed on each branch except the branches that originate from a component with the `OnPush` CD strategy and that has no changes in the bindings to its input properties. Components excluded from this CD cycle are depicted on the white background.

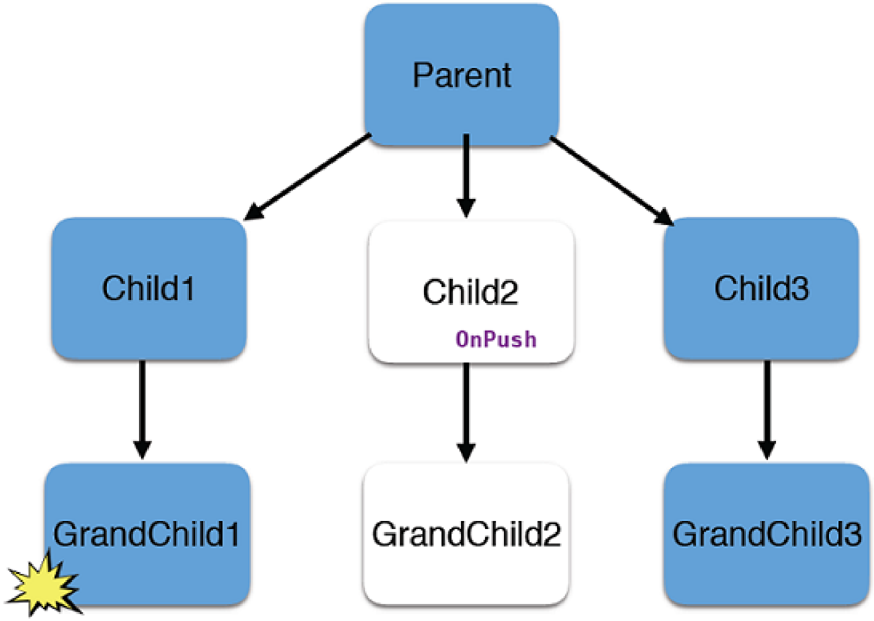


Figure 6.15 Excluding a branch from a CD cycle

This was a rather brief overview of the CD mechanism, which is probably the most sophisticated module of Angular. You should learn about CD in depth only if you need to work on performance tuning a UI-intensive application, such as a data grid containing hundreds of cells with constantly changing values.

For more details about change detection in Angular, read the article titled "Change Detection in Angular 2" by Victor Savkin at http://mng.bz/bD6v.

6.4 Exposing a child component's API

You've learned how a parent component can pass data to its child using bindings to input properties. But there are other cases when the parent simply needs to use the API exposed by the child. We'll show you an example that illustrates how a parent component can use the child's API from both the template and the TypeScript code.

Let's create a simple application in which a child component has a `greet()` method that will be invoked by the parent. To illustrate different techniques, the parent will use two instances of the same child component. These instances will have different template variable names:

```
<child #child1></child>
<child #child2></child>
```

Now you can declare a variable in your TypeScript code, annotated with `@ViewChild`. This annotation is provided by Angular for getting a reference to a child component, and we'll use it with the first child:

```
@ViewChild('child1')
firstChild: ChildComponent;
```

```
...
this.firstChild.greet('Child 1');
```

The preceding code instructs Angular to find the child component identified by the template variable `child1` and place the reference to this component into the variable `firstChild`.

To illustrate another technique, we'll access the second child component not from the TypeScript code but from the parent's template. It's as simple as this:

```
<button (click)="child2.greet('Child 2')">Invoke greet() on child 2</button>
```

The full code illustrating both techniques follows, and you can find it in the exposing-child-api.ts file as well.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component, ViewChild, AfterViewInit } from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

@Component({
    selector: 'child',
    template: `<h3>Child</h3>`

})
class ChildComponent {
    greet(name) {
        console.log(`Hello from ${name}.`);
    }
}

@Component({
    selector: 'app',
    template: `
    <h1>Parent</h1>
    <child #child1></child>
    <child #child2></child>

    <button (click)="child2.greet('Child 2')">Invoke greet() on child 2</button>
  `
})
class AppComponent implements AfterViewInit {
    @ViewChild('child1')
    firstChild: ChildComponent;

    ngAfterViewInit() {
        this.firstChild.greet('Child 1');
    }
}

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

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

When you run this app, it'll print "Hello from Child 1." on the console. Click on the button and it'll print "Hello from Child 2." as shown in figure 6.16.

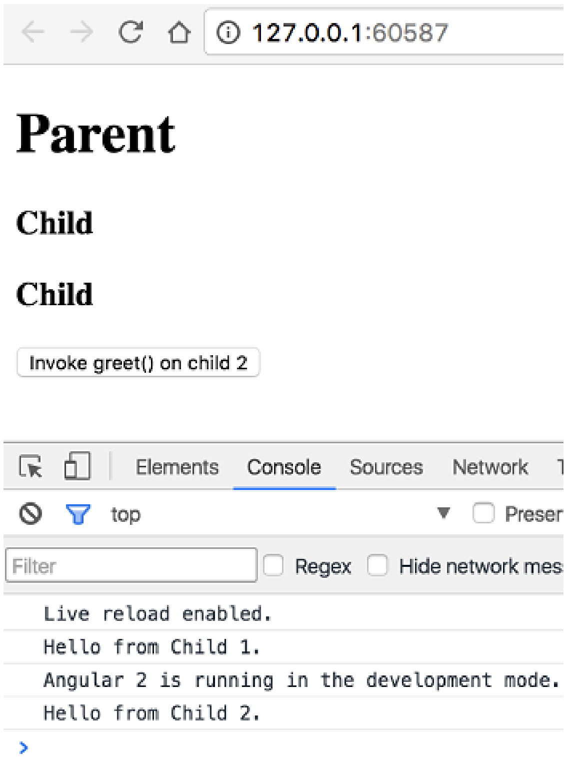


Figure 6.16 Accessing the child's API

NOTE	**Updating the UI from lifecycle hooks** In the preceding example we use the `ngAfterViewInit()` component lifecycle hook to invoke the API on the child. The child's `greet()` method doesn't change the UI this code works fine, but if you try to change the UI from `greet()`, Angular will throw an exception because the UI is changed after `ngAfterViewInit()` was fired. That's because this hook is called in the same event loop for both parent and child components. There are two ways to deal with this issue: run the application in production mode so Angular won't do the additional bindings check, or use `setTimeout()` for the code updating the UI so it runs in the next event loop.

6.5 Hands-on: Adding a rating feature to the online auction

In this hands-on section, we'll add a rating feature to our auction. Previous versions of this application just displayed the rating, but now we want to let users actually rate a product. In chapter 4 we created the Product Detail view, and now we'll add the Leave a Review button, which allows users to navigate to a view where they can assign one to five stars to a product and enter a review. A fragment of the new Product Detail view is shown in figure 6.17.

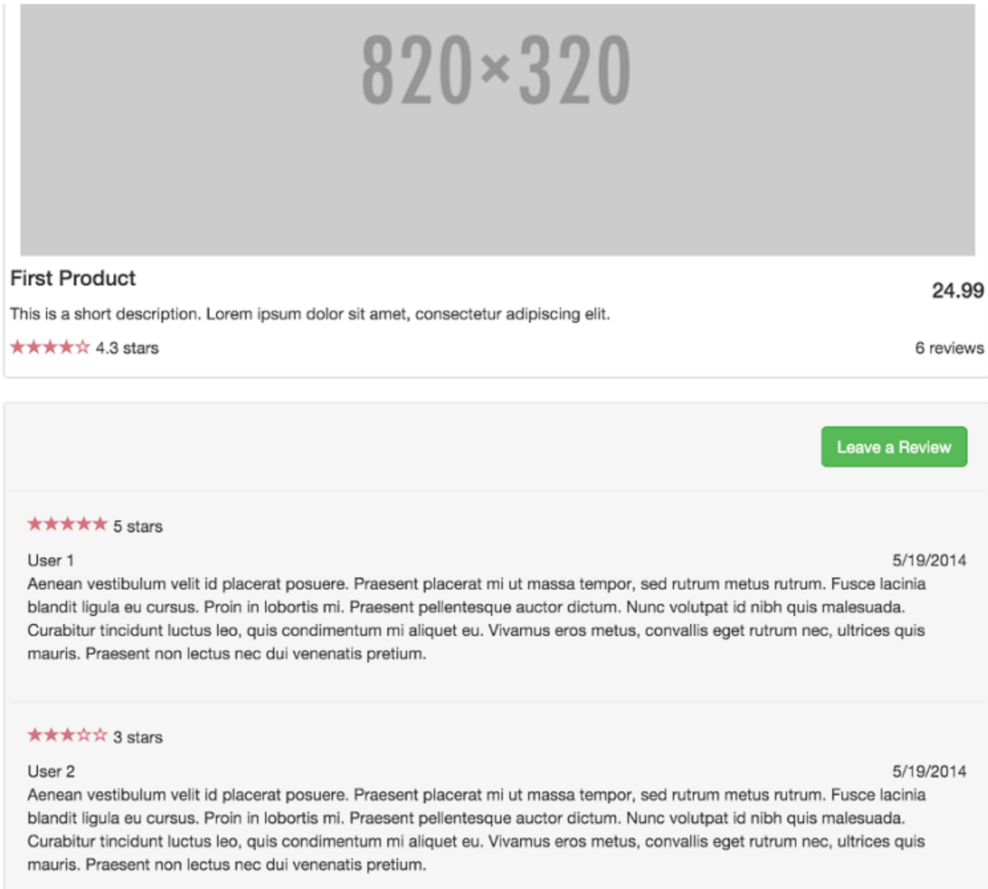


Figure 6.17 The Product Detail view

`StarsComponent` will have an input property, which will be modified, and the newly added rating's value needs to be communicated to its parent `ProductItemComponent`.

NOTE	**How to work on the online auction app** We'll use the auction application developed in chapter 5 as a starting point for this exercise. If you prefer to see the final version of this project, browse the source code in the auction folder for chapter 6. Otherwise, copy the auction folder from chapter 5 to a separate location. Then copy the package.json file from the auction folder for chapter 6, run `npm install`, and follow the instructions below.

NOTE **Installing a type definition file**

In this version of the app, we want to use the `Array.fill()` method in the `StarsComponent`, but this API is available only in ES6, and the TypeScript compiler will complain. We already have the ES6 shim installed locally as a part of the `core.js` package, but because we want to keep ES5 as a target for transpiling, we need an ES6 shim type declaration file so that this API is recognizable by the TypeScript compiler. We'll install an additional type definition file (see appendix B) from the npm repository. In general, you'll need to install type definition files whenever you add a third-party JavaScript library.

1. Install the type definitions file for ES6-shim. To do so, open a command window and run the following command:

   ```
   npm install @types/es6-shim --save-dev
   ```

   This command installs the es6-shim.d.ts file in the node_modules/@types directory and saves this configuration in the `devDependencies` section of package.json file. You should be using TypeScript 2.0, which knows to look for type definition files in the @types directory.
2. Modify the code of `StarsComponent`. The new version of the `StarsComponent` should work in two modes: read-only for displaying the stars based on the data provided by `ProductService`, and writable for allowing users to click on stars to set a new rating value.

   Figure 6.17 shows the rendering of the `ProductDetailComponent` (the parent) where `StarsComponent` (the child) is in read-only mode. If the user clicks on the Leave a Review button, read-only mode should be turned off. We'll add a `readonly` input variable to toggle this mode.

   The second input variable, `rating`, is for assigning ratings.

   We'll also add one output variable, `ratingChange`, that will emit an event with the newly set rating, which will be used by the parent component to recalculate the average rating.

   When the user clicks on one of the stars, it'll invoke the `fillStarsWithColor()` method, which will assign the value to `rating` and will emit the rating's value by dispatching an event.

   Modify the code of the stars.ts file so it looks like this:

   ```
   import {Component, EventEmitter, Input, Output} from '@angular/core';

   @Component({
     selector: 'auction-stars',
     styles: [`.starrating { color: #d17581; }`],
     templateUrl: 'app/components/stars/stars.html'
   })
   export default class StarsComponent {
     private _rating: number;
     private stars: boolean[];

     private maxStars: number =5;

     @Input() readonly: boolean = true;
   ```

```
  @Input() get rating(): number {
    return this._rating;
  }

  set rating(value: number) {
    this._rating = value || 0;
    this.stars = Array(this.maxStars).fill(true, 0, this.rating);
  }

  @Output() ratingChange: EventEmitter<number> = new EventEmitter();

  fillStarsWithColor(index) {

    if (!this.readonly) {
      this.rating = index + 1;
      this.ratingChange.emit(this.rating);
    }
  }
}
```

We use the setter for the input `rating`. This setter can be invoked either from within `StarsComponent` (to render an existing rating) or from its parent (when the user clicks on the stars). In our application, using `ngOnChange()` wouldn't work, because it would be invoked only once by the parent when `StarsComponent` is created.

Note the use of the ES6 method `fill()` in the `rating()` setter. We populate the `stars` array with the value `true` from element zero to whatever the rating value is. For each star that has to be filled with color, we store the value `true`, and for the empty stars we store `false`.

3. Modify the template of `StarsComponent`. Using the `ngFor` directive, we loop through the `stars` array, which stores Boolean values. We use the stock images that come with the Bootstrap library for filled and empty stars (see http://getbootstrap.com/components). Based on the value of the array's element, we render either a star filled with color or an empty one. When the user clicks on the star, we pass its index to the function `fillStarsWithColor()`.

   Now modify the content of the stars.html file so it looks like this:

```
<p>
  <span *ngFor="let star of stars; let i = index"
        class="starrating glyphicon glyphicon-star"
        [class.glyphicon-star-empty]="!star"
        (click)="fillStarsWithColor(i)">
  </span>
  <span *ngIf="rating">{{rating | number:'.0-2'}} stars</span>
</p>
```

   The `number` pipe formats the rating's value to show two digits after the decimal point.

4. Modify the template of `ProductDetailComponent`. The `ProductDetailComponent` has a Leave a Review button that should provide a means for rating a product and leaving a review. Clicking on this button will toggle the visibility of a `<div>` that allows users to click on stars and enter a review, as shown in figure 6.18.

   Here the `StarsComponent` works in the editable mode, and the user should be able to give up to five stars to the selected product. This is how the template implementing the view in figure 6.18 could look:

```
<div [hidden]="isReviewHidden">
    <div><auction-stars [(rating)]="newRating"
      [readonly]="false" class="large"></auction-stars></div>
    <div><textarea [(ngModel)]="newComment"></textarea></div>
```

```
    <div><button (click)="addReview()" class="btn">Add review</button></div>
</div>
```

The `readonly` mode is turned off. Note that we use two-way binding in two places: `[(rating)]` and `[(ngModel)]`. Earlier in this chapter we discussed the use of the `ngModel` directive for two-way binding, but if you have an input property (such as `rating`) and an output property that has the same name plus the suffix `Change` (such as `ratingChange`) you're allowed to use the `[()]` syntax with such properties.

The Leave a Review button toggles the visibility of the preceding `<div>`. This is how it can be implemented:

```
<button (click)="isReviewHidden = !isReviewHidden"
               class="btn btn-success btn-green">Leave a Review</button>
```

Replace the content of the product-detail.html file with the following:

```
<div class="thumbnail">
    <img src="http://placehold.it/820x320">
    <div>
        <h4 class="pull-right">{{ product.price }}</h4>
        <h4>{{ product.title }}</h4>
        <p>{{ product.description }}</p>
    </div>
    <div class="ratings">
        <p class="pull-right">{{ reviews.length }} reviews</p>
        <p><auction-stars [rating]="product.rating" ></auction-stars></p>
    </div>
</div>
<div class="well" id="reviews-anchor">
    <div class="row">
        <div class="col-md-12"></div>
    </div>
    <div class="text-right">
        <button (click)="isReviewHidden = !isReviewHidden"
                class="btn btn-success btn-green">Leave a Review</button>
    </div>

    <div [hidden]="isReviewHidden">
        <div><auction-stars [(rating)]="newRating"
          [readonly]="false" class="large"></auction-stars></div>
        <div><textarea [(ngModel)]="newComment"></textarea></div>
        <div><button (click)="addReview()" class="btn">Add review</button></div>
    </div>

    <div class="row" *ngFor="#review of reviews">
        <hr>
        <div class="col-md-12">
            <auction-stars [rating]="review.rating"></auction-stars>
            <span>{{ review.user }}</span>
            <span class="pull-right">{{ review.timestamp | date: 'shortDate' }}</span>
            <p>{{ review.comment }}</p>
        </div>
    </div>
</div>
```

After typing a review and giving stars to a product, the user clicks on the Add Review button, which invokes `addReview()` on the component. Let's implement it in TypeScript.

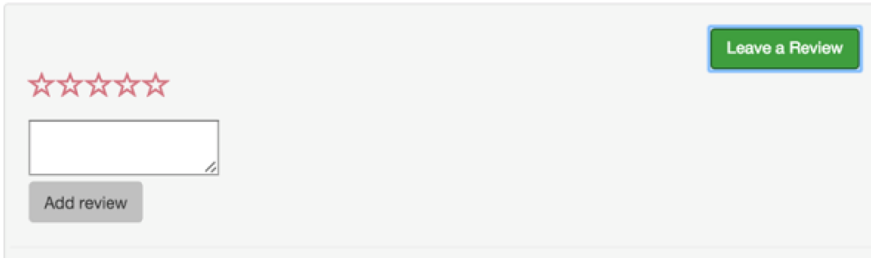


Figure 6.18 The Leave a Review view

5. Modify the product-detail.ts file. Adding a review should do two things: send the newly entered review to the server, and recalculate the average product rating on the UI. We'll recalculate the average on the UI, but we won't implement the communication with the server; we'll simply log the review on the browser's console. Then we'll add the new review to the array of existing reviews. The following code fragment from `ProductDetailComponent` implements this functionality.

```
addReview() {
  let review = new Review(0, this.product.id, new Date(), 'Anonymous',
      this.newRating, this.newComment);
  console.log("Adding review " + JSON.stringify(review));
  this.reviews = [...this.reviews, review];

  this.product.rating = this.averageRating(this.reviews);

  this.resetForm();
}

averageRating(reviews: Review[]) {
  let sum = reviews.reduce((average, review) => average + review.rating, 0);
  return sum / reviews.length;
}
```

After creating a new instance of the `Review` object, we need to add it to the `reviews` array. The spread operator allows us to write it in an elegant way:

```
this.reviews = [...this.reviews, review];
```

The `reviews` array will get the values of all existing elements (…`this.reviews`) plus the new one (`review`).

The recalculated average is assigned to the `rating` property, which will be propagated to the UI via binding.

What's left? Just replace the content of the product-detail.ts file with the following code, and this hands-on exercise is over!

```
import {Component} from '@angular/core';
import {ActivatedRoute} from '@angular/router';
import {Product, Review, ProductService} from '../../services/product-service';
import StarsComponent from '../stars/stars';

@Component({
  selector: 'auction-product-page',
  styles: ['auction-stars.large {font-size: 24px;}'],
  templateUrl: 'app/components/product-detail/product-detail.html'
})
export default class ProductDetailComponent {
  product: Product;
  reviews: Review[];
```

```
  newComment: string;
  newRating: number;

  isReviewHidden: boolean = true;

  constructor(route: ActivatedRoute, productService: ProductService) {

    let prodId: number = parseInt(route.snapshot.params['productId']);
    this.product = productService.getProductById(prodId);

    this.reviews = productService.getReviewsForProduct(this.product.id);
  }

  addReview() {
    let review = new Review(0, this.product.id, new Date(), 'Anonymous',
        this.newRating, this.newComment);
    console.log("Adding review " + JSON.stringify(review));
    this.reviews = [...this.reviews, review];
    this.product.rating = this.averageRating(this.reviews);

    this.resetForm();
  }

  averageRating(reviews: Review[]) {
    let sum = reviews.reduce((average, review) => average + review.rating, 0);
    return sum / reviews.length;
  }

  resetForm() {
    this.newRating = 0;
    this.newComment = null;
    this.isReviewHidden = true;
  }
}
```

6.6 Summary

Any Angular application is a hierarchy of components that need to communicate with each other. This chapter was dedicated to covering different ways of arranging such communication. Binding to the component’s input properties and dispatching events via the output properties allow you to create loosely coupled components.

By means of its change-detection mechanism, Angular intercepts changes in components’ properties to ensure that their bindings are updated.

Each component goes through a certain set of events during its lifecycle, and Angular provides several lifecycle hooks where you can write code for intercepting these events and apply custom logic there.

These are the main takeaways for this chapter:

- Parent and child components should avoid direct access to the internals of each other, but should communicate via input and output properties.
- A component can emit custom events via its output properties, and these events can carry an application-specific payload.
- Communications between unrelated components can be arranged by using the Mediator design pattern.
- A parent component can pass one or more template fragments to a child at runtime.

- Each Angular component allows the application developer to intercept major lifecycle events of a component and insert application-specific code there.
- The Angular change-detection mechanism automatically monitors changes to components' properties and updates the UI accordingly.
- You can mark selected branches of your app component tree to be excluded from the change-detection process.

7 Working with forms

This chapter covers

- Angular Forms API (NgModel, FormControl, FormGroup, form directives, FormBuilder)
- Template-driven forms
- Reactive forms
- Forms validation

Angular offers rich support for handling forms. It goes beyond regular data-binding by treating form fields as first-class citizens and providing fine-grained control over the form's data.

This chapter will start by demonstrating how you can implement a sample user registration form. While working on this form, we'll briefly discuss the standard HTML forms and their shortcomings. Then we'll see what the Angular Forms API brings to the table, and we'll cover the template-driven and reactive approaches to creating forms in Angular.

After covering the basics, we'll refactor the original version of our user registration form to use the template-driven approach, and we'll discuss its pros and cons. Then we'll do the same with the reactive approach. After that, we'll discuss form validation. At the end of the chapter we'll apply this new knowledge to the online auction application and start implementing its search form component.

SIDEBAR **Template-driven vs. reactive approaches**

In the *template-driven* approach, forms are fully programmed in the component's template. The template defines the structure of the form, the format of its fields, and the validation rules.

In contrast, the *reactive* approach creates the form model programmatically in the code (in TypeScript in our case). The template can be either statically defined and bound to an existing form model or dynamically generated based on the model.

By the end of the chapter, you'll become familiar with the Angular Forms API and the various ways of working with forms and applying data validation.

7.1 Overview of HTML forms

HTML provides basic features for displaying forms, validating entered values, and submitting the data to the server. But HTML forms may not be good enough for real-world business applications, which need a way to programmatically process the entered data, apply custom validation rules, display user-friendly error messages, transform the format of the entered data, and choose the way data is submitted to the server. For business applications, one of the most important considerations when choosing a web framework is how well it handles forms.

In this section we'll evaluate standard HTML form features using a sample user registration form, and we'll define a set of requirements that a modern web application needs to fulfill users' expectations. We'll also look at the form features provided by Angular.

7.1.1 Standard browser features

You might be wondering what we need from an application framework other than data-binding, if HTML already allows us to validate and submit forms? To answer this question, let's review an HTML form that uses only standard browser features.

Listing 7.1 Plain HTML user registration form

```
<form action="/register" method="POST">
  <div>Username:         <input type="text"></div>
  <div>SSN:              <input type="text"></div>
  <div>Password:         <input type="password"></div>
  <div>Confirm password: <input type="password"></div>
  <button type="submit">Submit</button>
</form>
```

The form contains a button and four input fields: username, SSN, password, and password confirmation. Users can enter whatever values they want: no input validation is applied here. When the user clicks the Submit button, the form's values are submitted to the server's `/register` endpoint using HTTP `POST`, and the page is refreshed.

The default HTML form behavior isn't a good fit for a SPA, which typically needs the following functionality:

- Validation rules should be applied to individual input fields.
- Error messages should be displayed next to the input fields that cause the problems.
- Dependent fields should be validated all together. Our form has password and password confirmation fields, so whenever any of them are changed, both fields should be revalidated.
- The application should be in control of the values submitted to the server. When user clicks the Submit button, the application should invoke an event-handler function to pass the form values. The application can validate the values or change their format before sending the submit request.
- The application should decide how the data is submitted to the server, whether it's a regular HTTP request, an AJAX request, or a WebSocket message.

HTML's validation attributes and semantic input types partially satisfy the first two requirements.

HTML VALIDATION ATTRIBUTES

There are several standard validation attributes that allow us to validate individual input fields: `required`, `pattern`, `maxlength`, `min`, `max`, `step`, and so on. For example, we could request that `username` be a required field, and its value should contain only letters and numbers:

```
<input id="username" type="text" required pattern="[a-zA-Z0-9]+">
```

We use a regular expression, `[a-zA-Z0-9]+`, to restrict what can be entered in this field. Now when the user clicks the Submit button, the form will be validated before the submit request is sent. In figure 7.1 you can see the default error message displayed in the Chrome browser when `username` doesn't conform to the specified pattern.

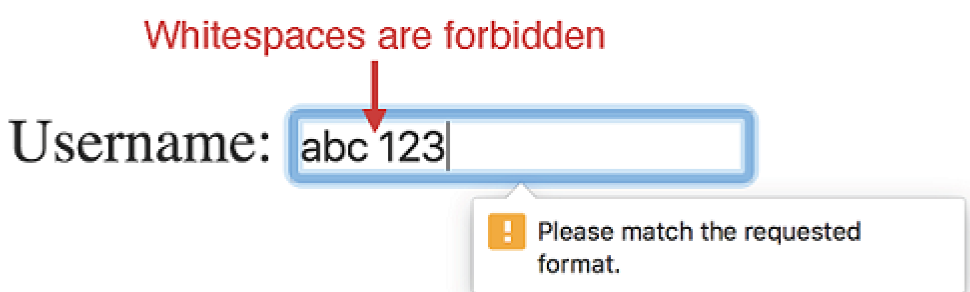


Figure 7.1 Validation error message

There are a number of problems with this message:

- It’s too vague and doesn’t help the user identify and fix the problem.
- As soon as the input field loses focus, the error message disappears.
- This message format likely won’t match other styles in your application.

This input field prevents users from submitting invalid values, but it doesn’t allow us to provide a decent user experience by helping the user with friendly client-side validation.

SEMANTIC INPUT TYPES

HTML supports multiple types of input elements: `text`, `number`, `url`, `email`, and so on. Choosing the right type for a field may prevent users from entering an invalid value. But although this provides a better user experience, it’s still not enough to satisfy application-specific validation needs.

Let’s consider a ZIP code field. It might be tempting to use the `number` input element, because a ZIP code is represented by a numeric value (at least in the USA). To keep the values within a certain range, we could use the `min` and `max` attributes. For example, for a 5-digit ZIP code we could use following markup:

```
<input id="zipcode" type="number" min="10000" max="99999">
```

But not every 5-digit number is a valid ZIP code. In a more complex example, we might also want to allow only a subset of ZIP codes from the user’s state.

To support all these real-world scenarios, we need more advanced forms support, and this is what an application framework can provide. Let’s see what Angular has to offer.

7.1.2 Angular’s Forms API

There are two approaches to working with forms in Angular: *template-driven* and *reactive*. These two approaches are exposed as two different APIs (sets of directives and TypeScript classes) in Angular.

With the template-driven approach, the form model is defined in the component’s template using directives. Because you’re limited to the HTML syntax while defining the form model, the template-driven approach suits only simple scenarios.

For complex forms, the reactive approach is a better option. With the reactive approach, the developer creates an underlying data structure in the code (not in the template). After the model is created, you link the HTML template elements to the model using special directives prefixed with `form*`. Unlike template-driven forms, reactive forms can be tested without a web browser.

Let’s highlight several important concepts to further clarify the difference between template-driven and reactive forms:

- Both types of forms have a *model*, which is an underlying data structure that stores the form's data. In the template-driven approach, the model is created implicitly by Angular based on the directives you attach to the template's elements. In the reactive approach, you create the model explicitly and then link the HTML template elements to that model.

- The model *isn't* an arbitrary object. It's an object constructed using classes defined in the `@angular/forms` module: `FormControl`, `FormGroup`, and `FormArray`. In the template-driven approach, you don't access these classes directly, whereas in the reactive approach you explicitly create instances of these classes.
- The reactive approach doesn't spare you from writing an HTML template. The view won't be generated for you by Angular.

SIDEBAR **Enabling Forms API support**

Both types of forms, template-driven and reactive, need to be explicitly enabled before you start using them. To enable template-driven forms, add `FormsModule` from `@angular/forms` to the `imports` list of the `NgModule` that uses the Forms API. For reactive forms, use `ReactiveFormsModule`. Here's how to do it:

```
import { NgModule } from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { FormsModule, ReactiveFormsModule } from '@angular/forms';

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

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

❶ Both form modules can be imported in the same application module.

We won't repeat this code for each code sample in this chapter, but all of them assume the modules are imported. All the downloadable code samples for the book import the modules in `AppModule`.

7.2 Template-driven forms

As we mentioned earlier, we can use only *directives* to define a model in the template-driven approach. But what directives can we use? These directives come with `FormsModule`: `NgModel`, `NgModelGroup`, and `NgForm`.

In chapter 5 we discussed how the `NgModel` directive can be used for two-way data binding. But in the Forms API, it plays a different role—it marks the HTML element that should become a part of the form model. Although these two roles are separate, they don't conflict and can be safely used at the same time on a single HTML element. We'll see examples later in this section.

Let's briefly look at these directives and then apply the template-driven approach to our sample registration form.

7.2.1 Directives overview

Here we'll briefly describe the three main directives from `FormsModule`: `NgModel`, `NgModelGroup`, and `NgForm`. We'll see how they can be used in the template and highlight their most important features.

NGFORM

`NgForm` is the directive that represents the entire form. It's automatically attached to every `<form>` element. `NgForm` implicitly creates an instance of the `FormGroup` class that represents the model and stores the form's data (more on `FormGroup` later in this chapter). `NgForm` automatically discovers all child HTML elements marked with the `NgModel` directive and adds their values to the form model.

The `NgForm` directive has multiple selectors that you can use to attach `NgForm` to non-`<form>` elements:

```
<div ngForm></div>      ❶
<ngForm></ngForm>       ❷
```

❶ Attribute selector

❷ Element selector

This syntax comes in handy if you're using a CSS framework that requires a certain structure for the HTML elements, and you can't use the `<form>` element.

If you want exclude a particular `<form>` from being handled by Angular, use the `ngNoForm` attribute:

```
<form ngNoForm></form>
```

The `ngNoForm` attribute prevents Angular from creating an instance of `NgForm` and attaching it to the `<form>` element.

`NgForm` has an `exportAs` property declared on its `@Directive` annotation, which allows you to use the value of this property to create a local template variable that references the instance of `NgForm`:

```
<form #f="ngForm"></form>
<pre>{{ f.value | json }}</pre>
```

First, you specify `ngForm` as the value of the `exportAs` property of NgForm, and `f` points at the instance of NgForm attached to the <form>. Then the variable f can be used to access instance members of the NgForm object. One of them is value, which represents the current value of all form fields as a JavaScript object. You can pass it through the standard json pipe to display the form's value on the page.

NgForm intercepts the standard HTML form's submit event and prevents automatic form submission. Instead it emits the custom ngSubmit event:

```
<form #f="ngForm" (ngSubmit)="onSubmit(f.value)"></form>
```

The code subscribes to the ngSubmit event using the event-binding syntax. onSubmit is an arbitrary name for the method defined in the component, and it's invoked when the ngSubmit event is fired. To pass all the form's values as an argument to this method, use the f variable to access NgForm's value property.

NGMODEL

In the context of the Forms API, NgModel represents a single field on the form. It implicitly creates an instance of the FormControl class that represents the model and stores the fields' data (more on FormControl later in this chapter).

You attach the FormControl object to an HTML element using the ngModel attribute. Note that the Forms API doesn't require either a value assigned to ngModel or any kind of brackets around the attribute:

```
<form>
  <input type="text"
         name="username"    ❶
         ngModel>           ❷
</form>
```

❶ The name attribute is required when you add ngModel to an element.

❷ No value or brackets denote the data-binding syntax. ngModel serves as a marker for the NgForm directive that represents the form.

The NgForm.value property points at the JavaScript object that holds the values of all form fields. The value of the field's name attribute becomes the property name of the corresponding property in the JavaScript object in NgForm.value.

Like NgForm, the NgModel directive has an exportAs property, so you can create a variable in the template that will reference an instance of NgModel and its value property:

```
<form>
```

```
  <input type="text"
         name="username"
         ngModel

         #c="ngModel">

  <pre>{{ c.value }}</pre>
</form>
```

1. The value of the exportAs property of NgModel directive is ngModel, and we assigned it to the local variable c.
2. The value property holds the current value entered in the previous <input> element.

NGMODELGROUP

`NgModelGroup` represents a part of the form and allows you to group form fields together. Like `NgForm`, it implicitly creates an instance of the `FormGroup` class. Basically, `NgModelGroup` creates a nested object inside the object stored in `NgForm.value`. All the child fields of `NgModelGroup` become properties on the nested object.

Here's how you can use it:

```
<form #f="ngForm">

  <div ngModelGroup="fullName">
    <input type="text" name="firstName" ngModel>
    <input type="text" name="lastName" ngModel>
  </div>
</form>

<!-- Access the values from the nested object-->

<pre>First name: {{ f.value.fullName.firstName }}</pre>

<pre>Last name:  {{ f.value.fullName.lastName }}</pre>
```

1. The ngModelGroup attribute requires a string value, which becomes a property name that represents the nested object with values of the child fields.
2. To access the values of the firstName and lastName fields, use the nested fullName object.

7.2.2 Enriching the HTML form

Let's refactor the sample user registration form from the beginning of the chapter. Back then it was a plain HTML form that didn't use any Angular features. Now we'll wrap it into an Angular component, add validation logic, and enable programmatic handling of the submit event. Let's start by refactoring the template, and then we'll move on to the TypeScript part.

First we'll modify the `<form>` element:

```
<form #f="ngForm" (ngSubmit)="onSubmit(f.value)">
        <!-- Form fields go here -->
</form>
```

Here we declare a local template variable `f` that points at the `NgForm` object attached to the `<form>` element. We need this variable to access the form's properties, such as `value` and `valid`, and to check whether the form has errors of a specific type.

We also configure the event handler for the `ngSubmit` event emitted by `NgForm`. We don't want to listen to the standard `submit` event, and `NgForm` intercepts the `submit` event and stops its propagation. This prevents the form from being automatically submitted to the server, resulting in a page reload. Instead, the `NgForm` emits its own `ngSubmit` event.

The `onSubmit()` method is the event handler. It's defined as the component's instance method. The `onSubmit()` method takes one argument—the form's value, which is a plain JavaScript object that keeps the values of all the fields on the form.

Next we'll change the `username` and `ssn` fields:

```
<div>Username: <input type="text" name="username" ngModel></div>   ❶
<div>SSN:      <input type="text" name="ssn"      ngModel></div>   ❷
```

❶ The ngModel attribute attaches the NgModel directive to the <input> element and makes this field a part of the form. We also add the name attribute.

❷ We make similar changes to the ssn field, but the value of the name attribute is different.

Now let's change the password fields. Because these fields are related and represent the same value, it's natural to combine them into a group. It will also be convenient to deal with both passwords as a single object when we implement form validation later in this chapter.

```
<div ngModelGroup="passwordsGroup">   ❶
  <div>Password:         <input type="password" name="password" ngModel></div>   ❷
  <div>Confirm password: <input type="password" name="pconfirm" ngModel></div>   ❷
</div>
```

❶ The ngModelGroup directive instructs NgForm to create a nested object within the form's value object that keeps the child fields. passwordsGroup will become the property name for the nested object.

❷ Changes for the password and pconfirm fields are similar to those for ngModelGroup, but the values of the name attributes differ.

The Submit button is the only HTML element left in the template, but it remains the same as in the plain HTML version of the form:

```
<button type="submit">Submit</button>
```

Now that we're done with the template refactoring, let's wrap it into a component. Here's the code of the component:

```
@Component({
  selector: 'app',
  template: `...`
})
class AppComponent {
  onSubmit(formValue: any) {
    console.log(formValue);
  }
}
```

We haven't included the content of the template to keep the listing terse, but the refactored version described earlier should be inlined here.

The `onSubmit()` event handler takes a single argument—the forms's value. As you can see, the handler doesn't use any Angular-specific API. Depending on the validity flag, we can decide whether to post the `formValue` to the server or not. In this example we just print it to the console.

Figure 7.2 displays the sample registration form with the form directives applied to it. Each form directive is highlighted so you can see what the form is made up of.

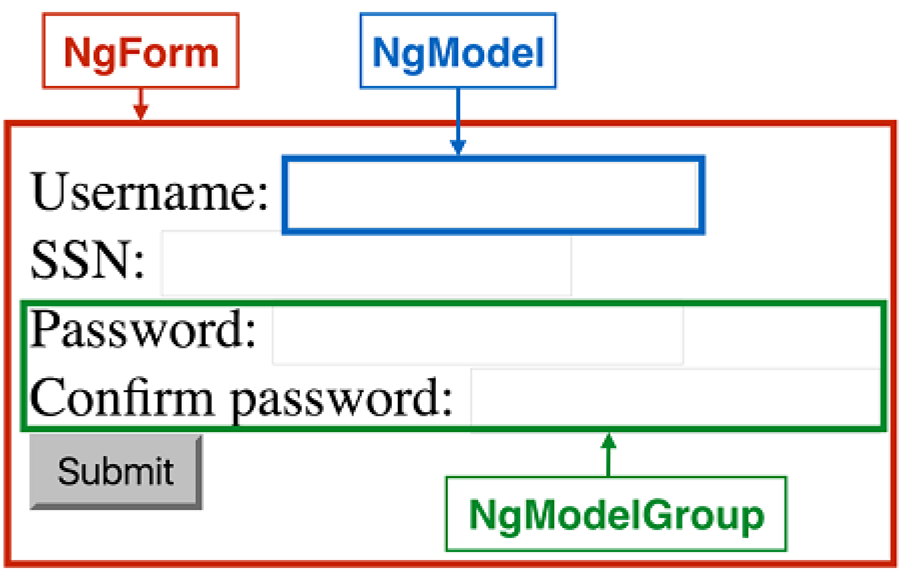


Figure 7.2 Form directives on the registration form

The complete running application that illustrates how to use form directives is located in the 01_template-driven.ts file, in the code that comes with the book.

7.3 Reactive forms

Unlike in the template-driven approach, creating a reactive form is a two-step process. First we need to create a model programmatically in the code, and then we'll link HTML elements to that model using directives in the template. Let's start from the first step, creating a model.

7.3.1 Form model

The form model is an underlying data structure that keeps the form's data. It's constructed out of special classes defined in the `@angular/forms` module: `FormControl`, `FormGroup`, and `FormArray`.

FORMCONTROL

`FormControl` is an atomic form unit. Usually it corresponds to a single `<input>` element, but it can also represent a more complex UI component like a calendar or a slider. `FormControl` keeps the current value of the HTML element it corresponds to, the element's validity status, and whether it has been modified or not.

Here's how you can create a control:

```
let username = new FormControl('initial value');    ❶
```

❶ You can pass the control's initial value as the first argument of the constructor.

FORMGROUP

`FormGroup` usually represents a part of the form and is a collection of `FormControls`. `FormGroup` aggregates the values and the statuses of each `FormControl` in the group. If one of the controls within a group is invalid, the entire group becomes invalid. It's convenient for managing related fields on the form. `FormGroup` is also used to represent the entire form.

For example, if a date range is represented by two `date` input fields, they can be combined into a single group to obtain the date range as a single value and display an error if either of the entered dates is invalid.

Here's how you can create a control group combining the `from` and `to` controls:

```
let formModel = new FormGroup({
  from: new FormControl(),
  to  : new FormControl()
});
```

FORMARRAY

`FormArray` is similar to `FormGroup`, but it has a variable length. Whereas `FormGroup` represents an entire form or a fixed subset of a form's fields, `FormArray` usually represents a growable collection of fields. For example, you could use `FormArray` to allow users to enter an arbitrary number of emails. Here's a model that would back such a form:

```
let formModel = new FormGroup({        ❶
  emails: new FormArray([              ❷
    new FormControl(),                 ❸
    new FormControl()
  ])
});
```

❶ FormGroup represents the entire form.

❷ Uses the FormArray to represent the emails field, because we want to allow users to enter multiple emails.

❸ Unlike FormGroup, controls within FormArray aren't associated with keys, but we can reference them by index.

7.3.2 Form directives

The reactive approach uses a completely different set of directives than template-driven forms. The directives for reactive forms come with the `ReactiveFormsModule` (see section 7.2).

All reactive directives are prefixed with the `form*` string, so you can easily distinguish the reactive from the template-driven approach just by looking at the template. Reactive directives aren't exportable, which means you can't create a variable in the template that references an instance of a directive. This is done intentionally to clearly separate the two approaches. In template-driven forms you don't access the model classes, and in reactive forms you can't operate the model in the template.

Table 7.1 shows how model classes correspond to form directives. In the first column you can see the model classes we covered in the previous section. In the second column are the directives that bind a DOM element to an instance of a model class using the property-binding syntax. As you can see, `FormArray` can't be used with the property binding. The third column lists directives that link a DOM element to a model class by name. They must only be used within the `formGroup` directive.

Table 7.1 Correspondence of model classes to form directives

Model class	*Form directives*	
	Bind	*Link*
`FormGroup`	`formGroup`	`formGroupName`
`FormControl`	`formControl`	`formControlName`
`FormArray`	—	`formArrayName`

Let’s look at the form directives.

FORMGROUP

`formGroup` often binds an instance of the `FormGroup` class that represents the entire form model to a top-level form’s DOM element, usually a `<form>`. All directives attached to the child DOM elements will be within the scope of `formGroup` and can link model instances by name.

To use the `formGroup` directive, first create a `FormGroup` in the component:

```
@Component(...)
class FormComponent {
  formModel: FormGroup = new FormGroup({});
}
```

Then add the `formGroup` attribute to an HTML element.

The value of the `formGroup` attribute references a component’s property that keeps an instance of the `FormGroup` class:

```
<form [formGroup]="formModel"></form>
```

FORMGROUPNAME

`formGroupName` can be used to link nested groups within a form. It needs to be in the scope of a parent `formGroup` directive to link one of its child `FormGroup` instances.

Here’s how we’d define a form model that can be used with `formGroupName`:

```
@Component(...)
class FormComponent {

  formModel: FormGroup = new FormGroup({         ❶

    dateRange: new FormGroup({                   ❷
      from: new FormControl(),
      to  : new FormControl()
    })
  })
}
```

❶ A FormGroup without a name. It’s bound to a DOM element using the formGroup directive and property-binding syntax.

❷ A child FormGroup with the name dateRange. We can use formGroupName to link this group to a DOM element in the template.

Now let’s take a look at the template:

```
<form [formGroup]="formModel">              ❶
  <div formGroupName="dateRange">...</div>  ❷
</form>
```

❶ Binds the FormGroup that represents the entire form using property-binding syntax.

❷ Links the <div> element to the FormGroup called dateRange defined within formModel.

In the `formGroup` scope, we can use `formGroupName` to link child model classes by names defined within the parent `FormGroup`. The value we assign to the `formGroupName` attribute must match the name we chose for the child `FormGroup` in the previous code sample (in our case, it’s `dateRange`).

> **SIDEBAR** **Property binding shorthand syntax**
> Because the value we assign to the `*Name` directive is a string literal, we can use a shorthand syntax and omit the square brackets around the attribute name. The long version would look like this:
>
> ```
> <div [formGroupName]="'dateRange'">...
> ```
>
> Note the square brackets around the attribute name and single quotes around the attribute value.

FORMCONTROLNAME

`formControlName` must be used in the scope of the `formGroup` directive, and it links one of its child `FormControl` instances to a DOM element.

Let’s continue the example of the date-range model we started while explaining the `fromGroupName` directive. The component and form model remain the same. We only need to complete the template:

```
<form [formGroup]="formModel">
  <div formGroupName="dateRange">
    <input type="date" formControlName="from">
    <input type="date" formControlName="to">
  </div>
</form>
```

As in the `formGroupName` directive, we just specify the name of a `FormControl` we want to link to the DOM element. Again, these are the names we chose while defining the form model.

FORMCONTROL

`formControl` can be used for single-field forms, when you don't want to create a form model with `FormGroup` but still want to leverage the Forms API features, like validation and the reactive behavior provided by the `FormControl.valueChanges` property. You saw an example in chapter 5 while discussing observables.

Here's the essence of that example:

```
@Component({...})
class FormComponent {

  weatherControl: FormControl = new FormControl();      ❶

  constructor() {

    this.weatherControl.valueChanges                     ❷
        .debounceTime(500)
        .switchMap(city => this.getWeather(city))
        .subscribe(weather => console.log(weather));
  }
}
```

❶ Instead of defining a form model with FormGroup, as we did earlier in this section, here we create a standalone instance of a FormControl.

❷ Uses valueChanges to get the value from the form.

We could use `ngModel` to sync the value entered by user with the component's property, but because we're using the Forms API, we can leverage its reactive features. In the preceding example we apply several RxJS operators to the Observable returned by the `valueChanges` property to improve the user experience. More details on this example can be found in chapter 5.

Here's the template of the `FormComponent` from the preceding code snippet:

```
<input type="text" [formControl]="weatherControl">      ❶
```

Because we're working with a standalone `FormControl` that's not a part of a `FormGroup`, we can't use the `formControlName` directive to link it by name. Instead we use `formControl` with the property-binding syntax.

FORMARRAYNAME

`formArrayName` must be used in the scope of a `formGroup` directive, and it links one of its child `FormArray` instances to a DOM element. Because form controls within `FromArray` don't have names, we can link them to DOM elements only by index. Usually we render them in a loop, using the `ngFor` directive.

Let's take a look at an example where we allow users to enter an arbitrary number of emails. We'll just highlight the key parts of the code here, but you can find the full runnable example in 02_growable-items-form.ts in the code distributed with the book.

First, let's define the model:

```
@Component(...)
class AppComponent {
  formModel: FormGroup = new FormGroup({
    emails: new FormArray([          ❶
      new FormControl()              ❷
    ])
  });
  //...
}
```

❶ Creates a FormGroup that will represent the form.

❷ Uses a FormArray for the emails collection to allow users to enter multiple emails.

In the template, email fields are rendered in the loop using the `ngFor` directive:

```
<ul formArrayName="emails">                                                  ❶
  <li *ngFor="let e of formModel.get('emails').controls; let i=index">      ❷
    <input [formControlName]="i">                                            ❸
  </li>
  <button type="button" (click)="addEmail()">Add Email</button>              ❹
</ul>
```

❶ formArrayName links the FormArray to the DOM element.

❷ Loops through the emails array and creates an input field for each entry.

❸ Links <input> element to an instance of FormControl by index.

❹ Defines the click event handler.

The `let i` notation in the `*ngFor` loop allows us to automatically bind the value of the array's `index` to the `i` variable available within the loop. The `formControlName` directive links the `FormControl` within `FormArray` to a DOM element, but instead of specifying a name, it uses the `i` variable that references the index of the current control.

When users click on the Add Email button, we push a new `FormControl` instance to the `FormArray`: `this.formModel.get('emails').push(new FormControl())`.

If you read an HTML version of this book, you can see the animated figure 7.3 illustrating how it works; otherwise you'll just see an image of the form with two email fields. Every time the user clicks the Add Email button, a new `FormControl` instance is pushed to the emails `FormArray`, and through data-binding a new input field is rendered on the page. The form's value will be updated below the form in real time via data-binding as well.

Figure 7.3 Form with a growable email collection

7.3.3 Refactoring the sample form

Now let's refactor the sample registration form we introduced at the beginning of the chapter. Originally it was a plain HTML form, and then we applied a template-driven approach. Now it's time for a reactive version.

We start reactive forms by defining a form model:

```
@Component(...)
class AppComponent {

  formModel: FormGroup;                           ❶

  constructor() {

    this.formModel = new FormGroup({              ❷
      'username': new FormControl(),
      'ssn': new FormControl(),
```

```
      'passwordsGroup': new FormGroup({     3
        'password': new FormControl(),
        'pconfirm': new FormControl()
      })
    });
  }

  onSubmit() {

    console.log(this.formModel.value);      4
  }
}
```

1. Declares a component property that will keep the form’s model.
2. Initializes the form model in the constructor.
3. A nested group for password fields.
4. Accesses the form’s value using the component’s formModel property.

The `formModel` property keeps an instance of the `FormGroup` type that defines the structure of the form. We’ll be using this property in the template to bind the model to the DOM element with the `formGroup` directive. It’s initialized programmatically in the constructor by instantiating model classes. The names that we give to form controls within the parent `FormGroup` will be used in the template to link the model to the DOM elements with the `formControlName` and `formGroupName` directives.

`passwordsGroup` is a nested `FormGroup` to group the password and password confirmation fields. It will be convenient to manage their values as a single object when we add form validation.

Because reactive form directives aren’t exportable, we can’t access them in the template and pass the form’s value directly to the `onSubmit()` method as an argument. Instead we access the value using the component’s property that holds the form’s model.

Now that the model is defined, we can write the HTML markup that binds to the model:

```
<form [formGroup]="formModel"     1

      (ngSubmit)="onSubmit()">     2

  <div>Username: <input type="text" formControlName="username"></div>     3

  <div>SSN:      <input type="text" formControlName="ssn"></div>     3


  <div formGroupName="passwordsGroup">     4

    <div>Password:         <input type="password" formControlName="password"></div>     5

    <div>Confirm password: <input type="password" formControlName="pconfirm"></div>     5
  </div>
  <button type="submit">Submit</button>
</form>
```

1. Binds the <form> element to the form model represented by a FormGroup class using the formGroup directive.
2. In the reactive approach we don't pass any params to the method that handles the ngSubmit event.
3. Uses the formControlName directive to link input fields to the FormControl instances defined within the parent FormGroup model.
4. The HTML structure mimics the model structure we defined in the component. To link the FormGroup to the DOM element, use the formGroupName directive.
5. Links password and pconfirm using the formControlName directive.

The behavior of this reactive version of the registration form will be identical to the template-driven version, but the internal implementation differs.

The complete application that illustrates how to create reactive forms is located in the 03_reactive.ts file, in the code that comes with the book.

7.3.4 Using FormBuilder

`FormBuilder` simplifies the creation of reactive forms. It doesn't provide any unique features compared to the direct use of the `FormControl`, `FormGroup`, and `FormArray` classes, but its API is more terse and saves you from the repetitive typing of class names.

Let's refactor the component class from the previous section to use `FormBuilder`. The template will remain exactly the same, but we'll change the way the `formModel` is constructed. Here's what it should look like:

```
constructor(fb: FormBuilder) {

  this.formModel = fb.group({

    'username': [''],
    'ssn': [''],

    'passwordsGroup': fb.group({
      'password': [''],
      'pconfirm': ['']

    })
  });
}
```

1. FormBuilder is an injectable service provided by ReactiveFormsModule, so we can inject it into the constructor. Its methods will be used to configure formModel.
2. The FormBuilder.group() method creates a FormGroup using a configuration object passed as the first argument. The configuration object has the same format as the one that FormGroup 's constructor accepts.
3. FormControl will be instantiated using the configuration array.
4. Like FormGroup, FormBuilder allows you to create nested groups.

5 The FormBuilder.group() method accepts an object with extra configuration parameters as the last argument. You can use it to specify group validators.

Unlike `FormGroup`, `FormBuilder` allows you to instantiate `FormControl` s using an array. Each item of the array has a special meaning. The first item is `FormControl` 's initial value. The second is a validator function. It can also accept a third argument, which is an async validator function. The rest of the array's items are ignored.

As you can see, configuring a form model with `FormBuilder` is less verbose and is based on the configuration objects rather than requiring explicit instantiation of the control's classes.

The complete application that illustrates how to use `FormBuilder` is located in the 04_form-builder.ts file in the code that comes with the book.

7.4 Forms validation

One of the advantages of using the Forms API, compared to regular data binding, is that forms have validation capabilities. Validation is available for both types of forms—template-driven and reactive. We create validators as plain TypeScript functions. In the reactive approach, we use functions directly, and in the template-driven approach we wrap them into custom directives.

Let's start by validating reactive forms and then move to template-driven ones. We'll cover the basics and apply validation to our sample registration form.

7.4.1 Validating reactive forms

Validators are just functions that conform to the following interface:

```
interface ValidatorFn {
  (c: AbstractControl): {[key: string]: any};     ❶
}
```

1 The type declaration {[key: string]: any} describes an object literal, where the property names are strings and values can be of any type.

The validator function should declare a single parameter of type `AbstractControl` and return an object literal. There are no restrictions on the implementation of the function—it's up to the validator's author. `AbstractControl` is the superclass for `FormControl`, `FormGroup`, and `FormArray`, which means that validators can be created for all model classes.

There are a number of predefined validators that ship with Angular: `required`, `minLength`, `maxLength`, and `pattern`. They're defined as static methods of the `Validators` class declared in the `@angular/forms` module, and they match standard HTML5 validation attributes.

Once you have a validator, you need to configure the model to use it. In the reactive approach, you provide validators as arguments to the constructors of the model classes. Here's an example:

```
import { FormControl, Validators } from '@angular/forms';

let usernameControl = new FormControl('', Validators.required);   ❶
```

❶ The first parameter is the default value, and the second is the validator function.

You can also provide a list of validators as the second argument:

```
let usernameControl = new FormControl('', [Validators.required, Validators.minLength(5)]);
```

To test the controls's validity, use the `valid` property, which returns either `true` or `false`:

```
let isValid: boolean = usernameControl.valid;   ❶
```

❶ Indicates whether the value entered in the field passes or fails the validation rules configured for the control.

If any of the validation rules fails, you can get error objects generated by the validator functions:

```
let errors: {[key: string]: any} = usernameControl.errors;
```

SIDEBAR

The error object

The error returned by a validator is represented by a JavaScript object that has a property with the same name as the validator. Whether it's an object literal or an object with a complex prototypal chain doesn't matter for the validator.

The property's value can be of any type and may provide additional error details. For example, the standard `Validators.minLength()` validator returns the following error object:

```
{
  minlength: {
    requiredLength: 7,
    actualLength: 5
  }
}
```

The object has a top-level property that matches the validator's name, `minlength`. Its value is also an object with two fields, `requiredLength` and `actualLength`. These error details can be used to display a user-friendly error message.

Not all validators provide the error details. Sometimes the top-level property just indicates that the error has occurred. In this case, the property is initialized with the value `true`. Here's an example of the standard `Validators.required()` error object:

```
{
  required: true
}
```

CUSTOM VALIDATORS

Standard validators are good for validating basic data types, like strings and numbers. If you need to validate a more complex data type or application-specific logic, you may need to create a custom validator. Because validators in Angular are just functions with a certain signature, they're fairly easy to create. You just need to declare a function that accepts an instance of one of the control types—`FormControl`, `FormGroup`, or `FormArray`—and returns an object that represents the validation error (see the sidebar about the Error object.

Here's an example of a custom validator that checks whether the control's value is a valid Social Security number (SSN), which is a unique ID given to each U.S. citizen:

```
function ssnValidator(control: FormControl): any {     ❶
  const value = control.value || '';                   ❷
  const valid = value.match(/^\d{9}$/);                ❸
```

```
  return valid ? null : { ssn: true };        ❹
}
```

❶ The type of the argument is FormControl, because we're testing an individual field.

❷ Angular may invoke the validator even before a user enters a real value, so make sure it's not null.

❸ Matches the value against a regular expression that represents the SSN format. It's a trivial check, but it works for our example.

❹ If the value is an invalid SSN, we return an error object. Otherwise null is returned, indicating that there are no errors. The error object doesn't provide any details.

Custom validators are used the same way as the standard ones:

```
let ssnControl = new FormControl('', ssnValidator);
```

The complete running application that illustrates how to create custom validators is located in the 05_custom-validator.ts file in the code that comes with the book.

GROUP VALIDATORS

You may want to validate not only individual fields but also groups of fields. Angular allows you to define validator functions for `FormGroup` s as well.

Let's create a validator that will make sure that the password and password confirmation fields on our sample registration form have the same value. Here's one possible implementation:

```
function equalValidator({value}: FormGroup): {[key: string]: any} {
  const [first, ...rest] = Object.keys(value || {});                   ❶
  const valid = rest.every(v => value[v] === value[first]);            ❷
  return valid ? null : {equal: true};                                 ❸
}
```

❶ Gets the names of all properties in the value object.

❷ Iterates through all of the values and makes sure they are equal.

❸ Returns either null or an error object.

The signature of the function conforms to the `ValidatorFn` interface—the first parameter is of type `FormGroup`, which is a subclass of `AbstractControl`, and the return type is an object literal. Note that we use an ECMAScript feature here called destructuring (see the "Destructuring" section in appendix A). We extract the `value` property from the instance of the `FormGroup` class that will be passed as an argument.

This makes sense here because we never access any other `FormGroup` property in the validator's code.

Next we get the names of all properties in the value object and saves them in two variables, `first` and `rest`. `first` is the name of a property that will be used as the reference value—values of all other properties must be equal to it to make validation pass. `rest` stores the names of all the other properties. Again we're using the destructuring feature here to extract references to the array items (see the "Destructuring of arrays" section in appendix A).

Finally we either return `null` if the values in the group are valid, or an object that indicates the error state.

VALIDATING THE SAMPLE REGISTRATION FORM

Now that we've covered the basics, let's add validation to the sample registration form. We'll use the `ssnValidator` and `equalValidator` implemented earlier in this section.

Here's the modified form model:

```
this.formModel = new FormGroup({
  'username': new FormControl('', Validators.required),          ❶
  'ssn': new FormControl('', ssnValidator),                      ❷
  'passwordsGroup': new FormGroup({
    'password': new FormControl('', Validators.minLength(5)),    ❸
    'pconfirm': new FormControl('')
  }, {}, equalValidator)                                         ❹
});
```

❶ For the username control we use the standard Validators.required validator. It makes sure that at least some non-empty value is entered in the field.

❷ For the ssn field we use the ssnValidator we implemented previously.

❸ For the password field we use the standard validators.minLength validator, which returns an error if the length of the entered string value is less than 5 characters long.

❹ Configures equalValidator for the passwordsGroup. It makes sure that the values of all fields in the group are the same. Unlike FormControl, we pass validators as the third argument to the FormGroup constructor.

Before printing the form's model to the console in the `onSubmit()` method, we check whether the form is valid or not:

```
onSubmit() {
  if (this.formModel.valid) {
    console.log(this.formModel.value);
  }
}
```

In the model-driven approach, configuring validators requires changes only in the code, but we still want to make some changes in the template. We want to display validation errors when the user enters an invalid value. Here's the modified version of the template:

```
<form [formGroup]="formModel" (ngSubmit)="onSubmit()" novalidate>
  <div>Username:
    <input type="text" formControlName="username">

    <span [hidden]="!formModel.hasError('required', 'username')">Username is required</span>   ❶
  </div>
  <div>SSN:
    <input type="text" formControlName="ssn">

    <span [hidden]="!formModel.hasError('ssn', 'ssn')">SSN is invalid</span>   ❷
  </div>

  <div formGroupName="passwordsGroup">
    <div>Password:
      <input type="password" formControlName="password">

      <span [hidden]="!formModel.hasError('minlength', ['passwordsGroup', 'password'])">   ❸
          Password is too short
      </span>
    </div>
    <div>Confirm password:
      <input type="password" formControlName="pconfirm">
      <span [hidden]="!formModel.hasError('equal', 'passwordsGroup')">
          Passwords must be the same
      </span>
    </div>
  </div>
  <button type="submit">Submit</button>
</form>
```

❶ Conditionally shows the error message for the username field.

❷ Adds an error message for the ssn field as we did for the username field.

❸ Conditionally shows the error message for the password field.

Note how we access the `hasError()` method available on the form model when we conditionally show error messages. It takes two parameters: the first one is the name of the validation error we want to check, and the second is the path to the field we're interested in within the form model. In the case of `username`, it's a direct child of the top-level `FormGroup` that represents the form model, so we specify just the name of the control. But the `password` field is a child of the nested `FormGroup`, so the path to the control is specified as an array of strings. The first element is the name of the nested group, and the second element is the name of the `password` field itself. Like the `username` field, `passwordsGroup` specifies the path as a string because it's a direct child of the top-level `FormGroup`.

The complete running application that illustrates how to use validator functions with reactive forms is located in the 09_reactive-with-validation.ts file in the code that comes with the book.

In this example we hardcoded the error messages in the template, but they can be provided by the validators. For the example that dynamically provides error messages, see the 07_custom-validator-error-message.ts file.

SIDEBAR

Configuring validators with `FormBuilder`

Validators can also be configured when you're using `FormBuilder` to define form models. Here's a modified version of the model for the sample registration form that uses `FormBuilder`:

```
@Component(...)
class AppComponent {
  formModel: FormGroup;

  constructor(fb: FormBuilder) {                                    ❶
    this.formModel = fb.group({
      'username': ['', Validators.required],                        ❷
      'ssn': ['', ssnValidator],
      'passwordsGroup': fb.group({
        'password': ['', Validators.minLength(5)],
        'pconfirm': ['']
      }, {validator: equalValidator})                               ❸
    });
  }
}
```

❶ FormBuilder is a registered provider, so you can inject it into the component's constructor instead of instantiating it directly with the new keyword.

❷ Validators are specified as the second array item while configuring FormControls.

❸ While configuring the FormGroup validators, we provide an options object as the second argument to the group() method, and we use the validator property on the object to specify the validators.

ASYNCHRONOUS VALIDATORS

The Forms API supports asynchronous validators. Async validators can be used to check form values against a remote server, which involves sending an HTTP request. Like regular validators, async validators are just functions. The only difference is that async validators should return either an Observable or a Promise.

Here's an async version of the SSN validator:

```
function asyncSsnValidator(control: FormControl): Observable<any> {   ❶
  const value: string = control.value || '';
  const valid = value.match(/^\d{9}$/);
```

```
  return Observable.of(valid ? null : { ssn: true }).delay(5000);     ❷
}
```

❶ In our case, the return value is of the Observable type.

❷ To keep this example simple, we emulate asynchrony with the RxJS delay operator. The validation result arrives 5 seconds after the function is invoked.

Async validators are passed as the third argument to constructors of model classes:

```
let ssnControl = new FormControl('', null, asyncSsnValidator);
```

The complete running application that illustrates how to use async validators is located in the 08_async-validator.ts file in the code that comes with the book.

CHECKING A FIELD'S STATUS AND VALIDITY

You're already familiar with control properties such as `valid`, `invalid`, and `errors` for checking field statuses. In this section we'll take a look at a number of other properties that help to improve the user experience.

NOTE	**Availability of status properties** All the properties discussed in the following subsections are available for the model classes `FormControl`, `FormGroup`, and `FormArray`, as well as for the template-driven directives `NgModel`, `NgModelGroup`, and `NgForm`.

TOUCHED AND UNTOUCHED FIELDS

Besides checking a control's validity, you can also use the `touched` and `untouched` properties to check whether a field was visited or not by the user. If the user puts the focus into a field using the keyboard or mouse, the field becomes `touched`; otherwise it's `untouched`. This can be useful when displaying error messages—if the value in a field is invalid but it was never visited by the user, you can choose not to highlight it with red, because it's not a user mistake. Here's an example:

```
<style>.hasError {border: 1px solid red;}</style>          ❶

<input type="text" required                                 ❷
       name="username" ngModel #c="ngModel"                 ❸
       [class.hasError]="c.invalid && c.touched">           ❹
```

❶ Defines a CSS class that highlights an input field's border with red, for invalid fields.

❷ Adds the required validator for the username field.

❸ Enables Forms API support for the field and saves a reference to the NgModel directive instance in the template-locale c variable.

❹ Conditionally applies the hasError CSS class to the <input> element.

Note the CSS class binding example in the last line of the preceding code. It conditionally applies the `hasError` CSS class to the element if the expression on the right side is `true`. If we would use only `c.invalid` the border would be highlighted as soon as the page is rendered, however it can confuse users especially if the page has a lot of fields. Instead we add one more condition—the field must be touched. Now the field is highlighted only after a user visits this field.

PRISTINE AND DIRTY FIELDS

Another useful pair of properties are `pristine` and its counterpart `dirty`. `dirty` indicates that the field was modified after it was initialized with its original value. These properties can be used for prompting the user to save changed data before leaving the page or closing the dialog window.

> **NOTE** **Styling form elements**
> All the preceding properties have corresponding CSS classes (`ng-touched` and `ng-untouched`, `ng-dirty` and `ng-pristine`, `ng-valid` and `ng-invalid`) that are automatically added to HTML elements when the property is `true`. These can be useful for styling elements in a certain state.

PENDING FIELDS

If you have async validators configured for a control, you may also find the Boolean property `pending` to be useful. It indicates whether the validity status is currently unknown. This happens when an async validator is still in progress and you need to wait for the results. This property can be used for displaying a progress indicator.

For reactive forms, the Observable `statusChanges` property can be more convenient. It emits one of three values: `VALID`, `INVALID`, and `PENDING`.

7.4.2 Validating template-driven forms

Directives are all we can use when we create template-driven forms, so we can wrap validator functions into directives to use them in the template. Let’s create a directive that wraps the SSN validator we implemented in the previous section:

```
@Directive({                    ❶

  selector: '[ssn]',            ❷
  providers: [{

    provide: NG_VALIDATORS,     ❸
```

```
    useValue: ssnValidator,
    multi: true
  }]
})
class SsnValidatorDirective {}
```

❶ Declares a directive using the @Directive annotation from the @angular/core module.

❷ Define directive's selector as an HTML attribute.

❸ Register ssnValidator as NG_VALIDATORS provider.

The square brackets around the `ssn` selector denote that the directive can be used as an attribute. This is convenient, because we can add the attribute to any `<input>` element or to an Angular component represented as a custom HTML element.

In this example we register the validator function using the predefined `NG_VALIDATORS` Angular token. This token is in turn injected by the `NgModel` directive, and `NgModel` gets the list of all validators attached to the HTML element. Then `NgModel` passes validators to the `FormControl` instance it implicitly creates internally. The same mechanism is responsible for running validators; directives are just a different way to configure them. The `multi` property allows us to associate multiple values with the same token. When the token is injected into the `NgMode` directive, `NgModel` gets a list of values instead of a single value. This enables us to pass multiple validators.

Here's how you can use `SsnValidatorDirective`:

```
<input type="text" name="my-ssn" ngModel ssn>
```

You can find the complete running application that illustrates directive validators in the 06_custom-validator-directive.ts file in the code that comes with the book.

VALIDATING THE SAMPLE REGISTRATION FORM

Now we can add form validation to the sample registration form. Let's start with the template:

```
<form #f="ngForm" (ngSubmit)="onSubmit(f.value, f.valid)" novalidate>    ❶
  <div>Username:

    <input type="text" name="username" ngModel required>    ❷

    <span [hidden]="!f.form.hasError('required', 'username')">Username is required</span>    ❸
  </div>
  <div>SSN:
    <input type="text" name="ssn" ngModel ssn>
    <span [hidden]="!f.form.hasError('ssn', 'ssn')">SSN in invalid</span>
  </div>


  <div ngModelGroup="passwordsGroup" equal>    ❹
    <div>Password:
```

```
      <input type="password" name="password" ngModel minlength="5">
      <span [hidden]="!f.form.hasError('minlength', ['passwordsGroup', 'password'])">
        Password is too short
      </span>
    </div>
    <div>Confirm password:
      <input type="password" name="pconfirm" ngModel>
      <span [hidden]="!f.form.hasError('equal', 'passwordsGroup')">
        Passwords must be the same
      </span>
    </div>
  </div>
  <button type="submit">Submit</button>
</form>
```

1. Pass the form's value and validity status to the onSubmit() method.
2. Validation directive is added as the required attribute.
3. Conditionally shows and hides error messages.
4. equal is a directive wrapper for the equalValidator we implemented earlier. Custom validator directives are added the same way as the standard ones.

In the template-driven approach we don't have a model in the component. Only the template can inform the form's handler whether the form is valid or not, and that's why we pass the form's value and validity status as arguments to the `onSubmit()` method. We also added the `novalidate` attribute to prevent standard browser validation from interfering with the Angular validation.

Validation directives are added as attributes. The `required` directive is provided by Angular and is available once we register Forms API support with `FormsModule`. Similarly, we can use the `minlength` directive for validating the password field.

To conditionally show and hide validation errors, we use the same `hasError()` method we used in the reactive version. However, to access this method we need to use a `form` property of type `FormGroup`, available on the `f` variable that references an instance of the `formGroup` directive.

In the `onSubmit()` method, check whether the form is valid or not before printing the value to the console:

```
@Component({ template: '...' })
class AppComponent {

  onSubmit(formValue: any, isFormValid: boolean) {

    if (isFormValid) {
      console.log(formValue);
    }
  }
}
```

1. Adds isFormValid parameter to the method declaration.

2. Prints the value of the form to the console if the form is valid.

Now for the last step: we need to add custom validator directives to the declarations list of the `NgModule` where we define `AppComponent`:

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

1. Add directives in the declarations list.

The complete running application that illustrates how to use validator directives with template-driven forms is located in the 10_template-driven-with-validation.ts file in the code that comes with the book.

7.5 Hands-on: Adding validation to the search form

This hands-on exercise will start where we left off in chapter 6. You'll need to modify the code of the `SearchComponent` to enable form validation and collect the data entered in the form. When the search form is submitted, you'll print the form's value on the browser's console. Chapter 8 is about communication with the server, and in that chapter we'll refactor the code so the search form will make a real HTTP request.

In this hands-on section you'll need to perform the following steps:

1. Add a new method to the `ProductService` class that returns an array of all available product categories.
2. Create a model representing the search form using `FormBuilder`.
3. Configure validation rules for the model.
4. Refactor the template to properly bind to the model created in the previous step.
5. Implement the `onSearch()` method to handle the form's submit event.

Figure 7.4 shows what the search form will look like after completing this hands-on exercise. It illustrates the validators in action.

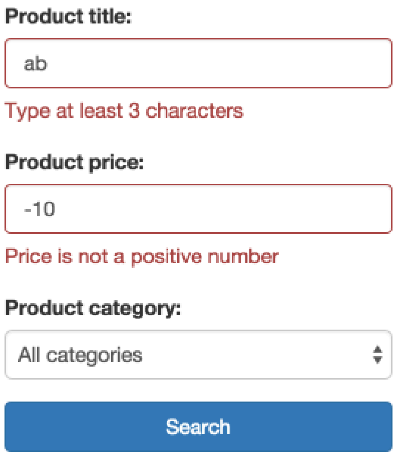


Figure 7.4 Search form with validators

If you prefer to see the final version of this project, browse the source code in the auction folder from chapter 7. Otherwise, copy the auction folder from chapter 6 to a separate location, and follow the instructions below.

MODIFYING THE ROOT MODULE TO ADD FORMS API SUPPORT

Update the app.module.ts file to enable reactive forms support for the application. Import `ReactiveFormsModule` from `@angular/forms` and add it to the list of imported modules to the main application NgModule:

```
import { ReactiveFormsModule } from '@angular/forms';

@NgModule({
  imports: [
    BrowserModule,
    FormsModule,
    ReactiveFormsModule,
    RouterModule.forRoot([ ... ])
  ],
```

ADDING A LIST OF CATEGORIES TO THE SEARCHCOMPONENT

Each product has the `categories` property, represented by an array of strings, and a single product can relate to multiple categories.

The form should allow users to select a category while searching for products, so we need a way to provide a list of all available categories to the form so it can display them to users. In a real-world application, the categories would likely come from the server. In our online auction example, we'll add a method to the `ProductService` class that will return hardcoded categories.

1. Open the app/services/product-service.ts file and add a `getAllCategories()` method that accepts no parameters and returns a list of strings. It should look like this:

```
getAllCategories(): string[] {
  return ['Books', 'Electronics', 'Hardware'];
```

```
}
```

2. Open the app/components/search/search.ts file and add an `import` statement for `ProductService`:

```
import {ProductService} from '../../services/product-service';
```

3. Configure this service as a provider for `SearchComponent`:

```
@Component({
  selector: 'auction-search',
  providers: [ProductService],
  //...
})
```

4. Declare a `categories: string[]` class property as a reference to the list of categories. We'll use it for the data binding:

```
export default class SearchComponent {
  categories: string[];
}
```

5. Declare a `constructor()` with one parameter: `ProductService`. Angular will inject it when the component is instantiated. Initialize the `categories` property using the `getAllCategories()` method:

```
constructor(private productService: ProductService) { ❶
  this.categories = this.productService.getAllCategories();
}
```

❶ The private keyword automatically creates a class property with the same name as the parameter and initializes it with the provided value.

CREATING A FORM MODEL

Now let's define the model that will handle the search form.

1. Open the app/components/search/search.ts file and add the Forms API-related imports. The `import` statement at the beginning of the file should look like this:

```
import {Component} from '@angular/core';
import {FormControl, FormGroup, FormBuilder, Validators} from '@angular/forms';
```

2. Declare a `formModel` class property of the `FormGroup` type:

```
export default class SearchComponent {
  formModel: FormGroup;
  //...
}
```

3. Inside the constructor, define the `formModel` using the `FormBuilder` class:

```
const fb = new FormBuilder();
this.formModel = fb.group({
  'title': [null, Validators.minLength(3)],
  'price': [null, positiveNumberValidator],
```

```
  'category': [-1]
})
```

4. Add a `positiveNumberValidator` function:

```
function positiveNumberValidator(control: FormControl): any {
  if (!control.value) return null;
  const price = parseInt(control.value);
  return price === null || typeof price === 'number' && price > 0
      ? null : {positivenumber: true};
}
```

`positiveNumberValidator()` attempts to parse an integer value from the `FormControl` 's value using the standard `parseInt()` function. If the parsed value is a valid positive number, the function returns `null`, meaning there are no errors. Otherwise the function returns an error object.

REFACTORING THE TEMPLATE

Let's add form directives to the template to bind the model defined in the previous step to the HTML elements.

1. We defined the form model in the code implementing the reactive approach, so in the template we should attach the `NgFormModel` directive to the `<form>` element:

```
<form [formGroup]="formModel"  ❶

      (ngSubmit)="onSearch()"  ❷

      novalidate>              ❸
```

❶ Binds the form to the model already created in the component.

❷ Subscribes to the ngSubmit event. The onSearch() method will be invoked every time the user clicks on the button. We'll define this method in the following steps.

❸ Disables the native browser's form validation so it doesn't interfere with Angular's.

2. Define the validation rules and conditionally display error messages for the title field:

```
<div class="form-group"
     [class.has-error]="formModel.hasError('minlength', 'title')">
  <label for="title">Product title:</label>
  <input id="title"
         placeholder="Title"
         class="form-control"
         type="text"
         formControlName="title"
         minlength="3">
  <span class="help-block"
       [class.hidden]="!formModel.hasError('minlength', 'title')">
    Type at least 3 characters
  </span>
</div>
```

In the preceding example we use the `form-group`, `form-control`, `has-error`, and `help-block` CSS classes defined in the Twitter Bootstrap library. They're required to properly render the form and highlight the field with the red border in the case of a validation error. You can read more on these classes in the Bootstrap documentation, Forms section.

3. Do the same for the product price field:

```
<div class="form-group"
      [class.has-error]="formModel.hasError('positivenumber', 'price')">
  <label for="price">Product price:</label>
  <input id="price"
          placeholder="Price"
          class="form-control"
          type="number"
          step="any"
          min="0"
          formControlName="price">
  <span class="help-block"
        [class.hidden]="!formModel.hasError('positivenumber', 'price')">
    Price is not a positive number
  </span>
</div>
```

4. Add validation rules and an error message for the product category field:

```
<div class="form-group">
  <label for="category">Product category:</label>
  <select id="category"
          class="form-control"
          formControlName="category">
    <option value="-1">All categories</option>
    <option *ngFor="let c of categories"
            [value]="c">{{c}}</option>
  </select>
</div>
```

The Submit button remains unchanged.

IMPLEMENTING THE ONSEARCH() METHOD

Add the following `onSearch()` method:

```
onSearch() {
  if (this.formModel.valid) {
    console.log(this.formModel.value);
  }
}
```

LAUNCHING THE ONLINE AUCTION

To launch the application, open a command window and start `http-server` in the root directory of the project. Enter http://localhost:8080 in a web browser, and you should see a Home page that includes the search form shown in 7.4. In this version of the application, we just illustrate form creation and validation without performing a search. We'll implement the search functionality in Chapter 8 when we discuss communication with servers.

7.6 Summary

In this chapter you’ve learned how to work with forms in Angular. These are the main takeaways from this chapter:

- There are two approaches to working with forms: template-driven and reactive. The template-driven approach is easier and quicker to configure, but the reactive one is easier to test, enables more flexibility, and provides more control over the form.
- The reactive approach offers advantages for applications that use not only the DOM renderer but another one (such as one from NativeScript) targeting nonbrowser environments. Reactive forms are programmed once and can be reused by more than one renderer.
- A number of standard validators ship with Angular, but you can also create custom ones. You should validate the user’s input, but client-side validation isn’t a replacement for performing additional validation on the server. Consider client-side validation as a way to provide instant feedback to the user, minimizing server requests involving invalid data.

8 Interacting with servers using HTTP and WebSockets

This chapter covers

- Creating a simple web server using the Node and Express frameworks
- Making server requests from Angular using the `Http` object API
- Communicating with the Node server from Angular clients using the HTTP protocol
- Wrapping a WebSocket client into an Angular service that generates an observable stream
- Broadcasting data from the server to multiple clients via WebSockets

Angular applications can communicate with any web server supporting HTTP or WebSocket protocols, regardless of what server-side platform is used. So far we've been covering mostly the client side of Angular applications, with the weather service example in chapter 5 being the only exception. In this chapter you'll learn how to communicate with web servers in more detail.

We'll first give you a brief overview of Angular's `Http` object, and then we'll create a web server using TypeScript and Node.js. This server will provide the data required for all our code samples, including our online auction. Then you'll learn how the client code can make HTTP requests to web servers and consume the responses using *observables*, which we introduced in chapter 5.

We'll also show you how to communicate with the server via WebSockets, focusing on the server-side data push.

In the hands-on section, we'll implement a product search function, in which the data about auction products and reviews will come from the server via HTTP requests. We'll also implement product bid notifications, which will be sent by the server using the

WebSocket protocol.

8.1 A brief overview of the Http object's API

Web applications run HTTP requests asynchronously so the UI remains responsive and the user can continue working with the application while the HTTP requests are being processed by the server. Asynchronous HTTP requests can be implemented using callbacks, promises, or observables. Although promises eliminate the callback hell (see appendix A), they have the following shortcomings:

- There's no way to cancel a pending request made with a `Promise`.
- When a `Promise` resolves or rejects, the client receives either the data or an error message, but in either case it'll just be a single piece of data. A `Promise` doesn't offer a way of handling a continuous stream of chunks of data delivered over time.

Observables don't have these shortcomings, and in section 5.2.2 we looked at a promise-based scenario that resulted in multiple unnecessary requests to get a price quote for a stock, generating unnecessary network traffic. Then, in the example with the weather services we demonstrated how you can cancel HTTP requests made with observables.

Let's take a look at Angular's implementation of the `Http` class, which is included in the `@angular/http` package. This package includes several classes and interfaces, as described in the Angular HTTP client documentation at http://mng.bz/87C3.

If you peek inside the @angular/http/src/http.d.ts type definition file, you'll see the following APIs in the `Http` class:

```
import {Observable} from 'rxjs/Observable';
...
export declare class Http {
...
   constructor(_backend: ConnectionBackend, _defaultOptions: RequestOptions);

   request(url: string | Request, options?: RequestOptionsArgs): Observable<Response>;

   get(url: string, options?: RequestOptionsArgs): Observable<Response>;

   post(url: string, body: string, options?: RequestOptionsArgs): Observable<Response>;

   put(url: string, body: string, options?: RequestOptionsArgs): Observable<Response>;

  delete(url: string, options?: RequestOptionsArgs): Observable<Response>;

  patch(url: string, body: string, options?: RequestOptionsArgs): Observable<Response>;

  head(url: string, options?: RequestOptionsArgs): Observable<Response>;
}
```

This code is written in TypeScript, and each of the `Http` object's methods has `url` as a mandatory argument, which can be either a `string` or a `Request` object. You can also pass an optional object of type `RequestOptionArgs`. Each method returns an

`Observable` that wraps an object of type `Response`.

The following code snippet illustrates one of the ways of using the `get()` API of the `Http` object, passing a URL as a `string`:

```
constructor(private http: Http) {
  this.http.get('/products').subscribe(...);
}
```

We haven't specified the full URL here (such as http://localhost:8000/products), assuming that the Angular application makes a request to the server where it was deployed, so the base portion of the URL can be omitted. The `subscribe()` method should receive an observer object with the code for handling the received data and errors.

The `Request` object offers a more generic API, where you can separately create a `Request` instance, specify an HTTP method, and include the search parameters and a `Header`:

```
let myHeaders:Headers  = new Headers();
myHeaders.append('Authorization', 'Basic QWxhZGRpb');

this.http
    .request(new Request({
      headers: myHeaders,
      method: RequestMethod.Get,
      url: '/products',
      search: 'zipcode=10001'
    }))
    .subscribe(...);
```

`RequestOptionsArgs` is declared as a TypeScript interface:

```
export interface RequestOptionsArgs {
    url?: string;
    method?: string | RequestMethod;
    search?: string | URLSearchParams;
    headers?: Headers;
    body?: any;
    withCredentials?: boolean;
    responseType?: ResponseContentType;
}
```

All members of this interface are optional, but if you decide to use them, the TypeScript compiler will ensure that you provide values of the proper data types.

```
var myRequest: RequestOptionsArgs = {
    url: '/products',
    method: 'Get'
};

this.http
    .request(new Request(myRequest))
    .subscribe(...);
```

In the hands-on section you'll see an example of using the `search` property of `RequestOptionsArgs` to make HTTP requests that have query string parameters.

SIDEBAR **What's Fetch API**

There is an effort to unify the process of fetching resources on the web. The Fetch API (https://fetch.spec.whatwg.org/) can be used as a replacement for the `XMLHttpRequest` object. The Fetch API defines generic `Request` and `Response` objects, which can be used not only with HTTP, but also with other emerging web technologies like Service Workers and the Cache API.

With the Fetch API, HTTP requests are made using the global function `fetch()`:

```
fetch('https://www.google.com/search?q=fetch+api')   ❶
  .then(response => response.text())                  ❷
  .then(result => console.log(result));               ❸
```

❶ The URL of the resource you want to fetch is the only required parameter.

❷ The fetch() call returns a Promise that successfully resolves to the Response object regardless of the HTTP response code.

❸ When the requested data is received, you can apply your application's logic to the data. Here we just print the data on the console.

To extract the body's content from the response, you need to use one of the methods in the `Response` object. Each method expects the body to be in a certain format. We simply read the body as plain text using the `text()` method, which in turn returns a `Promise`.

Unlike Angular's observable-based `Http` service, the Fetch API is promise-based. The Fetch API is mentioned in Angular documentation because several of Angular's classes and interfaces are inspired by the Fetch API (such as `Request`, `Response`, and `RequestOptionsArgs`).

Later in this chapter you'll see how to make requests using the `Http` object's API and how to handle HTTP responses by subscribing to observable streams. In chapter 5 we used the public weather server, but here we'll create our own web server using the Node.js framework.

8.2 Creating a web server with Node and TypeScript

There are many platforms that allow you to develop and deploy web servers. In this book we decided to use Node.js for the following reasons:

- Node allows you to create standalone applications. There's no need to learn a new programming language to understand the code.

- Node does a great job in the area of communications using HTTP or WebSockets.
- Using Node will allow us to continue writing code in TypeScript, instead of having to explain how to create a web server in Java, .NET, or Python.

In Node, a simple web server can be written with a few lines of code, and we'll start with a very basic one. Then we'll write a web server that can serve JSON data (product details, of course) using the HTTP protocol. A bit later we'll create yet another version of the server that will communicate with the client over a WebSocket connection. Finally, in the hands-on project, we'll teach you how to write the client portion of the auction so it communicates with our web server.

8.2.1 Creating a simple web server

In this section we'll create a standalone Node application that will run as a server supporting all our Angular code examples. When both the server and client sides are ready, the project's directory will have the structure shown in figure 8.1.

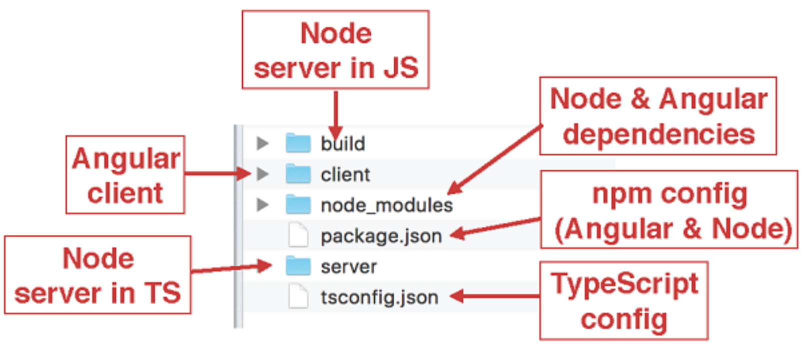


Figure 8.1 The project structure of an Angular-Node application

NOTE	**Installing TypeScript compiler** If you ran the code samples from appendix B, you already have the TypeScript compiler installed on your computer. Otherwise do that now.

Let's start by creating a directory named http_websocket_samples with a server subdirectory, and we'll configure a new Node project there by running the following command:

```
npm init -y
```

As you learned in chapter 2, the `-y` option instructs npm to create the package.json configuration file with default settings, without prompting you for any options.

Next we'll create the hello_server.ts file with the following content:

```
import * as http from 'http';    ❶

const server = http.createServer((request, response)=> {    ❷
```

```
    response.writeHead(200, {'Content-Type': 'text/plain'});
    response.end('Hello World!\n');
});

const port = 8000;

server.listen(port);    ❸
console.log('Listening on http://localhost:' + port);
```

❶ This code loads the Node module using the ES6 syntax import * as, which is supported by TypeScript as well.

❷ This basic server will only know how to respond with the HTTP status 200 and the text “Hello World!”, regardless of what the client requests.

❸ The listen() function will make this script run infinitely.

The preceding code needs to be transpiled, so we’ll create the tsconfig.json file in the http_websocket_samples directory to configure the tsc compiler:

```
{
  "compilerOptions": {
    "target": "es5",
    "module": "commonjs",    ❶
    "emitDecoratorMetadata": true,
    "experimentalDecorators": true,
    "outDir": "build"    ❷
  },
  "exclude": [
    "node_modules",    ❸
    "client"    ❹
  ]
}
```

❶ This line instructs tsc to transpile modules according to the CommonJS spec. The import statement in hello_server.ts will be transpiled into var http = require('http');.

❷ The transpiler will put the .js files into the build directory.

❸ tsc shouldn’t transpile the code located in the node_modules directory.

❹ A bit later we’ll create the client directory for the Angular part of the app, but that code doesn’t need to be transpiled because SystemJS will do it for us on the fly.

NOTE **TypeScript 2.0 and @types**
In this project we use a locally installed tsc compiler of version 2.0, which uses the `@types` packages for installing type definition files. That's because older versions of tsc didn't support the `types` compiler option, and if you have an older version of tsc installed globally, simply running tsc will use that version, causing compilation errors. To ensure that you use the local version of tsc, configure it as a command (`"tsc": "tsc"`) in the `scripts` section of package.json, and start the compiler by entering the `npm run tsc` command to transpile the server's files. Run this command from the same directory where the tsconfig.json file is located (the project root in the code samples for this chapter).

After running the `npm run tsc` command, the transpiled hello_server.js file will be saved in the build directory, and you can start your web server:

```
node build/hello_server.js
```

Node will start the V8 JavaScript engine that will run the script from hello-server.js; it will create a web server and print the following message on the console: "Listening on http://localhost:8000". If you open your browser at this URL, you'll see a web page with the text "Hello World!"

You need to have Node's type-definition files (see appendix B) to prevent TypeScript compilation errors. To install Node's type definitions for another project, just run the following command from the root directory of your project:

```
npm i @types/node --save
```

If you use the code samples that come with this chapter, you can just run the command `npm install`, because our package.json file includes the `@types/node` dependency for Node:

```
"@types/node": "^4.0.30"
```

8.2.2 Serving JSON

In all our auction code samples so far, the data about products and reviews has been hard-coded in the product-service.ts file as arrays of JSON-formatted objects. In the hands-on section we'll move this data to the server, so our Node web server needs to know how to serve JSON.

To send JSON to the browser, you need to modify the header to specify a MIME type of application/json:

```
const server = http.createServer((request, response) => {
    response.writeHead(200, {'Content-Type': 'application/json'});
    response.end('{"message": "Hello Json!"}\n');
});
```

The preceding code sample suffices as an illustration of sending JSON, but real-world servers perform more functions, such as reading files, routing, and handling various HTTP requests (GET, POST, and so on). Later, in our auction example, we'll need to respond with either product or review data depending on the request.

To minimize manual coding, let's install Express (http://expressjs.com), a Node framework that provides a set of features required by all web applications. We won't be using all of the functionality of Express, but it will help with creating a RESTful web service that will return JSON-formatted data.

To install Express, run the following command from the http_websocket_samples directory:

```
npm install express --save
```

This will download Express into the node_modules folder and will update the dependencies section in package.json.

Because this project's file has the entry "@types/express": "^4.0.31", you already have all the type definitions for Express in your node_modules directory. But if you want to install them in any other project, run the following command:

```
npm i @types/express --save
```

Now you can import Express into your application and start using its API while writing code in TypeScript. The following code shows the my-express-server.ts file that implements the server-side routing for HTTP GET requests:

```
import * as express from "express";
const app = express();    ❶

app.get('/', (req, res) => res.send('Hello from Express'));    ❷

app.get('/products', (req, res) => res.send('Got a request for products'));    ❸

app.get('/reviews', (req, res) => res.send('Got a request for reviews'));    ❹

const server = app.listen(8000, "localhost", () => {    ❺
  const {address, port} = server.address();    ❻
```

```
  console.log('Listening on http://localhost:' + port);
});
```

1. Instantiates the Express object using the app constant as a reference.
2. We've implemented routing only for GET requests using the Express API's get(), but Express has the methods required for handling all HTTP methods. You can find the declarations of all of them in express.d.ts.
3. Starts listening on port 8000 at the address localhost, and executes the code from the fat arrow function on startup.
4. We use destructuring here (see appendix A) to automatically extract the values of the address and port properties.

If we used the ES5 syntax instead of destructuring, we'd need to write two lines instead of one:

```
var address = server.address().address;
var port = server.address().port;
```

Transpile my-express-server.ts by running `npm run tsc`, and start this server (`node build/my-express-server.js`). You'll be able to request either products or services depending on which URL you enter in the browser, as shown in figure 8.2.

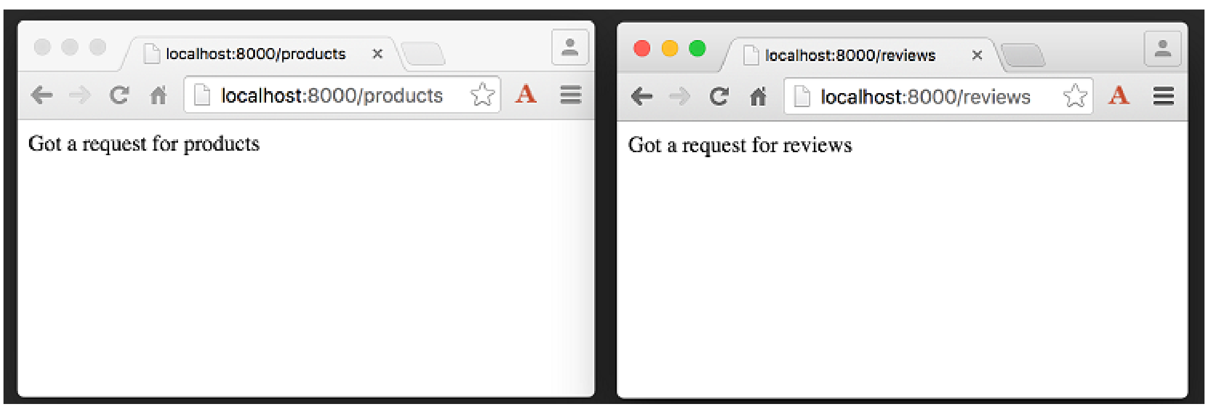


Figure 8.2 Server-side routing with Express

NOTE	**Debugging Node** To debug Node applications, refer to your preferred IDE documentation on debugging Node. You can also use the node-inspector command-line tool (https://github.com/node-inspector/node-inspector).

8.2.3 Live TypeScript recompilation and code reload

Our server-side examples are written in TypeScript, so we need to use tsc to transpile the code to JavaScript prior to deploying it in Node. In section B.3.1, in appendix B, we discuss the compilation option `-w` that runs tsc in watch mode, so whenever a TypeScript file changes, it gets recompiled automatically. To set the auto-compilation mode for your code, open a separate command window in the directory with the sources, and run the following command there:

```
tsc -w
```

When no filenames are specified, tsc uses the tsconfig.json file for compilation options. Now whenever you make a change in the TypeScript code and save the file, it'll generate a corresponding .js file in the build directory as specified in tsconfig.json. Accordingly, to start your web server with Node, you could use the following command:

```
node build/my-express-server.js
```

Live recompilation of the TypeScript code helps, but the Node server won't automatically pick up code changes after it has started. You'd need to manually restart the Node server to see your code changes in action, unless you use a handy utility, Nodemon (http://nodemon.io), which will monitor for any changes in your source, and on detecting changes will automatically restart your server and reload the code.

You can install Nodemon either globally or locally. For a global install, use the following command:

```
npm install -g nodemon
```

The following command will start your server in monitoring mode:

```
nodemon build/my-express-server.js
```

We'll install Nodemon locally (`npm install nodemon --save-dev`) and introduce npm scripts (https://docs.npmjs.com/misc/scripts) in the package.json file:

```
"scripts": {
  "tsc": "tsc",
  "start": "node build/my-express-server.js",
  "dev": "nodemon build/my-express-server.js"
},
"devDependencies": {
  "nodemon": "^1.8.1"
}
```

With this setup, you can start the server in development mode with `npm run dev` (auto restart/reload) or `npm start` in production (no restart/reload). We decided to give the name `dev` to the command that starts nodemon, but you can name it any way you want, such as `startNodemon`.

8.2.4 Adding the RESTful API for serving products

Our ultimate goal is to serve products and reviews for the auction application. In this section we'll illustrate how to prepare a Node server with REST endpoints to serve products in JSON format when the HTTP `GET` requests are received.

We'll modify the code in the my-express-server.ts file to serve either all products or a specific one (by ID). The modified version of this application, shown next, is located in the auction-rest-server.ts file.

```
import * as express from "express";
const app = express();

class Product {    ❶
    constructor(
        public id: number,
        public title: string,
        public price: number){}
}

const products = [    ❷
    new Product(0, "First Product", 24.99),
    new Product(1, "Second Product", 64.99),
    new Product(2, "Third Product", 74.99)
];

function getProducts(): Product[] {    ❸
    return products;
}

app.get('/', (req, res) => {    ❹
    res.send('The URL for products is http://localhost:8000/products');
});

app.get('/products', (req, res) => {    ❺
    res.json(getProducts());
});

function getProductById(productId: number): Product {    ❻
    return products.find(p => p.id === productId);
}

app.get('/products/:id', (req, res) => {    ❼
    res.json(getProductById(parseInt(req.params.id)));
});

const server = app.listen(8000, "localhost", () => {
    const {address, port} = server.address();
    console.log('Listening on %s %s', address, port);
});
```

❶ Defines the class Product.

❷ Creates an array of three Product instances with the hard-coded data.

❸ This function returns the entire array of Product instances.

❹ Returns the text prompt as a response to the GET request coming from the base URL.

❺ When Express receives the GET request containing /products, it invokes the getProducts() function and returns the result to the client in JSON format.

❻ Returns the product by ID. Here we use the new Array.prototype.find() method introduced in ES6. If your IDE doesn't know about this method, install the type definition file for the es6-shim polyfill: npm install @types/es6-shim --save-dev

❼ When Express receives GET requests with parameters, their values are stored in the params property of the request object. We convert the product ID from a string to an integer and invoke getProductById(). The result is sent to the client in JSON format.

Now you can start the auction-rest-server.ts application in Node (run `nodemon build/auction-rest-server.js`) and see if the browser will receive all products or a selected product. Figure 8.3 shows the browser window after entering the URL http://localhost:8000/products. Our server returned all the products in JSON format.

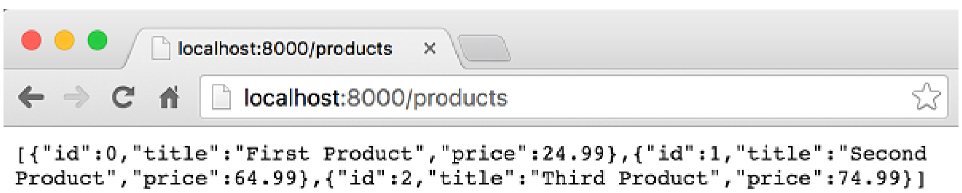


Figure 8.3 Node server responds to http://localhost:8000/products

Figure 8.4 shows the browser window after entering the URL http://localhost:8000/products/1. This time our server returned only the data about the product that has an `id` with the value of 1.

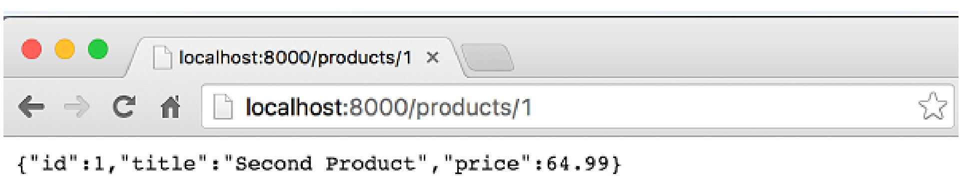


Figure 8.4 Node server responds to http://localhost:8000/products/1

The server is ready, so now we can learn how to initiate HTTP requests and handle responses in Angular applications.

8.3 Bringing Angular and Node together

Earlier in this chapter we created the http_websocket_samples folder containing the auction-rest-server.ts file, which is a Node application that responds to HTTP `GET` requests and supplies product details. In this section we'll write an Angular client that will issue HTTP requests and treat the product's data as an `Observable` object returned by our server. The code of our Angular application will be located in the client subdirectory (see figure 8.1).

8.3.1 Static resources on the server

A typical web application deployed on the server includes static resources (such as HTML, images, CSS, and JavaScript code) that have to be loaded in the browser when the user enters the application's URL. Because we use SystemJS, which does on-the-fly transpiling, the TypeScript files are static resources as well.

From Node's perspective, the Angular portion of this application is considered static resources. Because Angular apps will load dependencies from node_modules, this directory also belongs to the static resources required by the browser.

The Express framework has a special API to specify the directories with static resources, and we'll make slight modifications in the auction-rest-server.ts file shown in the previous section. In that file we didn't specify the directory with static resources because no client's app was deployed there. The new version of this file will be called auction-rest-server-angular.ts.

First, we'll add the following lines:

```
import * as path from "path";

app.use('/', express.static(path.join(__dirname, '..', 'client')));
app.use('/node_modules', express.static(path.join(__dirname, '..', 'node_modules')));
```

When the browser requests static resources, Node will look for them in the client and node_modules directories. Here we use Node's `path.join` API to ensure that the file path is created in a cross-platform way. You can use `path.join` when you need to build an absolute path for a specific file, and you'll see such examples below.

Let's keep the same REST endpoints on the server:

- `/` serves main.html, which is the landing page of our application
- `/products` gets all products
- `/products/:id` gets a product by its ID

Unlike in the my_express_server.ts application, we don't want Node to handle the base URL; we want Node to send the main.html file to the browser. In the auction-rest-server-angular.ts file we'll change the route for the base URL `/` to look like this:

```
app.get('/', (req, res) => {
  res.sendFile(path.join(__dirname, '../client/main.html'));
});
```

Now when the user enters the URL of our Node server in the browser, the main.html file will be served first, and then it'll load our Angular application with all dependencies.

THE COMMON NPM CONFIGURATION FILE

The new version of the package.json file will combine all dependencies required for both the Node-related code and our Angular application. Note that we declared several commands in the `script` section. The first command is for running the locally installed tsc, and the others are to start Node servers for the code samples included in this chapter.

```
{
  "private": true,
  "scripts": {
    "tsc": "tsc",
    "start": "node build/my-express-server.js",
    "dev": "nodemon build/my-express-server.js",
    "simpleWsServer": "node build/simple-websocket-server.js",
    "restServer": "nodemon build/auction-rest-server-angular.js",
    "twowayWsServer": "nodemon build/two-way-websocket-server.js",
    "bidServer": "nodemon build/bids/bid_server.js"
  },
  "dependencies": {
    "@angular/common": "2.0.0-rc.6",
    "@angular/compiler": "2.0.0-rc.6",
    "@angular/core": "2.0.0-rc.6",
    "@angular/forms": "2.0.0-rc.6",
    "@angular/http": "2.0.0-rc.6",
    "@angular/platform-browser": "2.0.0-rc.6",
    "@angular/platform-browser-dynamic": "2.0.0-rc.6",
    "@angular/router": "^3.0.0-rc.2",

    "core-js": "^2.4.0",
    "rxjs": "5.0.0-beta.11",
    "systemjs": "0.19.37",
    "zone.js": "0.6.17",

    "@types/express": "^4.0.31",
    "@types/node": "^4.0.30",
    "express": "^4.14.0",
    "ws": "^1.1.1"
  },
  "devDependencies": {
    "@types/es6-shim": "0.0.30",
    "@types/ws": "0.0.29",
    "nodemon": "^1.8.1",
    "typescript": "^2.0.0"
  }
}
```

Note that we included the `@angular/http` package here, which includes Angular's support for the HTTP protocol. We also included `ws` and `@types/ws`—we'll need them for WebSocket support later in the chapter.

SIDEBAR **npm scripts**

npm supports the `scripts` property in package.json with more than a dozen scripts available right out of the box (see the npm-scripts documentation for details, https://docs.npmjs.com/misc/scripts). You can also add new commands specific to your development and deployment workflow.

Some of these scripts need to be run manually (such as `npm start`) and some are invoked automatically (such as `postinstall`). In general, if any command in the `scripts` section starts with the `post` prefix, it'll run automatically after the command specified after this prefix. For example, if you define the command `"postinstall" : "myCustomIstall.js"`, each time you run `npm install`, the myCustomIstall.js script will run as well.

Similarly, if a command has a `pre` prefix, the command will runs before the command named after this prefix. For example, in chapter 10 in the section “Production configuration”, you can see the following commands in the package.json file:

```
"prebuild": "npm run clean && npm run test",
"build": "webpack --config webpack.prod.config.js --progress --profile --colors"
```

If you run the `build` command, npm will first run the script defined in `prebuild`, and then it'll run the script defined in `build`.

So far we've been using only two commands: `npm start` and `npm run dev`, but you can add any commands you like to the `scripts` section of your package.json file. For example, both the `build` and `prebuild` commands in the preceding example are our custom commands.

SIDEBAR **Common vs. separate configuration files**

In this chapter, all code samples for the client and server belong to a single npm project and share the same package.json file. All dependencies and typings are shared by the client and server applications. This setup may reduce the time for installing dependencies and save space on disk because some of the dependencies might be shared between the client and server.

But keeping the code for the client and server in a single project tends to complicate the build automation process for two reasons:

1. Client and server may require conflicting versions of a particular dependency.
2. We use build automation tools, which may require different configurations for client and server, and their node_modules directories wouldn't be located in the root directory of the project.

In chapter 10 we'll separate the client and server portions of the online auction into two independent npm projects.

The next step is to add an Angular app to the client directory.

8.3.2 Making GET requests with the Http object

When Angular's `Http` object makes a request, the response comes back as `Observable`, and our client's code will handle it by using the `subscribe()` method. Let's start with a simple application (client/app/main.ts) that retrieves all products from the Node server and renders them using an HTML unordered list:

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

import {HttpModule, Http} from '@angular/http';   ❶
import { Observable} from "rxjs/Observable";

import 'rxjs/add/operator/map';   ❷

@Component({
  selector: 'http-client',
  template: `<h1>All Products</h1>
  <ul>
    <li *ngFor="let product of products">
       {{product.title}}
    </li>
  </ul>
  `})
class AppComponent {

  products: Array = [];

    theDataSource: Observable;


    constructor(private http: Http) {   ❸


        this.theDataSource = this.http.get('/products')   ❹

            .map(res => res.json());   ❺
    }

    ngOnInit(){

        // Get the data from the server

        this.theDataSource.subscribe(   ❻
            data => {
                if (Array.isArray(data)){
                    this.products=data;
                } else{
                    this.products.push(data);
                }
            },
            err =>   ❼
                console.log("Can't get products. Error code: %s, URL: %s ",  err.status, err.url),

            () => console.log('Product(s) are retrieved')   ❽
        );

    }
}

@NgModule({
    imports:      [ BrowserModule,

                    HttpModule],   ❾
    declarations: [ AppComponent],
    bootstrap:    [ AppComponent ]
```

```
})
class AppModule { }

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

1. Imports HTTP module and the Http object that will be injected into AppComponent.
2. There are more than 100 operators in RxJS; we just need map() in this example.
3. The instance of the Http service is injected into our component.
4. Doesn't send a GET request to the /products endpoint of our Node server yet, because no one subscribed to it.
5. The map() operator will convert the data into a JSON string and return an Observable. No server requests are made until a subscribe() method is invoked.
6. The subscribe() method initiates the request to the server. subscribe() internally creates an Observer object, and this fat arrow expression assigns the received data to the products array.
7. The error callback will be invoked only if the server responds with an error.
8. The final callback is invoked after the handling of the stream of data is complete.
9. Declares HttpModule that defines providers required for injecting the Http object.

To see the error callback in action, change the endpoint from `'/products'` to something else. Your Angular application will print the following on the console: "Can't get products. Error code: 404, URL: http://localhost:8000/products".

IMPORTANT	**When the request goes to the server** The HTTP `GET` request is sent to the server only when you invoke the `subscribe()` method and not when you call the `get()` method.

We're ready to start the server and enter its URL in the browser to see our Angular app served. You can start your Node server either by running the long command:

```
node build/auction-rest-server-angular.js
```

or by using the npm script that we defined in the package.json file:

```
npm run restServer
```

Open the browser to http://localhost:8000, and you'll see the Angular app shown in figure 8.5.

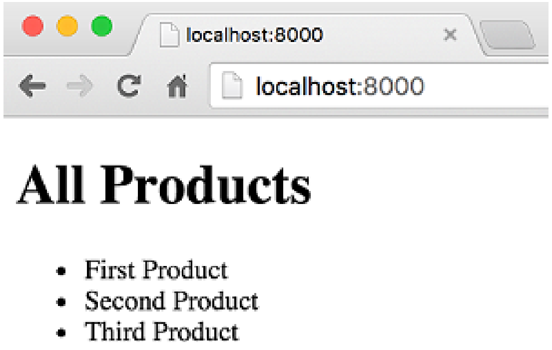


Figure 8.5 Retrieving all products from the Node server

NOTE	**Note** Make sure that the client/systemjs.config.js file maps the app package to main.ts.

NOTE	**Passing parameters in the HTTP `GET` request** You can make HTTP `GET` requests that pass parameters in the URL after the question mark (such as `myserver.com?param1=val1&param2=val2`). The `Http.get()` method can accept a second parameter, which is an object that implements `RequestOptionsArgs`. The `search` field of `RequestOptionsArgs` can be used to set either a `string` or a `URLSearchParams` object. You'll see an example of using `URLSearchParams` in the hands-on section of this chapter.

8.3.3 Unwrapping observables inside templates with AsyncPipe

In the previous section we handled the observable stream of products in the TypeScript code by invoking the `subscribe()` method. Angular offers an alternative syntax that allows observables to be handled right in the template of a component with pipes; it's covered in chapter 5.

Angular includes `AsyncPipe` (or `async` if used in templates), which can receive a `Promise` or `Observable` as input and subscribe to it automatically. To see this in action, let's make the following changes in the code from the previous section:

- Change the type of the `products` variable from `Array` to `Observable`.
- Remove the declaration of the `theDataSource` variable.
- Remove the invocation of `subscribe()` in the code. We'll simply assign the `Observable` returned by `http.get().map()` to `products`.
- Add the `async` pipe to the `*ngFor` loop in the template.

The following code (main-asyncpipe.ts) implements these changes.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import {HttpModule, Http} from '@angular/http';
import 'rxjs/add/operator/map';
import { Observable} from "rxjs/Observable";

@Component({
  selector: 'http-client',
  template: `<h1>All Products</h1>
  <ul>
    <li *ngFor="let product of products | async">    ❶
       {{product.title}}
    </li>

  </ul>
  `})
class AppComponent {


  products: Observable<Array<string>>;    ❷

  constructor(private http: Http) {

    this.products = this.http.get('/products')
        .map(res => res.json());    ❷
  }
}

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

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

❶ The async pipe will unwrap the array elements from the provided Observable stream of products.

❷ Now the products array has the type Observable, which wraps an array of strings.

❸ Assigns an observable that will be returned by map() to products.

Running this application will produce the same output as seen in figure 8.5.

NOTE	**`AsyncPipe` and errors** This version of `AppComponent` with `async` is ten lines shorter than the version in the previous section, but at the time of writing, the `async` pipe doesn't support parameters that would allow us to specify the error-processing function.

8.3.4 Injecting HTTP into a service

In this section you'll see an example of an injectable `ProductService` class that will encapsulate HTTP communications with the server. We'll create a small application in which the user can enter the product ID and have the application make a request to the server's `/products/:id` endpoint.

The user enters the product ID and clicks on the button, which starts a subscription to the observable property `productDetails` on the `ProductService` object. Figure 8.6 shows the injectable objects of the application we're going to build.

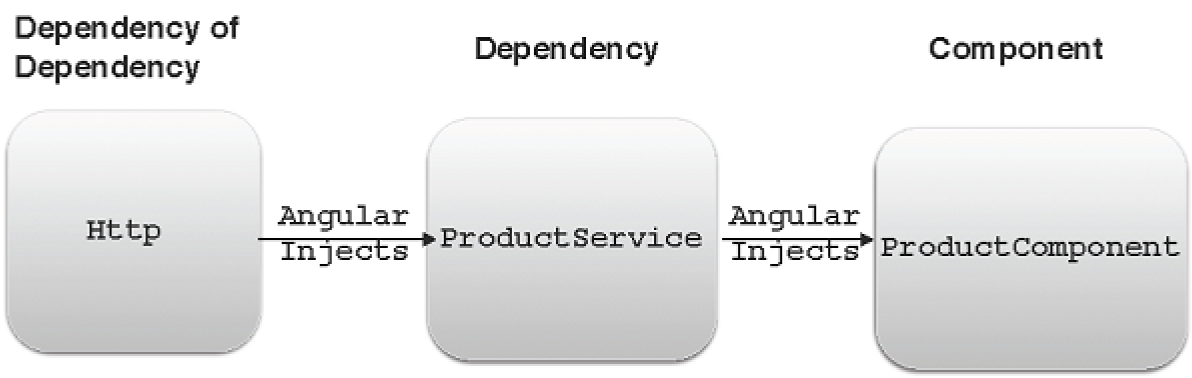


Figure 8.6 The client-server workflow

In chapter 7 you got familiar with the Forms API. Here we'll create an `AppComponent` with a simple form that has an input field and a Find Product button. This application will communicate with the Node web server we created earlier, and we'll implement the client portion in two iterations. In the first version (main-form.ts) we won't use the `ProductService` class. The `AppComponent` will get the `Http` object injected and will make requests to the server.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { FormsModule} from '@angular/forms';
import {HttpModule, Http} from '@angular/http';

@Component({
  selector: 'http-client',
  template: `<h1>Find Product By ID</h1>

     <form #f="ngForm" (ngSubmit) = "getProductByID(f.value)" >   ❶
       <label for="productID">Enter Product ID</label>
       <input id="productID" type="number" name = "productID" ngModel>
       <button type="submit">Find Product</button>
     </form>

     <h4>{{productTitle}} {{productPrice}}</h4>
  `})
class AppComponent {

  productTitle: string;
  productPrice: string;
```

```
  constructor(private http: Http) {}

  getProductByID(formValue){

    this.http.get(`/products/${formValue.productID}`)      ❷
        .map(res => res.json())
        .subscribe(

            data => {this.productTitle= data.title;      ❸
                     this.productPrice=`$` + data.price;},
            err => console.log("Can't get product details. Error code: %s, URL: %s ",

                  err.status, err.url),      ❹
            () =>    console.log( 'Done')
        );
  }
}

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

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

❶ Defines the form that invokes getProductByID() when the user clicks on the submit button.

❷ Uses string interpolation to attach the entered productID to the URL in the HTTP get() request. The HTTP GET request isn't issued yet at this point.

❸ subscribe() issues the GET request and assigns the received values to the productTitle and productPrice class variables, which are bound to the HTML template.

❹ In case of an error, prints the error code and the URL on the console.

Figure 8.7 shows a screenshot taken after the user entered 2 as a product ID and clicked the Find Product button, which sent a request to the URL http://localhost:8000/products/2. The Node Express server matched `/products/2` with the corresponding REST endpoint and routed this request to the method defined as `app.get('/products/:id')`.

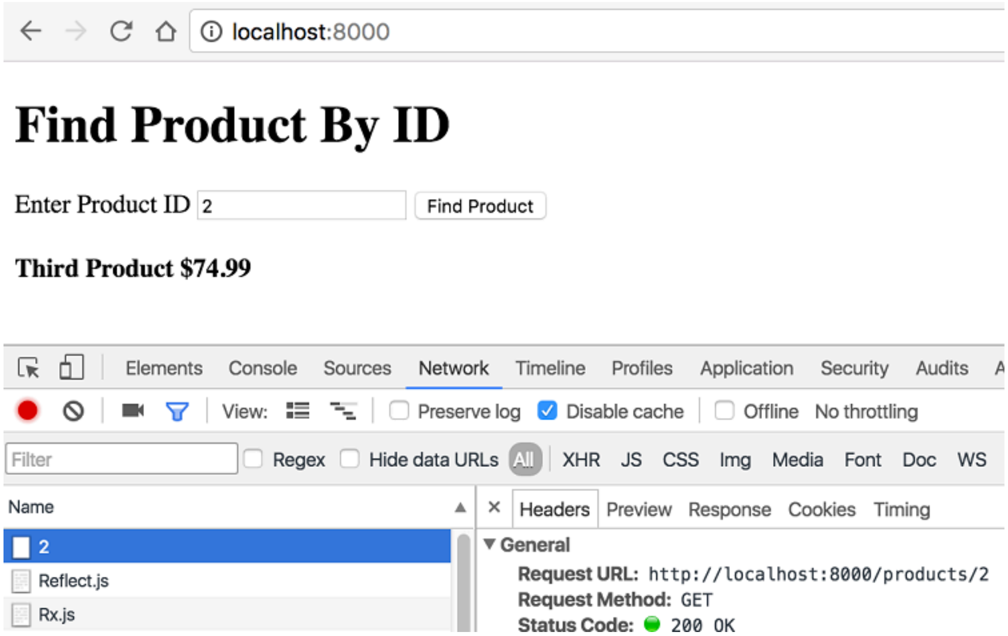


Figure 8.7 Getting product details by ID

INJECTING AN HTTP OBJECT INTO A SERVICE

Now let's introduce the `ProductService` class (product-service.ts). In the previous code sample we were injecting `Http` into the constructor of the `AppComponent`; now we'll move the code that uses `Http` into `ProductService`, so the code reflects the architecture in figure 8.6.

```
import { Http} from '@angular/http';
import { Injectable} from "@angular/core";
import {Observable} from 'rxjs/Observable';
import 'rxjs/add/operator/map';

@Injectable()   ❶
export class ProductService{

   constructor(private http: Http){}   ❷

   getProductByID(productID: string): Observable<any>{   ❸
      return this.http.get(`/products/${productID}`)
          .map(res => res.json());
   }
}
```

❶ We didn't use the @Injectable annotation in previous versions of ProductService because we didn't inject anything into the ProductService itself.

❷ Angular injects the instance of the Http object, and the private qualifier results in implicit creation of the http instance variable.

❸ The getProductByID() method forms the URL, but it doesn't invoke the subscribe() method. It simply returns an Observable object. The component that will be handling the data will provide an observer.

The `ProductService` class uses DI. The `@Injectable()` decorator instructs the TypeScript compiler to generate the metadata for `ProductService`, and using this decorator is required here. When we were injecting `Http` into the component that had another decorator (`@Component`), the TypeScript compiler would generate the metadata for the component required for DI. If the class `ProductService` didn't have any decorators, the TypeScript compiler wouldn't generate any metadata for it, and the Angular DI mechanism wouldn't know that it had some injection to do into `ProductService`.

The mere existence of the `@Injectable()` decorator is required for classes that represent services, and you shouldn't forget to include `"emitDecoratorMetadata": true` in the file tsconfig.json.

The new version of `AppComponent` (main-with-service.ts) will become a subscriber of the observable stream produced by `ProductService`.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import { FormsModule} from '@angular/forms';
import {HttpModule, Http} from '@angular/http';
import {ProductService} from './product-service';

@Component({
  selector: 'http-client',
  providers: [ProductService],
  template: `<h1>Find Product By ID Using ProductService</h1>
     <form #f="ngForm" (ngSubmit)="getProductByID(f.value)">
       <label for="productID">Enter Product ID</label>
       <input id="productID" type="number" ngControl="productID">
       <button type="submit">Find Product</button>
     </form>
     <h4>{{productTitle}} {{productPrice}}</h4>
  `})
class AppComponent {

  productTitle: string;
  productPrice: string;

  constructor(private productService: ProductService) {}    ❶

  getProductByID(formValue){

      this.productService.getProductByID(formValue.productID)    ❷

        .subscribe(    ❸
            data => {this.productTitle = data.title;
                     this.productPrice = `$` + data.price;},
            err => console.log("Can't get product details. Error code: %s, URL: %s ",
                      err.status, err.url),
            () => console.log('Done')
        );
  }
}

@NgModule({
    imports:      [ BrowserModule,  FormsModule, HttpModule],
    declarations: [ AppComponent],
```

```
    bootstrap:    [ AppComponent ]
})
class AppModule { }

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

1. Now Angular injects the ProductService, whereas in the previous version of this component it injected the Http object.
2. Invokes the method on ProductService that returns an Observable.
3. Subscribes to the Observable and handles the results.

`ProductService` isn't a component, but a class, and Angular doesn't allow us to specify providers for classes. As a result, we specified the provider for `Http` in the `AppComponent` by including the `providers` property in the `@Component` decorator. The other choice would be to declare providers in `@NgModule`. In this particular application, it wouldn't make a difference.

In chapter 4, while discussing DI, we mentioned that Angular can inject objects, and if they have their own dependencies, Angular will inject them as well. The preceding sample application proves that Angular's DI module works as expected.

8.4 Client-server communication via WebSockets

WebSocket is a low-overhead binary protocol supported by all modern web browsers. As opposed to the request-based HTTP, where a client sends a request over a connection and waits for a response to come back (half-duplex) as shown in figure 8.8, the WebSocket protocol allows data to travel in both directions simultaneously (full-duplex) over the same connection, as in figure 8.9. The WebSocket connection is kept alive, which has an additional benefit: there's low latency in the interaction between the server and the client.

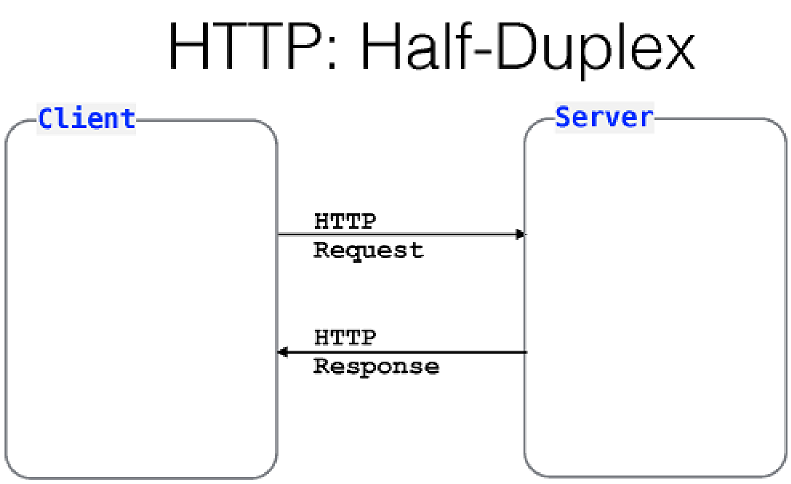


Figure 8.8 Half-duplex communication

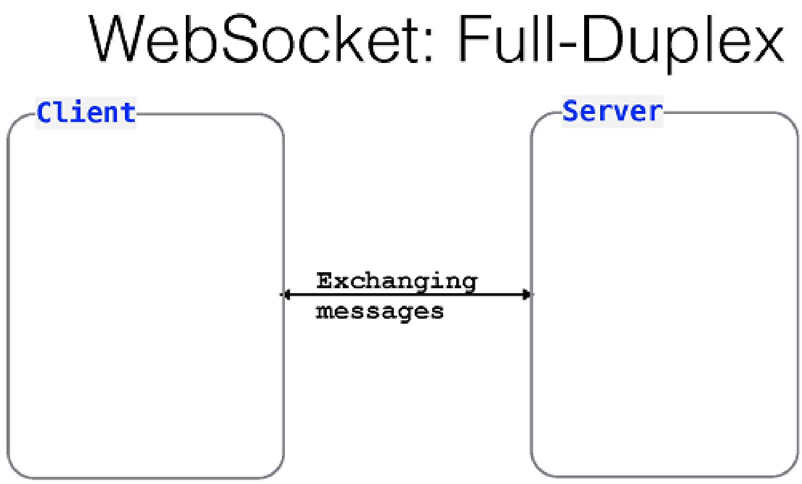


Figure 8.9 Full-duplex communication

Whereas a typical HTTP request/response adds several hundreds of bytes (the headers) to the application data, with WebSockets the overhead is as low as a couple of bytes. If you're not familiar with WebSockets, refer to the materials at websocket.org (http://www.websocket.org) or to one of the many tutorials available online.

8.4.1 Pushing data from a Node server

WebSockets are supported by most server-side platforms (Java, .NET, Python, and others), but we'll continue using Node to implement our WebSocket-based server. We'll implement one particular use case: the server will push data to a browser-based client as soon as the client connects to the socket. We purposely won't send a request for data from the client to illustrate that WebSockets are not about request-response communication. Either party can start sending the data over the WebSocket connection.

There are several Node packages that implement the WebSocket protocol—we'll use the npm package called `ws` (https://www.npmjs.com/package/ws). Install it by entering the following command in your project's directory:

```
npm install ws --save
```

Then install the type definition file for `ws`:

```
npm install @types/ws --save-dev
```

Now the TypeScript compiler won't complain when you use the API from the `ws` package. Besides, this file is handy for seeing the APIs and types available.

Our first WebSocket server will be pretty simple: it'll push the text "This message was pushed by the WebSocket server" to the client as soon as the connection is established. We purposely don't want the client to send any data request to the server to illustrate that a socket is a two-way street, and that the server can push the data without any request ceremony.

The following application (simple-websocket-server.ts) creates two servers. The HTTP server will run on port 8000 and will be responsible for sending the initial HTML file to the client. The WebSocket server will be running on port 8085 and will communicate with all connected clients through this port.

```
import * as express from "express";
import * as path from "path";
import {Server} from "ws";   ❶

const app = express();

app.use('/', express.static(path.join(__dirname, '..', 'client')));
app.use('/node_modules', express.static(path.join(__dirname, '..', 'node_modules')));

// HTTP Server
app.get('/', (req, res) => {
    res.sendFile(path.join(__dirname, '..', 'client/simple-websocket-client.html'));   ❷
});

const httpServer = app.listen(8000, "localhost", () => {   ❸
    console.log('HTTP Server is listening on port 8000');
});

// WebSocket Server
var wsServer: Server = new Server({port:8085});   ❹
console.log('WebSocket server is listening on port 8085');

wsServer.on('connection',   ❺
           websocket => websocket.send('This message was pushed by the WebSocket server'));   ❻
```

❶ This example uses the Server type from the ws module for the explicit variable declaration. That's why we import only the Server definition.

❷ Whenever the HTTP client connects to the base URL, the HTTP server will send the client/simple-websocket-client.html file back.

❸ The HTTP Server starts listening on port 8000.

❹ The WebSocket server starts listening on port 8085. The wsServer variable will know everything about this socket.

❺ As soon as the client connects to the socket, the connection event is dispatched on the object represented by wsSocket to this particular client.

❻ The send() method will push the message, "This message was pushed by the WebSocket server".

NOTE **Importing all members from the `ws` package**
In the previous code sample, we import only the `Server` module from `ws`. If we used other exported members, we could have written `import * as ws from "ws";`.

In the preceding example, HTTP and WebSocket servers are running on different ports, but we could have reused the same port by providing the newly created `httpServer` instance to the constructor of `WsServer`:

```
const httpServer = app.listen(8000, "localhost", () => {...});

const wsServer: WsServer = new WsServer({server: httpServer});.
```

In the hands-on section of this chapter, we'll reuse port 8000 for both HTTP and WebSocket communications (see the server/auction.ts file).

NOTE **Storing references to connected clients**
As soon as the new client connects to the server, the reference to this connection is added to the `wsServer.clients` array so you can broadcast messages to all connected clients if needed: `wsServer.clients.forEach(client  client.send('…'));`.

The content of the client's simple-websocket-client.html file is shown next. This client doesn't use either Angular or TypeScript. As soon as this file is downloaded to the browser, its script connects to our WebSocket server at ws://localhost:8085. Note that the protocol is `ws` and not `http`. For a secure socket connection, use the `wss` protocol.

```
<!DOCTYPE html>
<html>
<head>
    <meta charset="UTF-8">
</head>
<body>
<span id="messageGoesHere"></span>

<script type="text/javascript">
    var ws = new WebSocket("ws://localhost:8085");

    ws.onmessage = function(event) {
        var mySpan = document.getElementById("messageGoesHere");
        mySpan.innerHTML=event.data;
    };

    ws.onerror = function(event){
        console.log("Error ", event)
    }
```

```
</script>
</body>
</html>
```

❶ Establishes the socket connection. At this point, the server will upgrade the protocol from HTTP to WebSocket.

❷ When the message arrives from the socket, we display its content in the <span> element.

❸ In the case of an error, the browser will log the error message on the console.

To run the server that pushes data to the clients, start the Node server (`node build/simple-websocket-server.js` or `npm simpleWsServer`) and it'll print the following messages on the console:

```
WebSocket server is listening on port 8085
HTTP Server is listening on 8000
```

NOTE **Compiling the server's code**
If you'll be modifying the code located in the server directory, don't forget to run `npm run tsc` in the root directory of your project to create a fresh version of your JavaScript code in the build directory. Otherwise the `node` command will load the old JavaScript file.

To receive the message pushed from the server, open the browser to http://localhost:8000. You'll see the message, as shown in figure 8.10.

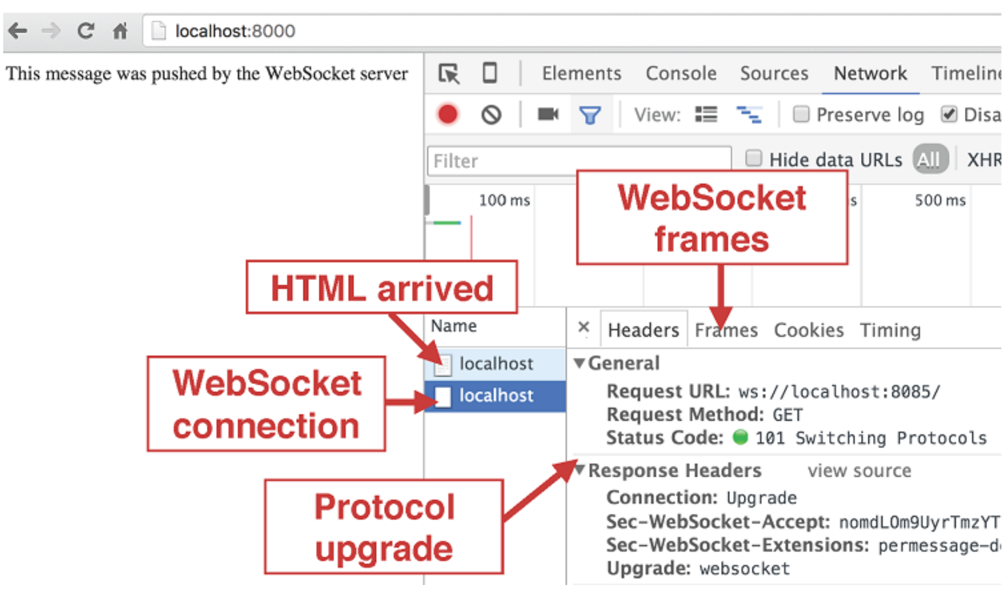


Figure 8.10 Getting the message from the socket

In this example, the HTTP protocol is used only to initially load the HTML file. Then the client requests the protocol upgrade to WebSocket (status code 101), and from then on this application won't use HTTP.

NOTE **Monitoring the socket's traffic**
You can monitor messages going over the socket by using the Frames tab in Chrome Developer Tools.

8.4.2 Turning a WebSocket into an observable

In the previous section, we wrote client in JavaScript (no Angular) using the browser's `WebSocket` object. Now we'll show you how create a service that will wrap the browser's `WebSocket` object in an observable stream so Angular components can subscribe to messages coming from the server over the socket connection.

Earlier, in section 8.3.2, the code that received the product data was structured as follows (in pseudocode):

```
this.http.get('/products')
  .subscribe(
      data => handleNextDataElement(),
      err => handleErrors(),
      () => handleStreamCompletion()
);
```

Basically our goal was to write the application code that would consume the observable stream provided by Angular's `Http` service. But Angular has no service that will produce an observable from a WebSocket connection, so we'll have to write such a service ourselves. This way, the Angular client will be able to subscribe to messages coming from the WebSocket the same way it did with the `Http` object.

WRAPPING ANY SERVICE IN AN OBSERVABLE STREAM

Now we'll create a small Angular application that won't use a WebSocket server but will illustrate how to wrap business logic into an Angular service that emits data via an observable stream. Let's start by creating an observable service that will simply emit hard-coded values without actually connecting to a socket. The following code (custom-observable-service.ts) creates a service that emits the current time every second.

```
import {Observable} from 'rxjs/Rx';

export class CustomObservableService{

  createObservableService(): Observable<Date>{

      return new Observable(
          observer => {
              setInterval(() =>
                  observer.next(new Date())
              , 1000);
          }
```

```
    );
  }
}
```

In this code we create an `Observable`, assuming that the subscriber will provide an `Observer` object that knows what to do with the data pushed by the observable. Whenever the observable invokes the method `next()` on the observer, the subscriber will receive the value given as an argument (`new Date()` in this example). Our data stream never throws an error and never completes.

NOTE	**Explicit creation of subscribers** You can also create a subscriber for an observable by explicitly invoking `Subscriber.create()`. You'll see such an example in the hands-on section of this chapter.

The following `AppComponent` (custom-observable-service-subscriber.ts) gets the `CustomObservableService` injected, invokes the `createObservableService()` method that returns `Observable`, and subscribes to it, creating an observer that knows what to do with the data. The observer in this application simply assigns the received time to the `currentTime` variable.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';
import 'rxjs/add/operator/map';

import {CustomObservableService} from "./custom-observable-service";

@Component({
  selector: 'app',
  providers: [ CustomObservableService ],
  template: `<h1>Simple subscriber to a service</h1>
       Current time: {{currentTime | date: 'jms'}}
  `})
class AppComponent {

  currentTime: Date;

  constructor(private sampleService: CustomObservableService) {

      this.sampleService.createObservableService()
        .subscribe( data => this.currentTime = data );
  }
}

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

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

For this app we created the index.html file in the root directory of the project. This app doesn't use any servers, and you can simply run it by entering the command `live-server` in the terminal window. In the browser's window the current time will be updated every second. We use the `DatePipe` here with the format `'jms'`, which displays only hours, minutes, and seconds (all date formats are described in the Angular DatePipe documentation at http://mng.bz/78lD).

This was a simple example, but it demonstrated a basic technique for wrapping any application logic in an observable stream and subscribing to it. In this case we used `setInterval()`, but you could replace the `setInterval()` with any application-specific code that generates one or more values and sends them as a stream.

Don't forget about error handling and completing the stream if need be. The following code snippet shows a sample observable that sends one element to the observer, may throw an error, and tells the observer that the streaming is complete.

```
return new Observable(
    observer => {
      try {
        observer.next('Hello from observable');

        //throw ("Got an error");

      } catch(err) {
         observer.error(err);
      } finally{
         observer.complete();
      }
    }
);
```

If you uncomment the line with `throw`, the `observer.error()` is invoked, which results in the invocation of the error handler on the subscriber, if there is one.

Now let's teach our Angular service to communicate with the WebSocket server.

ANGULAR TALKING TO A WEBSOCKET SERVER

Let's create a small Angular application with a WebSocket service (on the client) that interacts with our Node WebSocket server. The server-side tier can be implemented with any technology that supports WebSockets. Figure 8.11 illustrates the architecture of such an application.

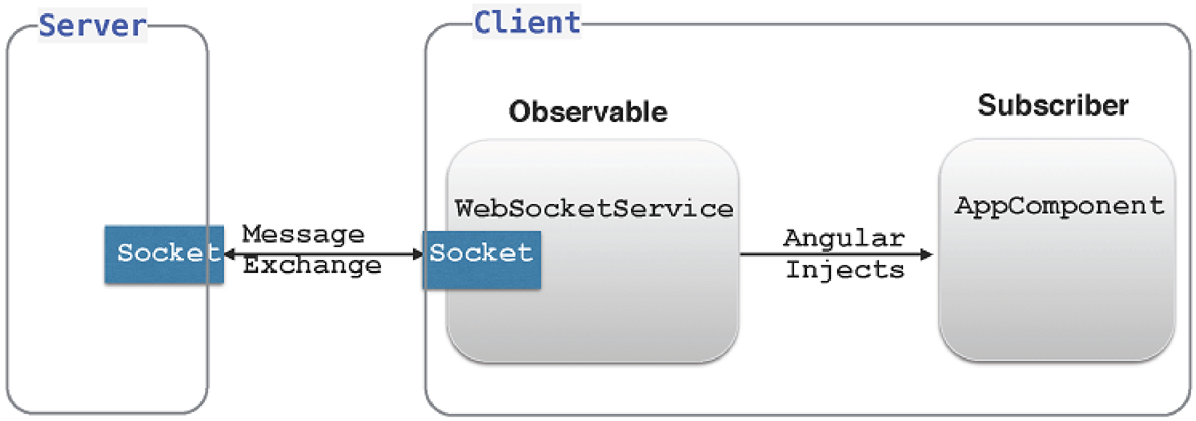


Figure 8.11 Angular interacting with a server via a socket

The following code wraps the browser's `WebSocket` object into an observable stream (websocket-observable-service.ts). This service creates an instance of `WebSocket` that's connected to the server based on the provided URL, and this instance handles messages received from the server. The `WebSocketService` also has a `sendMessage()` method so the client can send messages to the server.

```
import {Observable} from 'rxjs/Rx';

export class WebSocketService{

    ws: WebSocket;

    createObservableSocket(url:string):Observable{

        this.ws = new WebSocket(url);

        return new Observable(
          observer => {

            this.ws.onmessage = (event) =>
                      observer.next(event.data);

            this.ws.onerror = (event) => observer.error(event);

            this.ws.onclose = (event) => observer.complete();

        }
     );
    }

    sendMessage(message: any){
        this.ws.send(message);
    }
}
```

Following is the code of the `AppComponent` that subscribes to `WebSocketService`, which is injected into the `AppComponent` as seen in figure 8.11. This component (websocket-observable-service-subscriber.ts) can also send messages to the server when the user clicks on the Send Msg to Server button.

```
import { platformBrowserDynamic } from '@angular/platform-browser-dynamic';
import { NgModule, Component }      from '@angular/core';
import { BrowserModule } from '@angular/platform-browser';

import {WebSocketService} from "./websocket-observable-service";

@Component({
  selector: 'app',
  providers: [ WebSocketService ],
  template: `<h1>Angular subscriber to WebSocket service</h1>
       {{messageFromServer}}<br>
       <button (click)="sendMessageToServer()">Send msg to Server</button>
  `})
class AppComponent {

  messageFromServer: string;

  constructor(private wsService: WebSocketService) {

      this.wsService.createObservableSocket("ws://localhost:8085")
        .subscribe(
            data => {
              this.messageFromServer = data;
            },
            err => console.log( err),
            () =>  console.log( 'The observable stream is complete')
        );
  }

    sendMessageToServer(){
        console.log("Sending message to WebSocket server");

        this.wsService.sendMessage("Hello from client");
    }
}

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

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

The HTML file that renders the preceding component is called two-way-websocket-client.html. You need to make sure that websocket-observable-service-subscriber is configured as the main app script in systemjs.config.js.

```
<!DOCTYPE html>
<html>
<head>
  <title>Http samples</title>

  <script src="https://cdn.polyfill.io/v2/polyfill.js?features=Intl.~locale.en"></script>

  <script src="node_modules/zone.js/dist/zone.js"></script>
  <script src="node_modules/typescript/lib/typescript.js"></script>
  <script src="node_modules/reflect-metadata/Reflect.js"></script>
  <script src="node_modules/rxjs/bundles/Rx.js"></script>
  <script src="node_modules/systemjs/dist/system.src.js"></script>
  <script src="systemjs.config.js"></script>
  <script>
    System.import('app').catch(function (err) {console.error(err);});
```

```
  </script>
</head>
<body>
<app>Loading...</app>
</body>
</html>
```

Finally, we'll create another version of simple-websocket-server.ts to serve an HTML file with a different Angular client. This server will be implemented in the two-way-websocket-server.ts file and will have almost the same code with two small changes:

1. When the server receives a request to the base URL, it needs to serve the preceding HTML to the client:

```
app.get('/', (req, res) => { res.sendFile(path.join(__dirname, '..', 'client/two-way-websocket-cli
});
```

2. You need to add the `on('message')` handler to process messages arriving from the client.

```
wsServer.on('connection',
   websocket => {
       websocket.send('This message was pushed by the WebSocket server');

       websocket.on('message',
                      message => console.log("Server received: %s", message));
   });
```

To see this application in action, run `nodemon build/two-way-websocket_server.js` (or use the `npm run twowayWsServer` command that's configured in package.json) and open your browser to localhost:8000. You'll see the window with the message pushed from Node, and if you click on the button, a "Hello from client" message will be sent to the server. We took the screenshot in figure 8.12 after clicking on the button once (Chrome Developer Tools was opened to the Frames tab under Network).

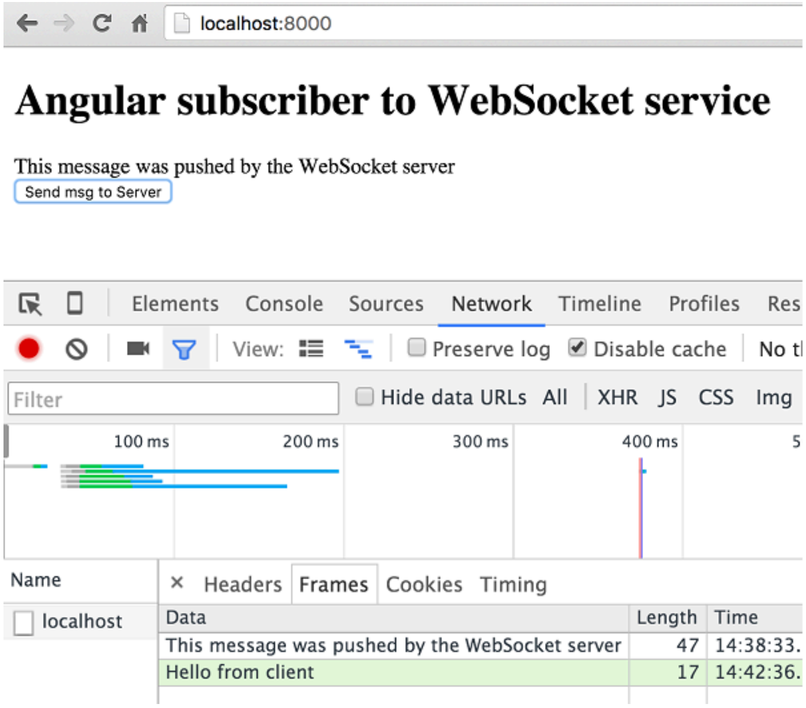


Figure 8.12 Getting the message in Angular from Node

Now that you know how to communicate with a server via the HTTP and WebSocket protocols, let's teach our online auction to interact with our Node server.

8.5 Hands-on: Implementing product search and bid notifications

The amount of code we'll add to this chapter's version of the auction is pretty substantial, so we decided to spare you from typing it all. In this hands-on exercise we'll just review the new or modified code fragments in the new version of the auction app that comes with this chapter. In this version of the application, we'll accomplish two main goals:

- We'll implement the product search functionality. The `SearchComponent` will connect the auction to the Node server via HTTP, and the data about products and reviews will come from the server.
- We'll add server-pushed bid notifications using the WebSocket protocol, so the user can subscribe and watch bid prices for a selected product.

Figure 8.13 depicts the main players involved in the product search implementation.

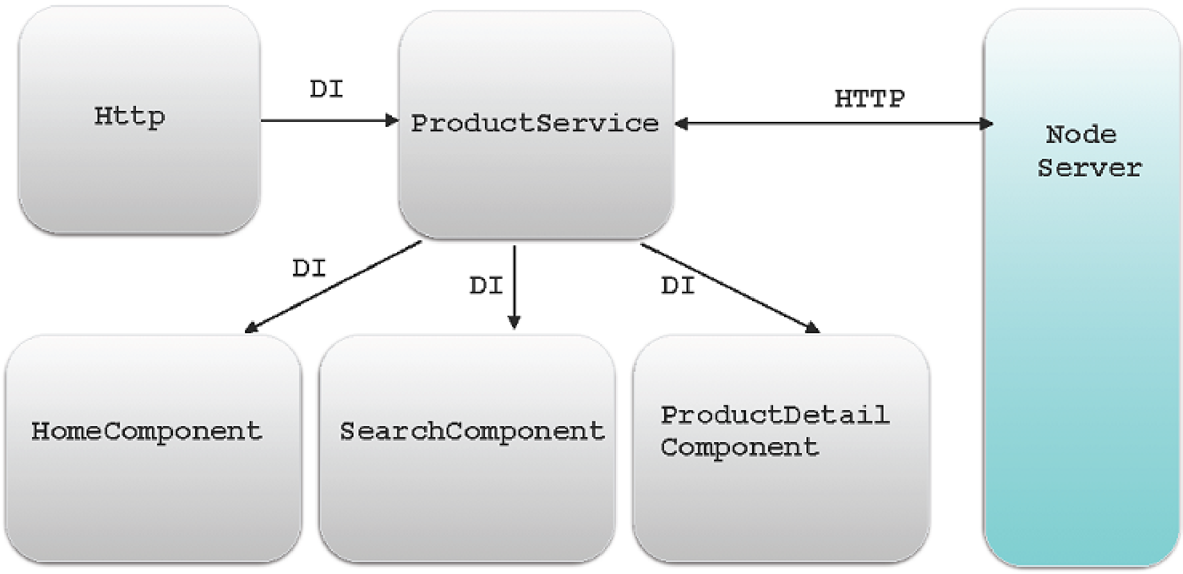


Figure 8.13 Product search implementation

The "DI" in the figure stands for *dependency injection*. Angular injects the `Http` object into `ProductService`, which in turn is injected into three components: `HomeComponent`, `SearchComponent`, and `ProductDetailComponent`. The `ProductService` object is responsible for all communications with the server.

NOTE	**Server-side technologies** We use the Node server in this project, but you can use any technology that supports the HTTP and WebSocket protocols such as Java, .NET, Python, Ruby, and so on.

In this hands-on exercise, we'll provide brief explanations about the code changes made in various scripts, but you should perform a detailed code review of the auction on your own.

In this chapter's version of the auction, the `scripts` section looks like this:

```
"scripts": {
  "tsc": "tsc",
  "start": "node build/auction.js",
  "dev": "nodemon build/auction.js"
}
```

Running `npm start` will start your Node server loading the auction.js script. In this project, the tsconfig.json file specifies the build directory as an output for the TypeScript compiler, and two files, auction.js and model.js, are created there when you run `npm run tsc` in the project root directory. If you have version 2.0 or later of the TypeScript compiler installed globally, you can just run the `tsc` command.

The TypeScript auction.ts source contains the code implementing the HTTP and

WebSocket servers, and model.ts contains the data that now resides on the server.

Running `npm run dev` will start your Node server in live reload mode.

8.5.1 Implementing product search using HTTP

The auction's home page has a Search form on the left side, and the user can enter their search criteria, click the button Search, and get matching products from the server. As shown in figure 8.14, `ProductService` is responsible for all HTTP communications with the server including the initial load of products information or finding products that meet certain criteria.

MOVING PRODUCT AND REVIEW DATA TO THE SERVER

So far, data about products and reviews has been hardcoded in the client-side `ProductService` class, and when the application starts it shows all the hard-coded products in the `HomeComponent`. When the user clicks on a product, the router navigates to the `ProductDetailComponent`, which shows product details and reviews, also hard-coded in `ProductService`.

Now we want the data about products and reviews to be located on the server. The server/auction.ts and server/model.ts files contain the code that will run as a Node application (the web server). The auction.ts file implements HTTP and WebSocket functionality, and the model.ts file declares the `Product` and `Review` classes, and the `products` and `reviews` arrays with the data. These arrays were also removed from the client/app/services/product-service.ts file.

NOTE **Adding product categories**
The `Product` class has a new `categories` property, which will be used in the `SearchComponent`.

THE PRODUCTSERVICE CLASS

The `ProductService` class will get the `Http` object injected, and most of the methods of this class will return observable streams generated by HTTP requests. The following code fragment shows the new version of the `getProducts()` method:

```
getProducts(): Observable<Product[]> {
  return this.http.get('/products')
    .map(response => response.json());
}
```

As you'll recall, the preceding method won't issue the HTTP `GET` request until some object subscribes to `getProducts()` or a component's template uses an `AsyncPipe` with the data returned by this method (you can find such an example in `HomeComponent`).

The `getProductById()` method looks similar:

```
getProductById(productId: number): Observable<Product> {
  return this.http.get(`/products/${productId}`)
    .map(response => response.json());
}
```

The `getReviewsForProduct()` method also returns an `Observable`:

```
getReviewsForProduct(productId: number): Observable<Review[]> {
  return this.http
    .get(`/products/${productId}/reviews`)
    .map(response => response.json())
    .map(reviews => reviews.map(
      (r: any) => new Review(r.id, r.productId,
        new Date(r.timestamp), r.user, r.rating, r.comment)));
}
```

The new `ProductService.search()` method is used when the user clicks on the Search button in the `SearchComponent`:

```
search(params: ProductSearchParams): Observable<Product[]> {
  return this.http
    .get('/products', {search: encodeParams(params)})
    .map(response => response.json());
}
```

The preceding `Http.get()` method uses a second argument, which is an object with the `search` property for storing the query string parameters. As you saw in the `RequestOptionsArgs` interface earlier, the `search` property can hold either a `string` or an instance of `URLSearchParams`.

Following is the code of the `ProductService.encodeParams()` method, which turns a JavaScript object into an instance of `URLSearchParams`:

```
function encodeParams(params: any): URLSearchParams {
  return Object.keys(params)
    .filter(key => params[key])
    .reduce((accum: URLSearchParams, key: string) => {
      accum.append(key, params[key]);
      return accum;
    }, new URLSearchParams());
}
```

The new `ProductService.getAllCategories()` method is used to populate the Categories dropdown in the `SearchComponent`:

```
getAllCategories(): string[] {
  return ['Books', 'Electronics', 'Hardware'];
}
```

The `ProductService` class also defines a new `searchEvent` variable of type

EventEmitter, and we'll explain its use in the next section when we discuss how to pass the search results to the HomeComponent.

PROVIDING SEARCH RESULTS TO HOMECOMPONENT

Initially our HomeComponent displays all products by invoking the ProductService.getProducts() method, but if the user performs a search by some criteria, we need to make a request to the server, which may return a subset of products or an empty data set if none of the products meet the search criteria.

The SearchComponent receives a result, which has to be passed to the HomeComponent. If both of these components were children of the same parent (such as AppComponent), we could use the parent as a mediator (see chapter 6) and input/output parameters of the children for the data. But HomeComponent is added to AppComponent dynamically by the router, and currently Angular doesn't support cross-route input/output parameters. We need another mediator, and the ProductService object can become one, because it's injected into both SearchComponent and HomeComponent.

The ProductService class has a searchEvent variable that's declared as follows:

```
searchEvent: EventEmitter = new EventEmitter();
```

The SearchComponent will use this variable to emit the searchEvent that carries the object with search parameters as the payload. The HomeComponent will subscribe to this event, as shown on figure 8.14.

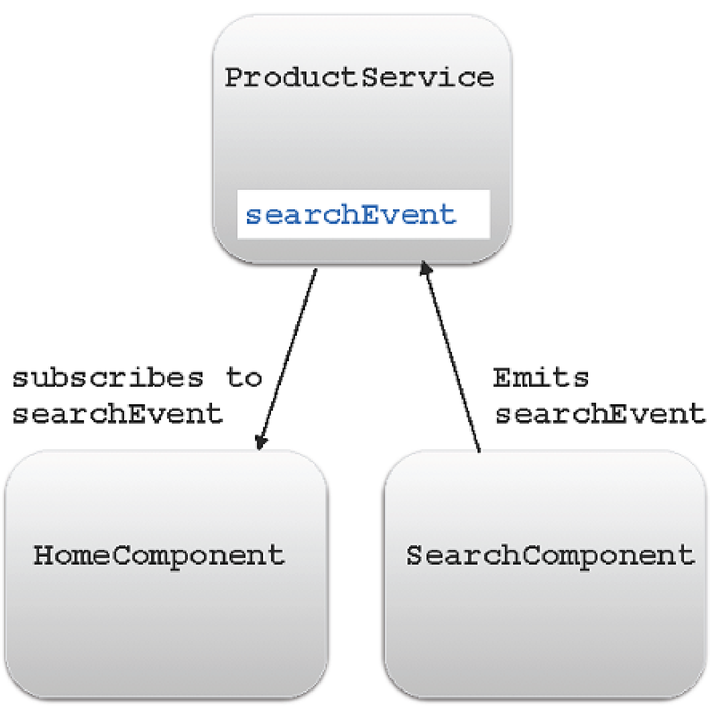


Figure 8.14 Component communication via events

SearchComponent is a form, and when the user clicks on the Search button, it has to notify the world which search parameters were entered. ProductService will do this by emitting the event with the search parameters:

```
onSearch() {
  if (this.formModel.valid) {
    this.productService.searchEvent.emit(this.formModel.value);
  }
}
```

HomeComponent is subscribed to the searchEvent that may arrive from the SearchComponent with a payload of search parameters. As soon as that happens, the ProductService.search() method is invoked:

```
this.productService.searchEvent
  .subscribe(
    params => this.products = this.productService.search(params),
    console.error.bind(console),
    () => console.log('DONE')
  );
```

NOTE **Our search limitations**

Our search solution assumes that HomeComponent is displayed on the screen when the user performs the product search, but if the user navigates to the Product Detail view, the HomeComponent is removed from the DOM and there are no listeners for the searchEvent. This isn't a serious shortcoming for an example in a book, and an easy fix would be to disable the search button if the user navigated from the Home route. You can also inject the Router object into the SearchComponent, and when the user clicks on the Search button while the home route isn't active (if (!router.isActive(url))), navigate to it programmatically by invoking router.navigate('home'), which returns a Promise. When the promise is resolved, you can emit the searchEvent from there.

HANDLING PRODUCT SEARCH ON THE SERVER

The following code fragment is from the auction.ts file that handles the product search request sent from the client. When the client hits the server's endpoint with query string parameters, we pass the received parameters as req.query to the getProducts() function, which performs a sequence of filters (as specified by the parameters) on the products array to filter out the non-matching products.

```
app.get('/products', (req, res) => {
  res.json(getProducts(req.query));
});
```

```
...

function getProducts(params): Product[] {
  let result = products;

  if (params.title) {
    result = result.filter(
      p => p.title.toLowerCase().indexOf(params.title.toLowerCase()) !== -1);
  }
  if ( result.length > 0 && parseInt(params.price)) {
    result = result.filter(
      p => p.price <= parseInt(params.price));
  }
  if ( result.length > 0 && params.category) {
    result = result.filter(
      p => p.categories.indexOf(params.category.toLowerCase()) !== -1);
  }

  return result;
}
```

TESTING THE PRODUCT SEARCH FUNCTIONALITY

Now that we've done a brief code review of our product search implementation, you can start the Node server using the command `npm run dev` and open the browser to localhost:8000. When the auction app loads, enter your search criteria in the form on the left, and see how the `HomeComponent` re-renders its children (`ProductItemComponent`) that meet the search criteria.

8.5.2 Broadcasting auction bids using WebSockets

In real auctions, multiple users can bid on products. When the server receives a bid from a user, the bid server should broadcast the latest bid to all users who are interested in receiving such notifications (those who subscribed for notifications). We've emulated the bidding process by generating random bids from random users.

When users open the product detail view, they should be able to subscribe to bid notifications made by other users on the selected product. We've implemented this functionality with a server-side push via WebSockets. Figure 8.15 shows the product detail view with the Watch toggle button that starts and stops the current bid notifications pushed by the server over the socket.

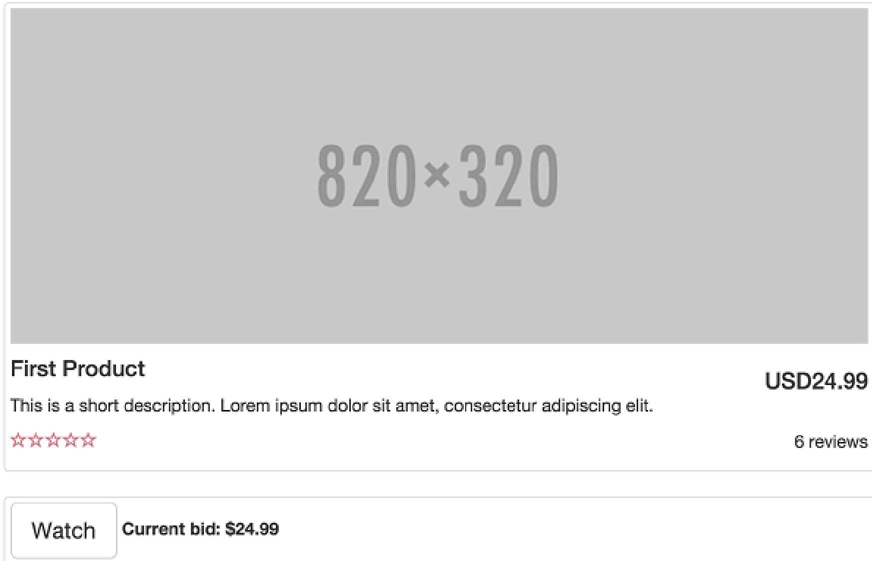


Figure 8.15 The toggle button for watching bids

Now we'll just briefly highlight the changes in the auction app related to bid notifications.

THE CLIENT SIDE

There are two new services located in the client/app/services directory: `BidService` and `WebSocketService`. `WebSocketService` is an observable wrapper for the `WebSocket` object. It's similar to the one we created earlier in section 8.4.2.

`BidService` gets the `WebSocketService` injected:

```
@Injectable()
export class BidService {
  constructor(private webSocket: WebSocketService) {}

  watchProduct(productId: number): Observable {
    let openSubscriber = Subscriber.create(
      () => this.webSocket.send({productId: productId}));

    return this.webSocket.createObservableSocket('ws://localhost:8000', openSubscriber)
      .map(message => JSON.parse(message));
  }
}
```

`BidService` is injected into `ProductDetailComponent`, and when the user clicks on the Watch toggle button, the `BidService.watchProduct()` method sends the product ID to the server, indicating that this user wants to start or stop watching the selected product:

```
toggleWatchProduct() {
  if (this.subscription) {
    this.subscription.unsubscribe();
    this.subscription = null;
    this.isWatching = false;
  } else {
```

```
    this.isWatching = true;
    this.subscription = this.bidService.watchProduct(this.product.id)
      .subscribe(
        products => this.currentBid = products.find((p: any) =>
            p.productId === this.product.id).bid,
        error => console.log(error));
  }
}
```

The template of the `ProductDetailComponent` has the Watch toggle button, and the latest bid received from the server is rendered as as HTML label:

```
<button class="btn btn-default btn-lg"
        [ngClass]="{active: isWatching}"
        (click)="toggleWatchProduct()"
        role="button">
  {{ isWatching ? 'Stop watching' : 'Watch' }}
</button>

<label>Current bid: {{ currentBid | currency }}</label>
```

There's also a small new client/app/services/services.ts script, in which we declared all the import statements and the array of services used for dependency injection:

```
import {BidService} from './bid-service';
import {ProductService} from './product-service';
import {WebSocketService} from './websocket-service';

export const ONLINE_AUCTION_SERVICES = [
  BidService,
  ProductService,
  WebSocketService
];
```

The providers declared in the `ONLINE_AUCTION_SERVICES` constant are used in the main.ts file that bootstraps the Angular portion of the auction:

```
@NgModule({
...
  providers:[ProductService,
             ONLINE_AUCTION_SERVICES,
             {provide: LocationStrategy, useClass: HashLocationStrategy}],
  bootstrap:[ ApplicationComponent ]
})
```

THE SERVER SIDE

The server/auction.ts script includes the code that maintains subscribed clients and generates random bids. Each generated bid can be up to five dollars higher than the last one. As soon as the new bid is generated, it's broadcast to all subscribed clients.

The following code from the server/auction.ts file handles bid notification requests and broadcasting bids to all subscribed clients.

```
const wsServer: WsServer = new WsServer({server: httpServer});

wsServer.on('connection', ws => {
  ws.on('message', message => {
    let subscriptionRequest = JSON.parse(message);
    subscribeToProductBids(ws, subscriptionRequest.productId);
  });
});


const subscriptions = new Map<any, number[]>();


function subscribeToProductBids(client, productId: number): void {
  let products = subscriptions.get(client) || [];
  subscriptions.set(client, [...products, productId]);
}


setInterval(() => {
  generateNewBids();
  broadcastNewBidsToSubscribers();
}, 2000);

const currentBids = new Map<number, number>();

function generateNewBids() {
  getProducts().forEach(p => {
    const currentBid = currentBids.get(p.id) || p.price;
    const newBid = random(currentBid, currentBid + 5); // Max bid increase is $5
    currentBids.set(p.id, newBid);
  });
}


function broadcastNewBidsToSubscribers() {

  subscriptions.forEach((products: number[], ws: WebSocket) => {
    if (ws.readyState === 1) { // 1 - READY_STATE_OPEN
      let newBids = products.map(pid => ({
        productId: pid,
        bid: currentBids.get(pid)
      }));
      ws.send(JSON.stringify(newBids));
    } else {
      subscriptions.delete(ws);
    }
  });
}
```

1. Creates the WebSocket server listening to the same port as the HTTP server.
2. Stores references to bid subscriptions in a Map where the key is a reference to the WebSocket connection that represents the user, and the value is an array of product IDs for which the client wants to receive bid notifications.
3. Finds the existing product subscriptions for the connected client, and adds a new product ID to the subscriptions array.
4. Every two seconds, generates a new bid and broadcasts it to all clients who subscribe to the specific product notifications.
5. For each connected client, sends the current bids for the subscribed products.

In the preceding code we test the `readyState` property of the WebSocket object to make sure that the client is still connected. For example, if the user closed the auction window, there would be no need to send bid notifications, so this socket connection is removed from the `subscriptions` map.

NOTE	**The spread operator** Note the use of the spread operator (…) in the method subscribeToProductBids()—we use it to copy an existing array of product IDs and add a new one.

We've covered the WebSocket-related code of the auction, and we encourage you to review the rest of the code on your own. To test the bid notification functionality, you'll need to start the application, click on a product title, and on the product detail view click on the Watch button. You should see the new bids on this product that are pushed from the server. Open the auction application in more than one browser to test that each browser properly turns on and off bid notifications.

8.6 Summary

The main subject of this chapter was enabling client-server interaction, which is the reason why web frameworks exist. Angular, combined with the RxJS extensions library, offers a unified approach for consuming data from the server: the client's code subscribes to the data stream coming from the server, whether it's an HTTP- or WebSocket-based interaction. The programming model is changed: instead of requesting the data as in AJAX-style applications, Angular consumes the data *pushed* by observable streams.

In this chapter we went through a series of sample applications that illustrated how you can work with observable streams, and then we applied those skills to the online auction application. As a bonus, you've learned the basics of creating HTTP and WebSocket servers using the Node.js framework and TypeScript.

Our auction application isn't an eBay killer, but in it you can find solutions to many problems you may face while working on real-world projects.

These are the main takeaways from this chapter:

- Angular comes with the `Http` object that supports HTTP communications with web servers.
- Providers for the HTTP services are located in the `HttpModule` module, and if your app uses HTTP, don't forget to include it in the `@NgModule` decorator.
- Public methods of `HttpObject` return `Observable`, and only when the client subscribes to it is the request to the server made.
- The WebSocket protocol is more efficient and concise than HTTP. It's bidirectional, and both client and server can initiate the communication.
- Creating a web server with NodeJS and Express is relatively simple, but an Angular client can communicate with web servers implemented in different technologies.

9 Unit testing Angular applications

This chapter covers

- The basics of unit testing with the Jasmine framework
- The main artifacts from the Angular testing library
- Testing the main players of an Angular app: services, components, and the router
- Running unit tests against different web browsers with the Karma test runner
- Implementing unit testing in our online auction example

To ensure that your software has no bugs, you need to test it. Moreover, even if your application has no bugs today, it may have them tomorrow after you modify the existing code or introduce the code. Even if you don't change the code in a particular module, it may stop working properly as a result of changes in another module. Your application code has to be retested regularly, and this process should be automated. You need to prepare test scripts and start running them as early as possible in your development cycle.

There are two main types of testing for the front end of web applications:

- *Unit testing* asserts that a small unit of code (such as a component or function) accepts the expected input data and returns the expected result. Unit testing is about testing isolated pieces of code, especially public interfaces. That's what we'll discuss in this chapter.
- *End-to-end testing* asserts that the entire application works as end users expect (this is also known as *functional testing*) and that all units properly interact with each other (a.k.a. *integration testing*). For end-to-end testing of Angular 2 applications, you can use the Protractor library (see https://angular.github.io/protractor).

NOTE	**Load testing**
	Load or stress testing shows how many concurrent users can work with a web application while it maintains the expected response time. Load-testing tools are mainly about testing the server side of web applications.

Unit tests are for testing the business logic of separate units of code, and typically you'll be running unit tests a lot more often than end-to-end tests. The end-to-end testing can emulate a user's actions (such as clicks on buttons) and check the behavior of your application. During end-to-end testing, you shouldn't run the unit-testing scripts.

This chapter is about unit-testing Angular applications. Several frameworks have been specifically created for implementing and running unit tests, and our framework of choice is Jasmine. Actually, it's not only our choice—as we write this, Angular's testing library only works with Jasmine for unit testing. This is described in the "Jasmine Testing 101" section of the Angular documentation (http://mng.bz/0nv3).

We'll start by covering the basics of unit testing with Jasmine, and toward the end of the chapter we'll write and run test scripts to unit-test selected components in our online auction. We'll give you a brief overview of Jasmine so you can quickly start writing unit tests; for more details, see the Jasmine documentation (http://jasmine.github.io). For running tests, we'll use the test runner called Karma, which is an independent command-line utility that can run tests written in different test frameworks.

9.1 Getting to know Jasmine

Jasmine allows you to implement a behavior-driven development (BDD) process, which suggests that tests of any unit of software should be specified in terms of the desired behavior of the unit. With BDD, you use natural language constructs to describe what you think your code should be doing. You write unit test specifications in the form of short sentences, such as "ApplicationComponent is successfully instantiated" or "StarsComponent emits the rating change event".

Because it's so easy to understand the meaning of the tests, they can serve as your program documentation. If another developer needs to get familiar with your code, he or she can start by reading the code of the unit tests to understand your intentions. Using natural language for describing tests has another advantage—it's easy to reason about the test results, as shown in figure 9.1.

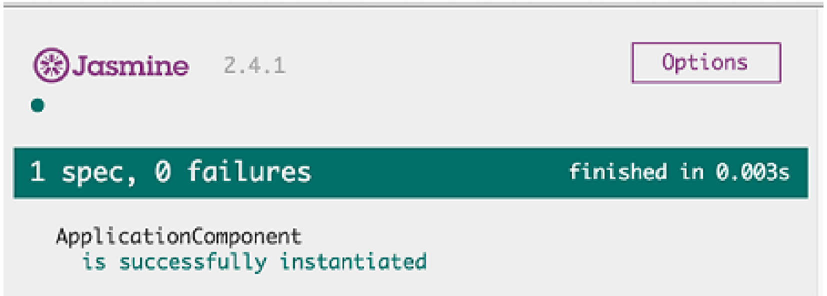


Figure 9.1 Running tests using Jasmine's test runner

NOTE	**Make your tests fail** As much as we'd like all our tests to pass, make a habit of ensuring that the tests fail first and see if the test results are easy to understand.

In Jasmine terminology, a test is called *spec*, and a combination of one or more specs is called a *suite*. A test suite is defined with the `describe()` function—this is where you describe what you're testing. Each test spec in the suite is programmed as an `it()` function, which defines the expected behavior of the code under test and how to test it. Here's an example:

```
describe('MyCalculator', () => {
  it('should know how to multiply', () => {
    // The code that tests multiplication goes here
  });
  it('should not divide by zero', () => {
    // The code that tests division by zero goes here
  });

});
```

Testing frameworks have the notion of an *assertion*, which is a way of questioning if an expression is true or false. If the assertion is false, the framework will throw an error. In Jasmine, assertions are specified using the function `expect()`, followed by *matchers*: `toBe()`, `toEqual()`, and so on. It's as if you're writing a sentence: "I expect 2+2 to equal 4".

```
expect(2 + 2).toEqual(4);
```

Matchers implement a Boolean comparison between the actual and expected values. If the matcher returns `true`, the spec passes. If you expect a test result not to have a certain value, just add the keyword `not` before the matcher:

```
expect(2 + 2).not.toEqual(5);
```

You can find the complete list of matchers at Jamie Mason's Jasmine-Matchers page on GitHub: https://github.com/JamieMason/Jasmine-Matchers.

We've given the test suites the same names as the files under test, adding the suffix *.spec* to the name, which is a standard practice; for example, application.spec.ts will contain the test script for application.ts. The following test suite is from the file application.spec.ts, and it tests that the instance of the `ApplicationComponent` is created:

```
import AppComponent from './app';

describe('AppComponent', () => {
  it('is successfully instantiated', () => {

    const app = new AppComponent();

    expect(app instanceof AppComponent).toEqual(true);
  });
});
```

This is a test suite containing just a single test. If you extract the texts from `describe()` and `it()` and put them together, you'll get a sentence that clearly indicates what you're testing here: "ApplicationComponent is successfully instantiated."

NOTE **Understanding the purpose of the test**
If other developers need to know what your spec tests, they can just read the text in `describe()` and `it()`. Each test should be self-descriptive and serve as program documentation.

The preceding code instantiates the `AppComponent` and expects the expression `app instanceof AppComponent` to be evaluated to `true`. From the `import` statement, you can guess that this test script is located in the same directory as the `AppComponent`.

SIDEBAR **Where to store test files**
The Jasmine framework is used to unit test JavaScript applications written in different frameworks or in pure JavaScript. One of the approaches to storing test files is to create a separate test directory and keep only the test scripts there, so they aren't mixed up with the application code.
In Angular applications we prefer to keep each test script in the same directory as the component or service under test. It's convenient for two reasons:

1. All component-related files are located together in the same directory. Typically we create a directory for storing the component's .ts, .html, .css, and files, and adding a .spec file there won't clutter the directory content.
2. There's no need to change the configuration of the SystemJS loader, which already knows where the application files are located. It will load the tests from the same locations.

If you want some code to be executed before each test (such as to prepare test dependencies), you can specify it in the *setup* functions `beforeAll()` and `beforeEach()`, which will run before the suite or each spec respectively. If you want to execute some code right after the suite or each spec is finished, use the *teardown* functions `afterAll()` and `afterEach()`.

NOTE	**Skipping selected tests** If you have a spec with multiple `it()` tests, and you want the runner to skip some tests, change them from `it()` to `xit()`.

WHAT TO TEST

Now that you have an understanding of how to test, the question is what to test. In Angular applications written in TypeScript, we can test functions, classes, and components.

- *Test functions*—Say you have a function that converts the passed string to uppercase. You can write multiple tests just for this function, for cases where the argument is null, an empty string, undefined, a lowercase word, an uppercase word, a mixed-case word, a number, and so on.
- *Test classes*—If you have a class containing several methods (like `ProductService`), you can write a test suite that includes all the tests needed to ensure that each of the class methods functions properly.
- *Test components*—You can test the public API of your services or components. Beside testing them for correctness, you'll show code samples of using publicly exposed properties or methods.

HOW TO INSTALL JASMINE

You can get Jasmine by downloading its standalone distribution, but we'll install it using npm, as we've done for all other packages in this book. The npm repository has several Jasmine-related packages, but we just need `jasmine-core`. Open the command window in the root of your project, and run the following command:

```
npm install jasmine-core --save-dev
```

To make sure that the TypeScript compiler knows about the Jasmine types, run the following command to install the Jasmine type definition file:

```
npm i @types/jasmine --save-dev
```

SIDEBAR **Using the standalone Jasmine distribution**

If you want to see the running Jasmine tests quickly, just download the zip file with the standalone version of Jasmine from https://github.com/jasmine/jasmine/releases. Unzip this file and open SpecRunner.html in your web browser. You'll see the window shown in figure 9.2.

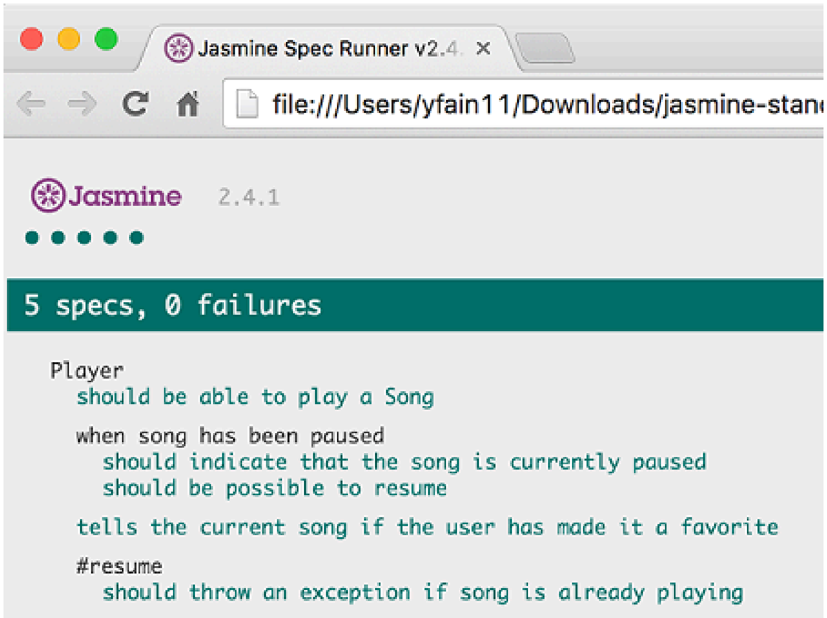


Figure 9.2 Testing the sample app that comes with Jasmine

When your tests are written, you need a test-runner application to run them. Jasmine comes with two runners: one for the command line (see the npm package jasmine) and the other is HTML-based. We'll start using the HTML-based runner, but for running tests from the command line we'll use Karma.

Although Jasmine comes with a preconfigured HTML-based runner as a sample app, we need to create an HTML file for testing ours. This HTML file will include the following script tags that load Jasmine:

```
<link rel="stylesheet" href="node_modules/jasmine-core/lib/jasmine-core/jasmine.css">
<script src="node_modules/jasmine-core/lib/jasmine-core/jasmine.js"></script>
<script src="node_modules/jasmine-core/lib/jasmine-core/jasmine-html.js"></script>
<script src="node_modules/jasmine-core/lib/jasmine-core/boot.js"></script>
```

We'll also need to add all required Angular dependencies, as we did in every index.html file in all the code samples in the book, plus the Angular testing library. We'll keep using the SystemJS loader, but this time we'll load the code of the unit tests (the .spec files), which will load the application code via `import` statements.

In this chapter we'll show you how to use the HTML-based runner first. Then we'll show you how to use another test runner called Karma that can run command-line tests reporting possible errors in different browsers. In chapter 10 we'll integrate Karma into the application build process, so the unit tests will run automatically as part of the build. In this chapter you'll learn how to write unit tests, but we're going to run them manually using both Jasmine's HTML-based runner and Karma.

9.2 What comes with Angular's testing library

Angular comes with a testing library that includes the wrappers for Jasmine's `describe()`, `it()`, and `xit()`, and also adds such functions as `beforeEach()`, `async()`, `fakeAsync()`, and others.

Because we don't configure and bootstrap the application during the test runs, Angular offers a `TestBed` helper class that allows us to declare modules, components, providers, and so on. `TestBed` includes such functions as `configureTestingModule()`, `createComponent()`, `inject()`, and others. For example, the syntax for configuring a testing module looks similar to configuring `@NgModule`:

```
beforeEach(() => {
  TestBed.configureTestingModule({
    imports: [ ReactiveFormsModule, RouterTestingModule,
               RouterTestingModule.withRoutes(routes)],
    declarations: [AppComponent, HomeComponent, WeatherComponent],
    providers: [{provide: WeatherService, useValue: {} }
    ]
  })
});
```

The `beforeEach()` function is used in test suites during the setup phase. It allows you to specify the required modules, components, and providers that may be needed by each test.

The `inject()` function creates an injector and injects the specified objects into tests, according to the app's providers configured for Angular DI:

```
inject([Router, Location], (router: Router, location: Location) => {
  // Do something
})
```

The `async()` function runs in the Zone and may be used with asynchronous services. The `async()` function doesn't complete the test until all its asynchronous operations have been completed or the specified timeout has passed.

```
it(' does something', async(inject([AClass], object => {
  myPromise.then(() => { expect(true).toEqual(true); });
}), 3000));
```

The `fakeAsync()` function allows you to speed up the testing of synchronous services by simulating the passage of time.

```
it('...', fakeAsync(() => {
  // Do something

  tick(1000); // simulate async passage of one sec
  expect(...);
}));
```

The Angular testing library has an `NgMatchers` interface that includes following matchers:

- `toBePromise()`—Expects the value to be a `Promise`
- `toBeAnInstanceOf()`—Expects the value to be an instance of a class
- `toHaveText()`—Expects the element to have exactly the given text
- `toHaveCssClass()`—Expects the element to have the given CSS class
- `toHaveCssStyle()`—Expects the element to have the given CSS styles
- `toImplement()`—Expects a class to implement the interface of the given class
- `toContainError()`—Expects an exception to contain the given error text
- `toThrowErrorWith()`—Expects a function to throw an error with the given error text when executed

The Angular Testing API for TypeScript is documented at http://mng.bz/ym8N. We'll show you how to test services, routers, event emitters, and components later in this chapter, but first let's go over some basics.

9.2.1 Testing services

Typically Angular services are injected into components, and to set up the injectors you need to define providers for an `it()` block. Angular offers the `beforeEach()` setup method, which runs before each `it()` call. You can inject the service into the `it()` using `inject()` to test synchronous functions inside the service.

Real services may need some time to complete, and this may slow down your tests, but there are two ways of speeding up tests:

- Create a class that implements a mock service by extending a class of the real service but that returns hard-coded data quickly. For example, you can create a mock service for `WeatherService` that returns immediately without making any requests to the remote server that returns actual weather data.

```
class MockWeatherService implement WeatherService {
  getWeather() {
    return Observable.empty();
  }
}
```

- Use the `fakeAsync()` function, which automatically identifies the asynchronous calls and replaces timeouts, callbacks, or promises with immediately executed functions. The `tick()` function allows you to fast-forward the time, so there's no need to wait until the timeout expires. You'll see examples of using `fakeAsync()` later in this chapter.

9.2.2 Testing navigation with the router

To test the router, your spec scripts can invoke such router methods as `navigate()` or `navigateByUrl()`. The `navigate()` method takes an array of configured routes (commands) that will construct the route as an argument, whereas `navigateByUrl()` takes a string representing the segment of the URL you want to navigate to.

If you use the `navigate()` method, you specify the configured path and route params, if any. If the router is properly configured, it should update the URL in the address bar of the browser.

The next code snippet shows how to programmatically navigate to the `product` route, pass 0 as a route param, and ensure that after the navigation the URL (represented by the `Location` object) has a segment of `/product/0`.

```
it('should be able to navigate to product details using commands API',
  fakeAsync(inject([Router, Location], (router: Router, location: Location) => {
    TestBed.createComponent(AppComponent);
    router.navigate(['/products', 0]);
    tick();
    expect(location.path()).toBe('/product/0');
  })
));
```

When you provide an array of values to the router, it's called a *commands API*. For the preceding code fragment to work, the route with parameter `/products/:productId` has to be configured, as explained in chapter 3.

The `it()` function invokes the callback provided as the second argument. `fakeAsync()` wraps a function provided as an argument (`inject()` in our code sample) and executes it in the Zone. The `tick()` function allows us to manually fast-forward the time and advance tasks in the microtasks queue in the browser's event loop. In other words, you can emulate the time that asynchronous tasks take, and execute asynchronous code synchronously, which simplifies and speeds up the execution of the unit tests.

With `TestBed.createComponent()` (explained in the next section) we created an instance of the component. Then we invoke the router's `navigate()` method, advance the async tasks that perform the navigation with the `tick()` function, and check whether the current location is the same as the expected one.

The `navigateByUrl()` function takes a specific URL segment and should properly build the `Location.path` that represents the client's portion in the address bar of the browser, and this is what we'll test:

```
router.navigateByUrl('/products');
...
```

```
expect(location.path()).toBe('/products');
```

You’ll see how to use `navigateByUrl()` in section 9.3.

While testing the router, you can use `SpyLocation`, which is a mock for the `Location` provider. It allows tests to fire simulated location events. For example, you can prepare a specific URL and simulate the change of the hash portion, the browser’s Back and Forward buttons, and more.

9.2.3 Testing components

Components are classes with templates. If your class contains methods implementing the application’ logic, you can test them as you would any other functions, but more often you’ll be testing the templates. In particular, we’re interested in testing that the bindings work properly and that they display the expected data.

Angular offers the `TestBed.createComponent()` method, which returns a `ComponentFixture` object that will be used to work with the component when it’s created. This fixture gives you access to both the component and the native HTML element’s instances, so you can assign values to the component’s properties as well as find specific HTML elements within the component’s template.

You can also trigger the change-detection cycle on the component by invoking the `detectChanges()` method on the fixture. After the change detection has updated the UI, you can run the `expect()` function to check the rendered values. The following code snippet illustrates these actions using a `ProductComponent` that has a `product` property, assuming that it’s bound to the template element `<h4>`:

```
let fixture = TestBed.createComponent(ProductDetailComponent);
let element = fixture.nativeElement;
let component = fixture.componentInstance;
component.product = {title: 'iPhone 7', price: 700};

fixture.detectChanges();
expect(element.querySelector('h4').innerHTML).toBe('iPhone 7');
```

Now let’s write a sample application in which we’ll implement unit tests for a component, router, and service.

9.3 Testing a sample weather application

Let’s try testing Angular components and services using an application that has a main page with two links: Home and Weather. We’ll use a router to navigate to the Weather page, which is a refactored version of the weather app we created in chapter 5 (observable-events-http.ts).

In chapter 5, a large chunk of the code was placed in the constructor of the `AppComponent`, which complicates testing because we can’t invoke the code of the constructor after an object is created.

Now the `WeatherComponent` will get the `WeatherService` injected, and `WeatherService` uses the remote server from chapter 5 to get the weather information. Figure 9.3 shows what the window looks like after we ran this application, navigated to the `Weather` route, and entered "New York" in the input field.

Figure 9.3 Checking weather component in the test_samples project

Figure 9.4 shows the structure of this project (see the test_weather directory). Note the .spec files, which contain the code for unit testing the components and the weather service.

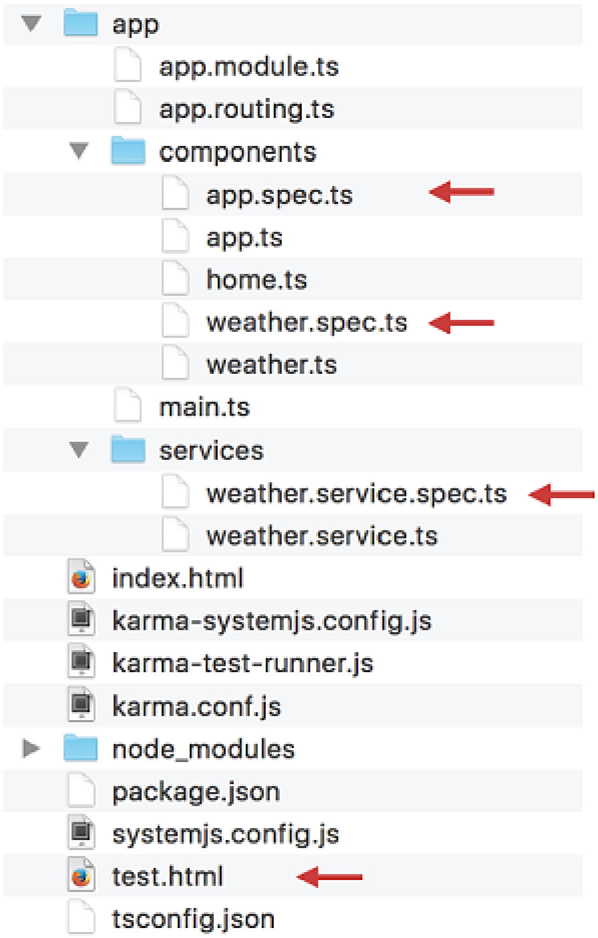


Figure 9.4 The structure of the test_samples project

To run these tests, we've created a test.html file that loads all the spec.ts files marked with arrows in figure 9.4:

```
<!DOCTYPE html>
<html lang="en">
<head>
  <meta charset="utf-8">
  <title>Testing the Weather Application</title>
  <base href="/">

  <!-- TypeScript in-browser compiler -->
  <script src="node_modules/typescript/lib/typescript.js"></script>

  <!-- Polyfills -->
  <script src="node_modules/reflect-metadata/Reflect.js"></script>


  <!-- Jasmine -->
  <link rel="stylesheet" href="node_modules/jasmine-core/lib/jasmine-core/jasmine.css">
  <script src="node_modules/jasmine-core/lib/jasmine-core/jasmine.js"></script>
  <script src="node_modules/jasmine-core/lib/jasmine-core/jasmine-html.js"></script>
  <script src="node_modules/jasmine-core/lib/jasmine-core/boot.js"></script>

  <!-- Zone.js -->
  <script src="node_modules/zone.js/dist/zone.js"></script>
  <script src="node_modules/zone.js/dist/proxy.js"></script>
  <script src="node_modules/zone.js/dist/sync-test.js"></script>
```

```
  <script src="node_modules/zone.js/dist/jasmine-patch.js"></script>
  <script src="node_modules/zone.js/dist/async-test.js"></script>
  <script src="node_modules/zone.js/dist/fake-async-test.js"></script>
  <script src="node_modules/zone.js/dist/long-stack-trace-zone.js"></script>

  <!-- SystemJS -->
  <script src="node_modules/systemjs/dist/system.src.js"></script>
  <script src="systemjs.config.js"></script>
</head>
<body>
<script>
  var SPEC_MODULES = [
    'app/components/app.spec',
     'app/components/weather.spec',
     'app/services/weather.service.spec'
  ];


  Promise.all([
    System.import('@angular/core/testing'),
    System.import('@angular/platform-browser-dynamic/testing')
  ])
  .then(function (modules) {
    var testing = modules[0];
    var browser = modules[1];


     testing.TestBed.initTestEnvironment(
         browser.BrowserDynamicTestingModule,
         browser.platformBrowserDynamicTesting());

    // Load all the spec files.
    return Promise.all(SPEC_MODULES.map(function (module) {
      return System.import(module);
    }));
  })
  .then(window.onload)
  .catch(console.error.bind(console));
</script>
</body>
</html>
```

1. Loads Jasmine files.
2. Declares an array with the names of the specs to be loaded.
3. Loads two Angular modules required for testing.
4. When the testing modules are loaded, stores their references in the variables.
5. Initializes the test environment. If we configure AppModule in the app, we replace it with BrowserDynamicTestingModule in tests.
6. After the frameworks and specs are loaded, initiates the event handler for the load event so Jasmine will run the tests.

CONFIGURING SYSTEMJS

To use an HTML-based test runner, you need to add Angular testing modules to your SystemJS configuration. Here's the fragment from the systemjs.config.js file that comes with this project:

```
  '@angular/common/testing'                 :
      'ng:common/bundles/common-testing.umd.js',
  '@angular/compiler/testing'               :
      'ng:compiler/bundles/compiler-testing.umd.js',
  '@angular/core/testing'                   :
      'ng:core/bundles/core-testing.umd.js',
  '@angular/router/testing'                 :
      'ng:router/bundles/router-testing.umd.js',
  '@angular/http/testing'                   :
      'ng:http/bundles/http-testing.umd.js',
  '@angular/platform-browser/testing'       :
      'ng:platform-browser/bundles/platform-browser-testing.umd.js',
  '@angular/platform-browser-dynamic/testing':
      'ng:platform-browser-dynamic/bundles/platform-browser-dynamic-testing.umd.js',
 },
 paths: {
  'ng:': 'node_modules/@angular/'
 },
```

9.3.1 Testing the weather router

The router for this application is configured in the app.routing.ts file:

```
import { Routes, RouterModule } from '@angular/router';
import { HomeComponent } from './components/home';
import { WeatherComponent } from './components/weather';

export const routes: Routes = [
  { path: '',        component: HomeComponent },
  { path: 'weather', component: WeatherComponent }
];

export const routing = RouterModule.forRoot(routes);
```

Although you can configure the routes either inside your app module or in a separate file, having the routes configured in a separate file is a best practice, as it allows you to reuse the route configuration for running both the application and the test scripts.

The script in app.module.ts of the weather app uses the `routes` constant in the declaration of `@NgModule`:

```
@NgModule({
  imports: [BrowserModule, HttpModule, ReactiveFormsModule, routing],
  declarations: [AppComponent, HomeComponent, WeatherComponent],
  bootstrap: [AppComponent],
  providers: [
    { provide: LocationStrategy,   useClass:
        HashLocationStrategy },
    { provide: WEATHER_URL_BASE,   useValue:
        'http://api.openweathermap.org/data/2.5/weather?q=' },
    { provide: WEATHER_URL_SUFFIX, useValue:
        '&units=imperial&appid=ca3f6d6ca3973a518834983d0b318f73' },
    WeatherService
  ]
})
```

The test script for the routes is located in the app.spec.ts file, and it reuses the same `routes` constant:

```
import { TestBed, fakeAsync, inject, tick } from '@angular/core/testing';
import { Location } from '@angular/common';
import { ReactiveFormsModule } from '@angular/forms';
import { provideRoutes, Router } from '@angular/router';
import { RouterTestingModule } from '@angular/router/testing';

import { routes } from '../app.routing';
import { WeatherService } from '../services/weather.service';
import { AppComponent } from './app';
import { HomeComponent } from '../components/home';
import { WeatherComponent } from '../components/weather';

describe('Router', () => {   ❶

  beforeEach(() => {   ❷
    TestBed.configureTestingModule({
      imports: [ ReactiveFormsModule, RouterTestingModule,
                 RouterTestingModule.withRoutes(routes)],   ❸
      declarations: [AppComponent, HomeComponent, WeatherComponent],
      providers: [{provide: WeatherService, useValue: {} }   ❹
      ]
    })
  });

  it('should be able to navigate to home using commands API',   ❺
    fakeAsync(inject([Router, Location], (router: Router, location: Location) => {
      TestBed.createComponent(AppComponent);   ❻
      router.navigate(['/']);
      tick();   ❼
      expect(location.path()).toBe('/');
    })
  ));

  it('should be able to navigate to weather using commands API',   ❽
    fakeAsync(inject([Router, Location], (router: Router, location: Location) => {
      TestBed.createComponent(AppComponent);
      router.navigate(['/weather']);
      tick();
      expect(location.path()).toBe('/weather');
    })
  ));

  it('should be able to navigate to weather by URL',   ❾
    fakeAsync(inject([Router, Location], (router: Router, location: Location) =>
      TestBed.createComponent(AppComponent);
      router.navigateByUrl('/weather');
      tick();
      expect(location.path()).toEqual('/weather');
    })
  ));

});
```

❶ This is the test suite for the routes defined in app.routing.ts.

❷ Before running each test, we configure the testing module to include the components and providers required for testing our router.

3. Provides routes for the router testing module.
4. Tests navigation to WeatherComponent, which gets the WeatherService injected, so we need to register a provider for the fake service here.
5. Tests that the router can navigate to the route /. The / route doesn't add anything to the base URL, so we expect it to be an empty string.
6. We need to create the AppComponent because it declares the <router-outlet>.
7. Fast forwards the time required for the asynchronous creation of AppComponent.
8. Tests if the router can navigate to the /weather route using the navigate() method.
9. Tests if the router can navigate to the /weather route using the navigateByUrl() method.

Note that we import `ReactiveFormsModule` because `WeatherComponent` uses the Forms API.

> **NOTE** **Don't unit-test third-party code in your app**
> In the preceding code we used an empty object as a provider for `WeatherService`, which in the real app makes calls to a remote weather server. What if that remote server is down when you run your test specs? Unit tests should assert that your scripts work fine, and not someone else's software. That's why we don't use an actual `WebService` in the preceding spec and use an empty object instead.

When testing the client-side navigation of your application, you'll be using the `Router` class and its `navigate()` and `navigateByUrl()` methods.

The preceding example illustrates the use of both the `navigate()` and `navigateByUrl()` methods for testing that the programmatic navigation properly updates the address bar of the application. But because we don't run that app during the test, there's no browser address bar, so it has to be emulated. That's why instead of `RouterModule`, we use `RouterTestingModule`, which knows how to check the expected content of the address bar using the `Location` class.

Now let's look at testing the injection of services. As a matter of fact, we've already been injecting services while testing routes:

```
fakeAsync(inject([Router, Location],...))
```

But in the next section we'll show you a different way of initializing the required services: we'll get ahold of the `Injector` object and invoke its `get()` method.

9.3.2 Testing the weather service

The `WeatherService` class (weather.service.ts) encapsulates the communications with the weather server:

```
import {Inject, Injectable, OpaqueToken} from '@angular/core';
import {Http, Response} from '@angular/http';
import {Observable} from 'rxjs/Observable';
import 'rxjs/add/operator/filter';
import 'rxjs/add/operator/map';

export const WEATHER_URL_BASE = new OpaqueToken('WeatherUrlBase');
export const WEATHER_URL_SUFFIX = new OpaqueToken('WeatherUrlSuffix');

export interface WeatherResult {
  place: string;
  temperature: number;
  humidity: number;
}

@Injectable()
export class WeatherService {
  constructor(
      private http: Http,
      @Inject(WEATHER_URL_BASE) private urlBase: string,
      @Inject(WEATHER_URL_SUFFIX) private urlSuffix: string) {
  }

  getWeather(city: string): Observable<WeatherResult> {
    return this.http
        .get(this.urlBase + city + this.urlSuffix)
        .map((response: Response) => response.json())
        .filter(this._hasResult)
        .map(this._parseData);
  }

  private _hasResult(data): boolean {
    return data['cod'] !== '404' && data.main;
  }

  private _parseData(data): WeatherResult {
    let [first,] = data.list;
    return {
     place: data.name || 'unknown',
      temperature: data.main.temp,
      humidity: data.main.humidity
    };
  }
}
```

Note the use of the `OpaqueToken` type mentioned in chapter 4. We use it twice to inject into `urlBase` and `urlSuffix` the values provided in the `@NgModule` decorator. Using dependency injection for `urlBase` and `urlSuffix` makes it simpler to replace the real weather server with a mock, if need be.

The `getWeather()` method in the preceding service forms the URL for the HTTP `get()` by concatenating the `urlBase`, `city`, and `urlSuffix`. The result is processed by `map()`, `filter()`, and another `map()` so the `Observable` will emit objects of type `WeatherResult`.

NOTE **Private methods**
We aren't testing the `_hasResult()` and `_parseData()` methods because private methods can't be unit-tested. Should you decide to test them, change their access level to public.

For testing the `WeatherService` we'll use the `MockBackend` class, which is one of Angular's implementations of the `Http` object. `MockBackend` doesn't make any HTTP requests but intercepts them and allows you to create and return hardcoded data in the format of the expected result.

Before each test we'll get a reference to the `Injector` object, which will get us the new instances of `MockBackend` and `WeatherService`. The testing code for the `WeatherService` is located in the weather.service.spec.ts file:

```
import {async, getTestBed, TestBed, Injector} from '@angular/core/testing';
import {Response, ResponseOptions, HttpModule, XHRBackend} from '@angular/http';
import {MockBackend, MockConnection} from '@angular/http/testing';
import {WeatherService, WEATHER_URL_BASE, WEATHER_URL_SUFFIX} from './weather.service';

describe('WeatherService', () => {
  let mockBackend: MockBackend;
  let service: WeatherService;

  let injector: Injector;

  beforeEach(() => {
    TestBed.configureTestingModule({
      imports: [HttpModule],
      providers: [
        { provide: XHRBackend, useClass: MockBackend },
        { provide: WEATHER_URL_BASE, useValue: '' },
        { provide: WEATHER_URL_SUFFIX, useValue: '' },
        WeatherService
      ]
    });

    injector = getTestBed();    ❶
  });

  beforeEach(() => {
    mockBackend = injector.get(XHRBackend);    ❷
    service = injector.get(WeatherService);    ❸
  });

  it('getWeather() should return weather for New York', async(() => {
    let mockResponseData = {    ❹
      cod: '200',
      list: [{
        name: 'New York',
        main: {
          temp: 57,
          humidity: 44
        }
      }]
    };
```

```
    mockBackend.connections.subscribe((connection: MockConnection) => {
      let responseOpts = new ResponseOptions({body: JSON.stringify(mockResponseData)});
      connection.mockRespond(new Response(responseOpts));
    });

    service.getWeather('New York').subscribe(weather => {
      expect(weather.place).toBe('New York');
      expect(weather.humidity).toBe(44);
      expect(weather.temperature).toBe(57);
    });
  }));
});
```

1. Gets an instance of the Injector. The TestBed class implements the Injector interface, and getTestBed returns an object that implements the injector's API.
2. Sets the providers that the test injector should use for the XHRBackend token.
3. Sets the providers that the test injector should use for the WeatherService token.
4. The test starts with creating a mock object to represent the weather for New York. The structure of this object mimics the actual response data from the real web service.
5. Configures the MockBackend by subscribing to "HTTP requests" and emulates the real response with the content of mockResponseData. The body of this response is created by instantiating ResponseOptions.
6. The invocation of getWeather('New York') is expected to return the mock data for New York. The getWeather() method internally uses Http emulated by the MockBackend.

These are the main takeaways from testing services injection:

- Prepare the providers.
- If you're using services that make requests to external servers, mock them up.

We've shown you how to test the navigation and services; now let's look at how you can test an Angular component.

9.3.3 Testing the weather component

The `WeatherService` is injected into the `WeatherComponent` (weather.ts) via constructor, where we subscribe to the observable's messages coming from the `WeatherService`. When the user starts entering the name of a city in the UI, the `getWeather()` method is invoked and the returned weather data is displayed in the template via binding.

```
import {Component} from '@angular/core';
import {FormControl} from '@angular/forms';
import 'rxjs/add/operator/debounceTime';
import 'rxjs/add/operator/switchMap';

import {WeatherService, WeatherResult} from '../services/weather.service';
```

```
@Component({
  selector: 'my-weather',
  template: `
    <h2>Weather</h2>
    <input type="text" placeholder="Enter city" [formControl]="searchInput">
    <h3>Current weather in {{weather?.place}}:</h3>
    <ul>
      <li>Temperature: {{weather?.temperature}}F</li>
      <li>Humidity: {{weather?.humidity}}%</li>
    </ul>
  `,
})
export class WeatherComponent {
  searchInput: FormControl;
  weather: WeatherResult;

  constructor(weatherService: WeatherService) {
    this.searchInput = new FormControl('');
    this.searchInput.valueChanges
        .debounceTime(300)
        .switchMap((place: string) => weatherService.getWeather(place))
        .subscribe(
            (wthr: WeatherResult) => this.weather = wthr,
            error => console.error(error),
            () => console.log('Weather is retrieved'));
  }
}
```

NOTE **The elvis operator**

The template of the `WeatherComponent` includes expressions with question marks, such as `weather?.place`. The question mark in this context is called the *elvis operator*. The `weather` property is populated asynchronously, and if `weather` is `null` by the time the expression is evaluated, the `weather.place` expression would throw an error. To suppress null dereferencing, we use the elvis operator to short circuit further evaluation if `weather` is null. The elvis operator offers an explicit notation to show which values could be null.

We want to write a test to check that when the `weather` property gets the values, the template is properly updated via bindings. We also want to test that when the value of the `searchInput` object changes, the observable emits data via its `valueChanges` property.

The test suite will contain one test to check that data bindings work as expected. `TestBed.createComponent(WeatherComponent);` will create a `ComponentFixture` that contains references to the `WeatherComponent` as well as the DOM object that represents this component. In the preceding code we used the `weather` property for bindings, and we'll initialize this property with the object literal containing hard-coded values for `place`, `humidity`, and `temperature`.

After that, we'll force change detection by invoking the `detectChanges()` method on the instance of `ComponentFixture`. We expect to see the values from `weather` in one `<h3>` and two `<li>` tags in the component's template.

The code for this test is located in the weather.spec.ts file:

```
import { TestBed} from '@angular/core/testing';
import { ReactiveFormsModule } from '@angular/forms';

import { WeatherComponent } from './weather';
import { WeatherService } from '../services/weather.service';

describe('WeatherComponent', () => {

  beforeEach(() => {
    TestBed.configureTestingModule({
      imports: [ ReactiveFormsModule ],
      declarations: [ WeatherComponent],
      providers: [{provide: WeatherService, useValue: {} }]    ❶
    })
  });

  it('should display the weather ', () => {
    let fixture = TestBed.createComponent(WeatherComponent);    ❷
    let element = fixture.nativeElement;    ❸
    let component = fixture.componentInstance;    ❹
    component.weather = {place: 'New York', humidity: 44, temperature: 57};    ❺

    fixture.detectChanges();    ❻

    expect(element.querySelector('h3').innerHTML).toBe('Current weather in New York:');    ❼
    expect(element.querySelector('li:nth-of-type(1)').innerHTML).toBe('Temperature: 57F');    ❽
    expect(element.querySelector('li:nth-of-type(2)').innerHTML).toBe('Humidity: 44%');
  });
});
```

❶ Our WeatherComponent expects WeatherService to be injected, and we replace the real service with an empty object.

❷ Creates an instance of WeatherComponent, and get a ComponentFixture back.

❸ Gets a reference to the component under test.

❹ Gets a reference to the HTML element rendered for this component.

❺ Initializes the component’s weather property as if the data came from the server.

❻ Initiates change detection.

❼ Compares the text of the <h3> element with the expected value.

❽ Compares the text of the first and second <li> with the expected values. We use the CSS selector li:nth-of-type() to get the text of the <li> element by its position.

NOTE **Mocking services**

In the preceding code we used an empty object to mock the `WeatherService` because we didn't plan to invoke any methods on it. But we could define the mock service as `class MockWeatherService implements WeatherService` and provide implementations for the real methods, but they would return hardcoded values. When defining a mock service in real-world applications, it's advisable to create classes that implement the interfaces of the real services.

NOTE **Reactive forms and testing**

In chapter 7 you learned two approaches for creating forms in Angular. Although the template-driven approach requires little coding, using reactive forms makes them more testable without requiring the DOM object.

RUNNING TESTS IN THE HTML-BASED RUNNER

Let's run our test suite for the weather application in the HTML-based runner. Just run the live-server and enter the URL http://localhost:8080/test.html in the browser. All the tests should pass, and the browser window should look like figure 9.5.

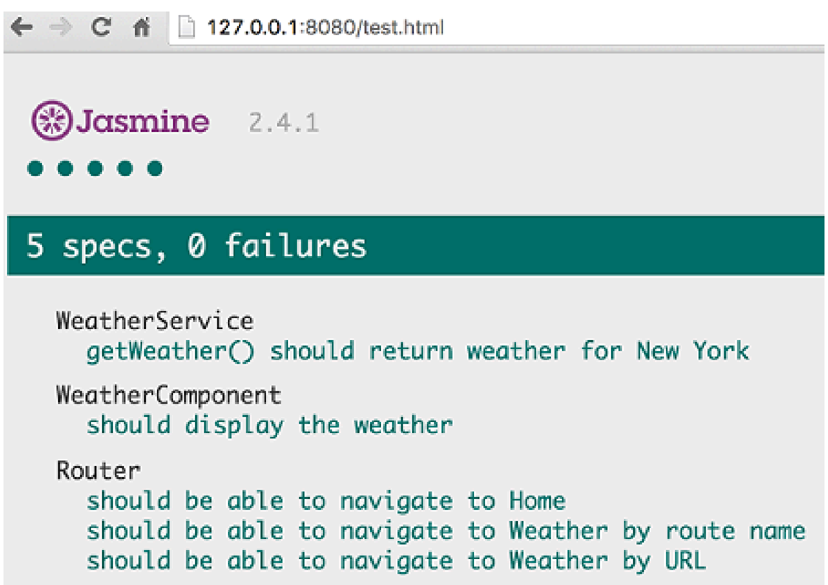


Figure 9.5 The test suite passed

When you write tests, you want to see how they fail. Let's make one of our tests fail to see how it's going to be reported. Let's change the temperature to be 58 degrees in the line where we initialize the `weather` property:

```
component.weather = {place: 'New York', humidity: 44, temperature: 58};
```

Our test still expects the UI to render the temperature as 57 degrees:

```
expect(element.querySelector('li:nth-of-type(1)').innerHTML).toBe('Temperature: 57F');
```

The test output shown in figure 9.6 reports the failure of one of five tests.

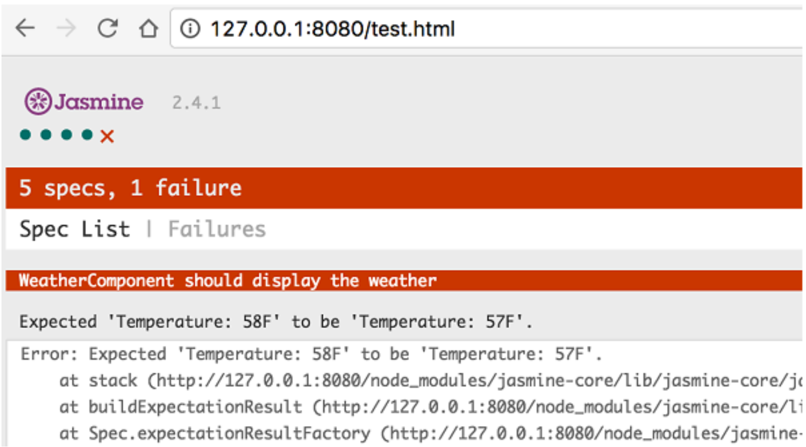


Figure 9.6 The test suite failed

Manually running tests in the web browser isn't the best way to unit-test your code. We want a testing process that can be run as a script from a command line, so it can be integrated into the automated build process. Jasmine has a runner that can be used from a command prompt, but we prefer to use an independent test runner, Karma, that can work with a variety of unit-test frameworks. We'll show you how to use the Karma runner next.

9.4 Running tests with Karma

Karma is a test runner that was originally created by the AngularJS team, but it's being used for testing JavaScript code written with or without frameworks. Karma is built using Node.js, and although it doesn't run inside a web browser, it can run tests to check if your application will work in multiple browsers (we'll run tests for Chrome and Firefox).

For our Weather application, we'll install Karma and the plugins for Jasmine, Chrome, and Firefox, and we'll save them in the `devDependencies` section of package.json:

```
npm install karma karma-jasmine karma-chrome-launcher karma-firefox-launcher --save-dev
```

To run Karma, we'll configure the npm `test` command of our project as follows:

```
"scripts": {
  "test": "karma start karma.conf.js"
}
```

NOTE	**Karma executable** The karma executable is a binary file located in the node_modules/.bin directory.

We've also created a small karma.conf.js configuration file to let Karma know about our project. This file is located in the root directory of the project and includes paths for Angular files as well as configuration options for the Karma runner.

```
module.exports = function (config) {
  config.set({
    browsers: ['Chrome', 'Firefox'],   ❶
    frameworks: ['jasmine'],   ❷
    reporters: ['dots'],   ❸
    singleRun: true,   ❹
    files: [   ❺
      // Paths loaded by Karma.
      'node_modules/typescript/lib/typescript.js',
      '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/async-test.js',
      'node_modules/zone.js/dist/fake-async-test.js',
      'node_modules/zone.js/dist/long-stack-trace-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',

      // Paths loaded via module imports.
      {pattern: 'karma-systemjs.config.js',          included: true,  watched: false},   ❻
      {pattern: 'karma-test-runner.js',              included: true,  watched: false},   ❼
      {pattern: 'node_modules/@angular/**/*.js',     included: false, watched: false},
      {pattern: 'node_modules/@angular/**/*.js.map', included: false, watched: false},
      {pattern: 'node_modules/rxjs/**/*.js',         included: false, watched: false},
      {pattern: 'node_modules/rxjs/**/*.js.map',     included: false, watched: false},
      {pattern: 'app/**/*.ts',               included: false, watched: true}   ❽
    ],
    proxies: {   ❾
      '/app/': '/base/app/'
    },
    plugins: [   ❿
      'karma-jasmine',
      'karma-chrome-launcher',
      'karma-firefox-launcher'
    ]
  })
};
```

❶ Tests the application against the Chrome and Firefox browsers.

❷ The unit tests are written using Jasmine.

❸ Prints dots on the console to indicate the tests' progress.

❹ Runs the tests once and stops. This option is useful when Karma runs as part of an automated build.

5. Karma should know about files from the Angular framework (including the testing library).
6. Karma SystemJS configuration. Identical to the systemjs.config.js file but additionally defines baseURL: 'base'.
7. This script will run the tests.
8. Files are loaded via module imports and can contain either the test scripts or the application code included in the import statements.
9. Required for component assets fetched by Angular's compiler. The filenames that start with /app in the styleUrls and templateUrl properties (not used in the weather app) should be proxied via the Karma-generated /base/app path.
10. Plugins required for the run.

Most of the preceding configuration file lists the paths where required files are located. Karma generates a temporary HTML page that will include the files that are listed with `included: true`. The files listed with `included: false` will be dynamically loaded at runtime. All the Angular files, including the testing ones, are loaded dynamically by SystemJS.

We'll need to add one more file to our project: karma-test-runner.js. It's the script that actually runs our tests.

```
Error.stackTraceLimit = Infinity;   1

jasmine.DEFAULT_TIMEOUT_INTERVAL = 1000;   2

__karma__.loaded = function () {};   3

function resolveTestFiles() {   4
  return Object.keys(window.__karma__.files)
      .filter(function (path) { return /\.spec\.ts$/.test(path); })
      .map(function (moduleName) { return System.import(moduleName); });
}

Promise.all([   5
    System.import('@angular/core/testing'),
    System.import('@angular/platform-browser-dynamic/testing')
  ]).
  then(function (modules) {   6
    var testing = modules[0];
    var browser = modules[1];

    testing.TestBed.initTestEnvironment(   7
        browser.BrowserDynamicTestingModule,
        browser.platformBrowserDynamicTesting());
  }).
  then(function () { return Promise.all(resolveTestFiles()); })   8
  .then(function () { __karma__.start(); },   9
       function (error) { __karma__.error(error.stack || error); });
```

1. Lets the browser show full stack traces in case of errors.
2. The default Jasmine timeout for the async function calls is five seconds, but this line changes it to one second.
3. Because the app code and specs are loaded asynchronously, don't run Karma on he loaded event. We'll call karma.start() later once all the specs are loaded.
4. Finds all files with the spec.ts name extension.
5. Loads two Angular modules required for testing.
6. After the modules are loaded, specifies the default Angular providers.
7. Initializes the test environment.
8. Loads our test specs.
9. Runs our tests.

Now we're ready to run our tests using the command `npm test` from the command line. During the run, Karma will open and close each configured browser and will print the test results, as shown in figure 9.7.

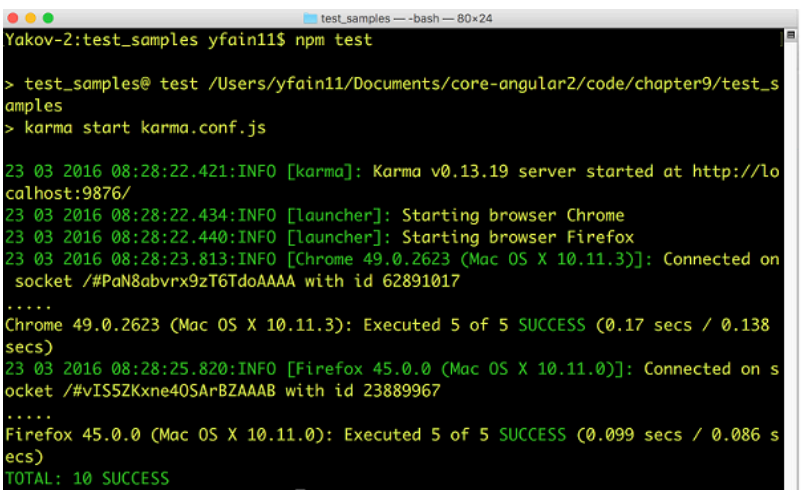


Figure 9.7 Testing the weather application with Karma

Developers tend to use the latest versions of the browser that has the best dev tools, which is Google Chrome. We've seen real-world projects in which a developer demos the application running perfectly in Chrome, and then users complain about an error in Safari. Make sure that the development process uses Karma and tests the application against all browsers. Before giving your application to the QA team or showing it to your manager, make sure that your Karma runner doesn't report any errors in all the required browsers.

Now that we've given you an overview of writing and running unit tests, let's implement tests for the online auction.

9.5 Hands-on: Unit testing the online auction

The goal of this exercise is to show you how to unit-test selected modules of our online auction application. In particular, we'll add unit tests for `ApplicationComponent`, `StarsComponent`, and `ProductService`. We'll run the tests using Jasmine's HTML-based runner and then with Karma.

NOTE	**How to work on the online auction app** We're going to use the auction application from chapter 8 as a starting point, so copy it to a separate directory and follow the instructions below. If you prefer to review the code instead of typing it, use the code that comes with chapter 9 and run the tests.

Install Jasmine, Karma, the type definition files for Jasmine, and all Angular dependencies by running the following commands:

```
npm install jasmine-core karma karma-jasmine karma-chrome-launcher
    karma-firefox-launcher --save-dev

npm install @types/jasmine --save-dev
npm install
```

In the client directory, create a new auction-unit-tests.html file for loading Jasmine tests. Give it the following content:

```
<!DOCTYPE html>
<html>
<head>
  <title>[TEST] Online Auction</title>

  <!-- TypeScript in-browser compiler -->
  <script src="node_modules/typescript/lib/typescript.js"></script>

  <!-- Polyfills -->
  <script src="node_modules/reflect-metadata/Reflect.js"></script>

  <!-- Jasmine -->
  <link rel="stylesheet" href="node_modules/jasmine-core/lib/jasmine-core/jasmine.css">
  <script src="node_modules/jasmine-core/lib/jasmine-core/jasmine.js"></script>
  <script src="node_modules/jasmine-core/lib/jasmine-core/jasmine-html.js"></script>
  <script src="node_modules/jasmine-core/lib/jasmine-core/boot.js"></script>

  <!-- Zone.js -->
  <script src="node_modules/zone.js/dist/zone.js"></script>
  <script src="node_modules/zone.js/dist/proxy.js"></script>
  <script src="node_modules/zone.js/dist/sync-test.js"></script>
  <script src="node_modules/zone.js/dist/jasmine-patch.js"></script>
  <script src="node_modules/zone.js/dist/async-test.js"></script>
  <script src="node_modules/zone.js/dist/fake-async-test.js"></script>
  <script src="node_modules/zone.js/dist/long-stack-trace-zone.js"></script>

  <!-- SystemJS -->
  <script src="node_modules/systemjs/dist/system.src.js"></script>
  <script src="systemjs.config.js"></script>
</head>
<body>
```

```
<script>
  var SPEC_MODULES = [
    'app/components/application/application.spec',
    'app/components/stars/stars.spec',
    'app/services/product-service.spec'
  ];

  Promise.all([
    System.import('@angular/core/testing'),
    System.import('@angular/platform-browser-dynamic/testing')
  ])
          .then(function (modules) {
            var testing = modules[0];
            var browser = modules[1];

            testing.TestBed.initTestEnvironment(
                    browser.BrowserDynamicTestingModule,
                    browser.platformBrowserDynamicTesting());

            // Load all the spec files.
            return Promise.all(SPEC_MODULES.map(function (module) {
              return System.import(module);
            }));
          })
          .then(window.onload)
          .catch(console.error.bind(console));
</script>
</body>
</html>
```

The content of this file is similar to test.html from the weather application. The only difference is that we're loading different spec files here: application.spec, stars.spec, and product-service.spec.

TESTING APPLICATIONCOMPONENT

Create an application.spec.ts file in the client/app/components/application directory to test that the `ApplicationComponent` is successfully instantiated. This isn't an overly useful test, but it can serve as an illustration of testing whether an instance of a TypeScript class (not even one related to Angular) was successfully created. Add the following content to the application.spec.ts file:

```
import ApplicationComponent from './application';

describe('ApplicationComponent', () => {
  it('is successfully instantiated', () => {
    const app = new ApplicationComponent();
    expect(app instanceof ApplicationComponent).toEqual(true);
  });
});
```

TESTING PRODUCTSERVICE

To test `ProductService` create a product-service.spec.ts file in the app/services directory. In this spec we'll test the HTTP service, and although the `it()` function is rather small, there will be lots of preparation before the test runs. Add the following content to the product-service.spec.ts file:

```
import {async, getTestBed, TestBed, inject, Injector} from '@angular/core/testing';
import {Response, ResponseOptions, HttpModule, XHRBackend} from '@angular/http';
import {MockBackend, MockConnection} from '@angular/http/testing';   ❶
import {ProductService} from './product-service';

describe('ProductService', () => {
  let mockBackend: MockBackend;   ❷
  let service: ProductService;   ❷

  let injector: Injector;

  beforeEach(() => {
    TestBed.configureTestingModule({
      imports: [HttpModule],
      providers: [
        { provide: XHRBackend, useClass: MockBackend },   ❸
        ProductService
      ]
    });
    injector = getTestBed();
  });

  beforeEach(inject([XHRBackend, ProductService], (_mockBackend, _service) => {
    mockBackend = _mockBackend;
    service = _service;
  }));

  it('getProductById() should return Product with ID=1', async(() => {
    let mockProduct = {id: 1};   ❹
    mockBackend.connections.subscribe((connection: MockConnection) => {   ❺
      let responseOpts = new ResponseOptions({body: JSON.stringify(mockProduct)});
      connection.mockRespond(new Response(responseOpts));
    });

    service.getProductById(1).subscribe(p => {
      expect(p.id).toBe(1);   ❻
    });
  }));
});
```

❶ MockBackend will serve as an implementation of our HTTP service. MockConnection represents the connection.

❷ Keeps references to the injected services so the test can use them.

❸ Overrides the default implementation of Http by explicitly instantiating this object and passing it the MockBackend as an argument. We don't change the BaseRequestOption, but it's a required argument.

❹ Prepares the fake data to be returned by the MockBackend.

❺ Configures the mock backend.

❻ Invoking getProductById(1) on the service should return the object with ID equal to 1.

First we create an object literal, `mockProduct = {id: 1}`, which is used to emulate the data that could come from the server as an HTTP response. We want `mockBackend` to mock and return an object with hardcoded values for each HTTP request. We could have created an instance of `Product` with more properties, but for this simple test, having just the ID suffices.

TESTING STARSCOMPONENT

For the last test, we picked `StarsComponent` because it allows us to demonstrate how you can test a component's properties and the event emitter.

The `StarsComponent` loads its HTML from a file, which requires special processing during testing. Angular loads the files specified in `templateUrl` asynchronously and performs just-in-time compilation on these files. We'll need to do the same in our test spec by invoking `TestBed.compileComponents()`. This step is required for any component that uses the `templateUrl` property.

In the client/app/components/stars directory, create a stars.spec.ts file with the following content:

```
import { TestBed, async, fakeAsync, inject } from '@angular/core/testing';
import StarsComponent from './stars';

describe('StarsComponent', () => {
  beforeEach(() => {
    TestBed.configureTestingModule({
      declarations: [ StarsComponent ]
    });
  });

  beforeEach(async(() => {

    TestBed.compileComponents();    ❶
  }));


  it('is successfully injected', () => {    ❷

    let component = TestBed.createComponent(StarsComponent).componentInstance;    ❸
    expect(component instanceof StarsComponent).toEqual(true);
  });


  it('readonly property is true by default', () => {    ❹
    let component = TestBed.createComponent(StarsComponent).componentInstance;
    expect(component.readonly).toEqual(true);
  });


  it('all stars are empty', () => {    ❺
    let fixture = TestBed.createComponent(StarsComponent);
    let element = fixture.nativeElement;
    let cmp = fixture.componentInstance;
    cmp.rating = 0;

    fixture.detectChanges();

    let selector = '.glyphicon-star-empty';
    expect(element.querySelectorAll(selector).length).toBe(5);
  });


  it('all stars are filled', () => {    ❻
```

```
    let fixture = TestBed.createComponent(StarsComponent);
    let element = fixture.nativeElement;
    let cmp = fixture.componentInstance;
    cmp.rating = 5;

    fixture.detectChanges();

    let selector = '.glyphicon-star:not(.glyphicon-star-empty)';
    expect(element.querySelectorAll(selector).length).toBe(5);
  });


  it('emits rating change event when readonly is false', async(() => {
    let component = TestBed.createComponent(StarsComponent).componentInstance;
    component.ratingChange.subscribe(r => {
      expect(r).toBe(3);
    });
    component.readonly = false;
    component.fillStarsWithColor(2);
  }));
});
```

1. Compiles the content of the file used in templateUrl.
2. Checks that the instance was injected (compare with application.spec from the section Testing ApplicationComponent).
3. Creates a fixture and gets the reference to the component's instance.
4. Checks that the readonly input property of the StarsComponent is true by default. The user should be able to click on stars only in the Leave Review mode.
5. Checks that all empty stars are rendered if the rating is equal to zero.
6. Checks that all filled stars are rendered if the rating is equal to five.
7. Checks that EventEmitter works.

`TestBed` creates a new instance of `StarsComponent` (we don't use the injected one here) and it gives us a fixture with references to the component and the native element. To test that all the stars are empty, we assign zero to the input `rating` property on the component instance. The `rating` property is actually a setter on `StarsComponent` that modifies both `rating` and the `stars` array:

```
set rating(value: number) {
  this._rating = value || 0;
  this.stars = Array(this.maxStars).fill(true, 0, this.rating);
}
```

Then we start the change-detection cycle, which will force the `*ngFor` loop to re-render the star images in the template of the `StarsComponent`, which looks like this:

```
<p>
  <span *ngFor="let star of stars; let i = index"
        class="starrating glyphicon glyphicon-star"
        [class.glyphicon-star-empty]="!star"
        (click)="fillStarsWithColor(i)">
```

```
  </span>
  <span *ngIf="rating">{{rating | number:'.0-2'}} stars</span>
</p>
```

The CSS for the filled stars is `starrating glyphicon glyphicon-star`. The empty stars have an additional CSS class, `glyphicon-star-empty`. The test `'all stars are empty'` uses the `glyphicon-star-empty` selector and expects that there are exactly five native elements with this class.

The test `'all stars are filled'` assigns the rating 5 and uses the CSS selector `.glyphicon-star:not(.glyphicon-star-empty)`, which uses the `not` operator to ensure that the stars aren't empty.

The test `'emits rating change event when readonly is false'` uses the injected component. There we subscribe to the `ratingChange` event, expecting the values of the rating to be 3. When a user wants to change the rating, they click on the third star (while leaving a review), which invokes the `fillStarsWithColor` method on the component, passing 3 as the argument `index`:

```
fillStarsWithColor(index) {
  if (!this.readonly) {
    this.rating = index + 1; // to prevent zero rating
    this.ratingChange.emit(this.rating);
  }
}
```

Because there's no user to do the clicking during the unit testing, we invoke this method programmatically:

```
component.readonly = false;
component.fillStarsWithColor(2);
```

If you want to see how this test fails, change the argument of `fillStarsWithColor()` to any number other than 2.

NOTE **The order of operations in testing events**

The code of the test `'emits rating change event when readonly is false'` may make you wonder why we write the preceding two lines at the end of the test after `subscribe()` is invoked? The subscription to observable is lazy, and it'll receive the next element only after the `fillStarsWithColor(2)` method is invoked, emitting the event. If you move the `subscribe()` method down, the event will be emitted before the subscriber is created, and the test will fail on timeout because the `done()` method will never be invoked.

RUNNING THE TESTS

To run the tests, first recompile the server's code by running `npm run tsc`. Then start the auction application by entering `npm start` on the console. It'll start the Node server on port 8000. Then enter http://localhost:8000/auction-unit-tests.html in the browser, and the tests should run, producing the output shown in figure 9.8.

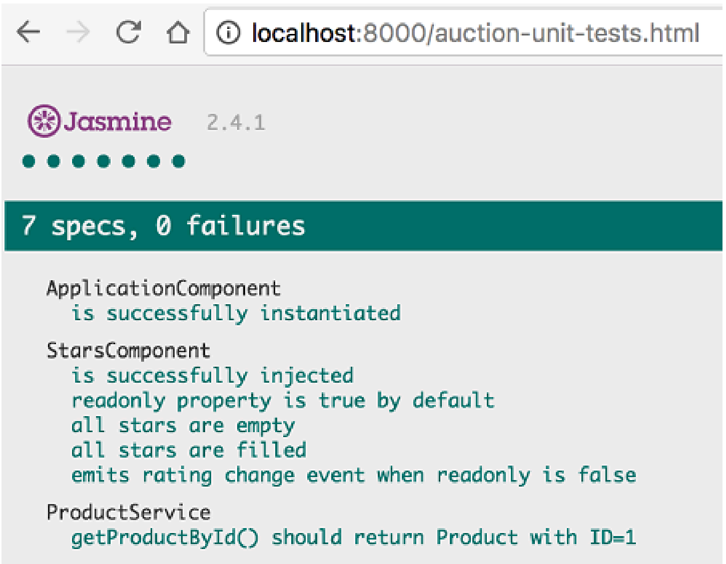


Figure 9.8 Testing the online auction with the HTML-based runner

To run the same tests using Karma, copy the files karma.conf and karma-test-runner from chapter 8's auction directory into the root directory of your project. (These files were explained in section 9.4.) Run `npm test`, and you should see the output shown in figure 9.9.

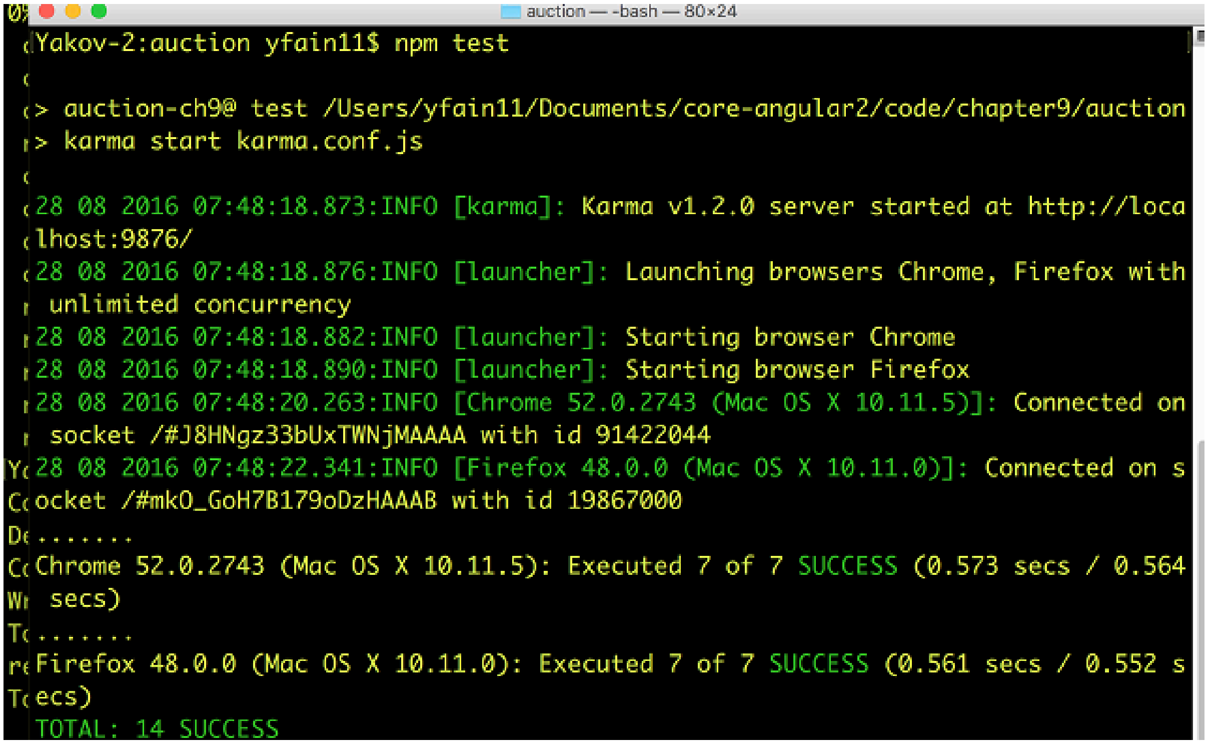


Figure 9.9 Testing the Auction with HTML-based runner

9.6 Summary

We can’t overstate the importance of running unit tests in your Angular applications. Unit tests allow you to ensure that each component or service of your application works as expected. In this chapter we’ve demonstrated how to write unit tests using the Jasmine framework, and how to run them either with Jasmine or with Karma.

These are the main takeaways for this chapter:

- A component or a service is a good candidate for writing a test suite.
- Although you can keep all test files separate from your application, it’s more convenient to keep them next to the components they test.
- Unit tests run quickly, and most of application business logic should be tested with unit tests.
- While you’re writing tests, make them fail to see that their failure report is easy to understand.
- If you decide to implement end-to-end testing, don’t rerun unit tests during this process.
- Running the unit tests has to be part of your automated build process, and we’ll show you how to do that in chapter 10.

10 Bundling and deploying applications with Webpack

This chapter covers

- Bundling apps for deployment using Webpack
- Configuring Webpack for bundling Angular apps in dev and prod
- Integrating the Karma test runner into the the automated build process
- Creating a prod build for the online auction

Over the course of this book, we've written and deployed multiple versions of the online auction and lots of smaller applications. Web servers properly served our applications to the user. So why not just copy all the application's files to the production server, run `npm install`, and be done with deployment?

No matter which programming language or framework you use, you'll want to achieve two goals:

- The deployed web application should be small in size (so it can load faster).
- The browser should make a minimal number of requests to the server on startup (so it can load faster).

When a browser makes requests to the server, it gets HTML documents, which may include additional files like CSS, images, videos, and so on. Let's take our online auction application as an example. On startup it makes hundreds of requests to the server just to load Angular with its dependencies and the TypeScript compiler, which weigh 5.5 MB combined. Add to this the code we wrote, which is a couple of dozen HTML, TypeScript, and CSS files, let alone images! It's a lot of code to download, and way too many server requests for such a small application. Take a look at figure 10.1, which shows the content of the Network tab in Chrome Developer Tools after our auction was loaded into the browser.

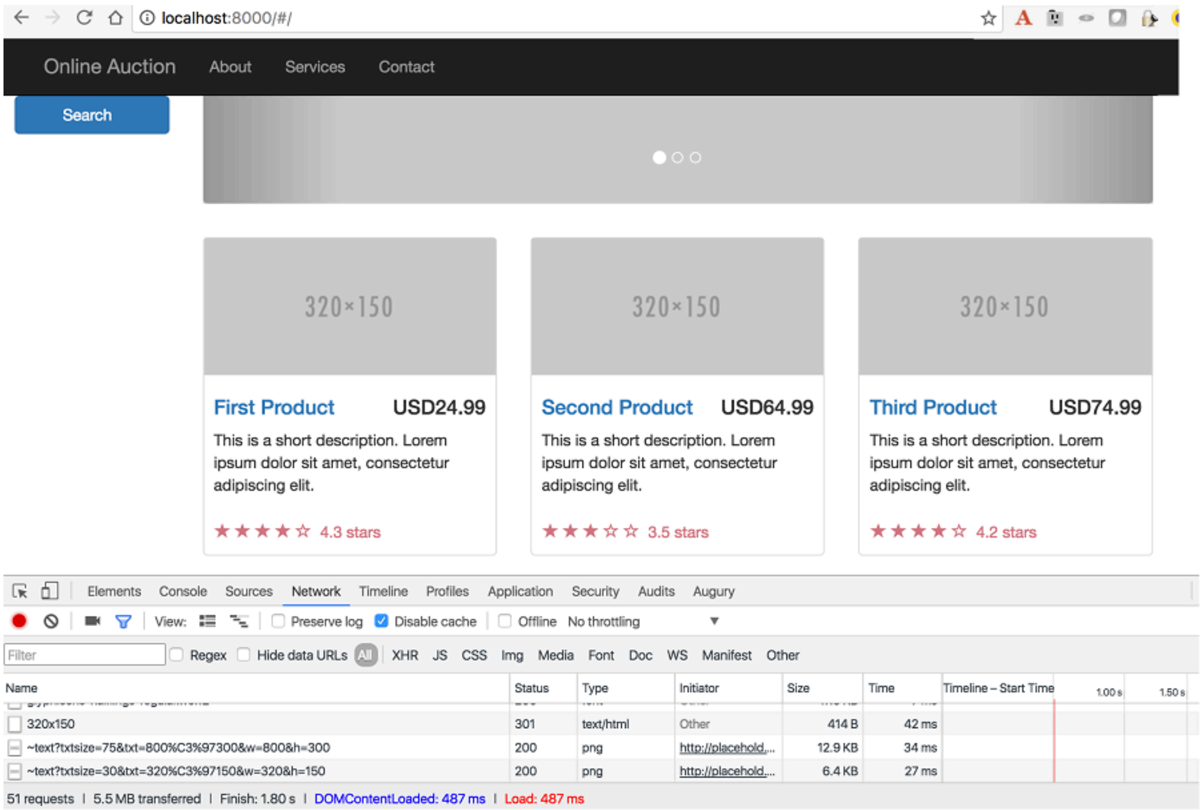


Figure 10.1 Monitoring the development version of the online auction application

Real-world applications consist of hundreds and even thousands of files, and we want to minimize, optimize, and bundle them together during deployment. Besides, for production we can precompile the code into JavaScript, so we won't need to load the 3 MB TypeScript compiler in the browser.

There are several popular tools used to deploy JavaScript web applications. All of them run using Node and are available as npm packages. These tools fit into two main categories:

- Task runners
- Module loaders and bundlers

Grunt and Gulp are widely used general-purpose task runners. They know nothing about your JavaScript application, but they allow you to configure and run the tasks required for deploying the application. Grunt and Gulp are not easy to maintain for build processes, as their configuration files are several hundred lines long.

In this book we used npm scripts for running tasks, and a task is a script or a binary file that can be executed from a command line. Configuring npm scripts is simpler than using Grunt and Gulp, and we'll continue using them in this chapter. If the complexity of your project increases and the number of npm scripts becomes unmanageable, consider using Grunt or Gulp for running builds.

So far we've used SystemJS for loading modules. Browserify, Webpack, Broccoli, and Rollup are all popular bundlers. Each of them can create code bundles to be consumed by the browsers. The simplest is Webpack, which allows you to convert and combine all your application assets into bundles with minimal configuration. A concise comparison of various bundlers is available on the Webpack site: http://mng.bz/136m.

The Webpack bundler was created specifically for web applications running in a browser, and many typical tasks required for preparing web application builds are supported out of the box with minimal configuration and without the need to install additional plugins.

This chapter starts by introducing Webpack, and then we'll prepare two separate builds (dev and prod) for our online auction. Finally, we'll run an optimized version of the online auction and we'll compare the size of the application with what was shown in figure 10.1.

We won't be using SystemJS in this chapter—Webpack will invoke the TypeScript compiler while bundling our apps. The compilation will be controlled by a special loader that will use tsc internally to transpile TypeScript into JavaScript.

NOTE **Angular CLI**
At the time of writing, the Angular team was working on Angular CLI (https://github.com/angular/angular-cli), which is a command-line interface for automating an application's creation, testing, and deployment. Angular CLI uses Webpack bundler. You should check it out when it's released.

10.1 Getting to know Webpack

While preparing for a trip, you may pack dozens of items into a couple of suitcases. Savvy travelers use special vacuum-seal bags that allow them to squeeze even more clothes into the same suitcase. Webpack is an equivalent tool. It's a module loader and a bundler that allows you to group your application files into bundles, and you can optimize their sizes to fit more into the same bundle.

For example, you can prepare two bundles for deployment: all your application files will be merged into one bundle, and all required third-party frameworks and libraries are in another. With Webpack you can prepare separate bundles for development and production deployment, as shown in figure 10.2. In dev mode, we'll be creating the bundles in memory, whereas in production mode Webpack will generates actual files on disk.

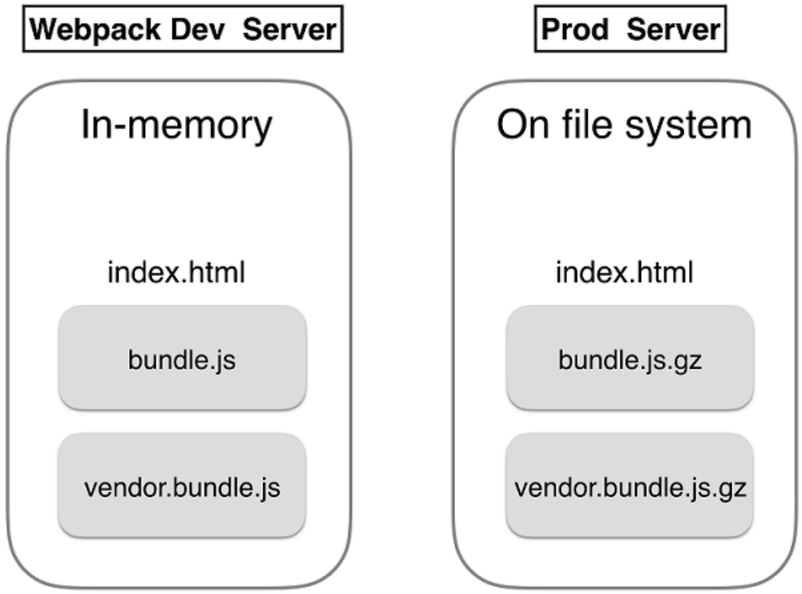


Figure 10.2 Dev and prod deployments

It's convenient to write an application as a set of small modules where one file is one module, but for deployment you'll need a tool to pack all these files into a small number of bundles. This tool should know how to build the module dependencies tree, sparing you from manually maintaining the order of the loaded modules. Webpack is such a tool, and in the Webpack philosophy, everything can be a module, including CSS, images, and HTML.

The process of deployment with Webpack consists of two major steps:

1. Build the bundles (this step can include code optimization).
2. Copy the bundles to the desired server.

Webpack is distributed as an npm package, and like all tools, you can install it either globally or locally. Let's start by installing Webpack globally:

```
npm install webpack -g
```

NOTE	**Installing Webpack 2.1.0** We use Webpack 2.1.0, which at the time of this writing is in beta. To install it globally we used the command `npm i webpack@2.1.0-beta.21 -g`.

A bit later we'll install Webpack locally by adding it into the `devDependencies` section of the package.json file, but installing Webpack globally will let us quickly demonstrate the process of turning an application into a bundle.

> **NOTE** **Webpack resources**
> There’s curated list of Webpack resources (documentation, videos, libraries, and so on) on GitHub. Take a look at the awesome-webpack: https://github.com/d3viant0ne/awesome-webpack.

10.1.1 Hello World with Webpack

Let’s get familiar with Webpack via a very basic Hello World example consisting of two files: index.html and main.js. Here’s the index.html file.

```
<!DOCTYPE html>
<html>
<body>
  <script src="main.js"></script>
</body>
</html>
```

The main.js file is even shorter:

```
document.write('Hello World!');
```

Open a command prompt window in the directory where these file are located, and run the following command:

```
webpack main.js bundle.js
```

The main.js file is a source file, and bundle.js is the output file in the same directory. We usually include the word *bundle* in the output filename. Figure 10.3 shows the result of running the preceding command.

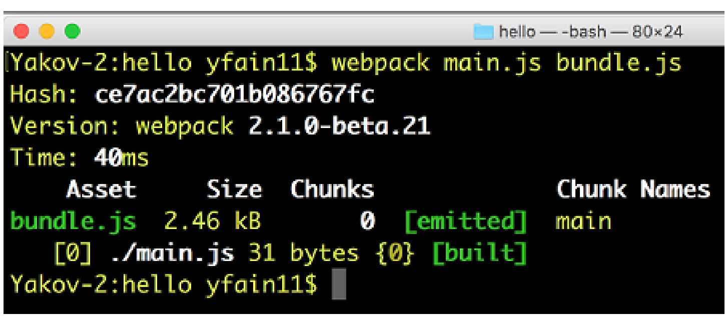


Figure 10.3 Creating the first bundle

Note that the size of the generated bundle.js is larger than that of main.js because Webpack didn’t just copy one file into another but added other code required by this bundler. Creating a bundle from a single file is not overly useful, as it will increase the file size, but in a multi-file application, bundling files together makes sense, and you'll see this as you read this chapter.

Now you'll need to modify the `<script>` tag in the HTML file to include bundle.js instead of main.js, and this tiny application will render the same "Hello World!" message as the original one.

Webpack allows you to specify various options on the command line, but it's better to configure the Webpack bundling process in the webpack.config.js file, which is a JavaScript file. A simple configuration file is shown here:

```
const path = require('path');

module.exports = {
  entry: "./main",
  output: {
    path: './dist',
    filename: 'bundle.js'
  }
};
```

To create a bundle, Webpack needs to know the main module (the *entry point*) of your application, which may have dependencies on other modules or third-party libraries (other entry points). By default, Webpack adds the *.js* extension to the name of the entry point specified in the `entry` property. Webpack loads the entry point module and builds a memory tree of all dependent modules.

By reading the preceding configuration file, Webpack will know that the application entry is located in the ./main.js file and that the resulting bundle.js file has to be saved in the ./dist directory, which is a common name for the distribution bundles.

NOTE	**Separating sources and generated bundles** Storing the output files in a separate directory will allow you to configure your version control system to exclude the generated files. If you use a Git version control system just add the dist directory to the .gitignore file.

We could specify more than one entry point by providing an array as a value for the `entry` property:

```
entry: ["./other-module", "./main"]
```

In this case, each of these modules will be loaded upon startup.

NOTE **Configuring entry points for multiple bundles**
To create multiple bundles, you need to specify the values of the `entry` property not as strings, but as objects. You'll see such an example later in this chapter, where we instruct Webpack to put the Angular's code in one bundle and the application code in another.

If the Webpack configuration file is present in the current directory, you don't need to provide any command-line parameters; you can simply run the `webpack` command to create your bundles. The other choice is to run Webpack in watch mode using the `--watch` or `-w` command-line option, so whenever you make a change to your application files, Webpack will automatically rebuild the bundle:

```
webpack --watch
```

You could also instruct Webpack to run in watch mode by adding the following entry to webpack.config.js:

```
watch: true
```

USING WEBPACK-DEV-SERVER

In previous chapters we used live-server to serve our applications, but Webpack comes with its own webpack-dev-server that has to be installed separately. Usually we add Webpack to the existing npm project and install both Webpack and its development server locally by running the following command:

```
npm install webpack webpack-dev-server --save-dev
```

This command will install all required files in the node_modules subdirectory and will add webpack and webpack-dev-server to the `devDependencies` section of package.json.

Our next version of Hello World is located in the directory hello-world-devserver and will include the index.html file shown next:

```
<!DOCTYPE html>
<html>
<body>
  <script src="/bundle.js"></script>
</body>
</html>
```

The main.js JavaScript file remains as simple as this:

```
document.write('Hello World!');
```

Our package.json file in the hello-world-devserver project looks like this:

```
{
  "name": "first-project",
  "version": "1.0.0",
  "description": "",
  "main": "main.js",
  "scripts": {
    "start": "webpack-dev-server"
  },
  "keywords": [],
  "author": "",
  "license": "ISC",
  "devDependencies": {
    "webpack": "^2.1.0-beta.21",
    "webpack-dev-server": "^2.1.0-beta.0"
  }
}
```

Note that we've configured the `npm start` command for running the local webpack-dev-server.

NOTE	**Serving apps to the browser with webpack-dev-server** When you serve your application with webpack-dev-server, it'll run on the default port 8080 and will generate the bundles in memory without saving them in a file. The webpack-dev-server will recompile and serve the new versions of the bundles every time you modify the code.

You can add the configuration section of webpack-dev-server in the `devServer` section of the webpack.config.js file. There you can put any options that webpack-dev-server allows on the command line (see the Webpack product documentation at http://mng.bz/gn4r). This is how you could specify that the files should be served from the current directory:

```
devServer: {
  contentBase: '.'
}
```

The complete configuration file for our hello-world-devserver project is shown here and can be reused by both the webpack and webpack-dev-server commands:

```
const path = require('path');

module.exports = {
  entry: {
    'main': './main.js'
  },
  output: {
    path: './dist',
    filename: 'bundle.js'
```

```
  },
  watch: true,
  devServer: {
    contentBase: '.'
  }
};
```

In the preceding file, two of the options are needed only if you're planning to run the `webpack` command in watch mode and generate output files on disk:

- The Node module `path` resolves relative paths in your project (in this case it specifies the ./dist directory).
- The `watch: true` starts Webpack in watch mode.

If you run the `webpack-dev-server` command, the preceding two options aren't used. The `webpack-dev-server` always runs in watch mode, doesn't output files on disk, and builds bundles in memory.

The `contentBase` property will let `webpack-dev-server` know where your index.html file is located.

Let's try to run our Hello World application by serving the application with the webpack-dev-server. In the command window, run `npm start` to start webpack-dev-server. On the console, webpack-dev-server will log the output, which starts with the URL that you can use with the browser, which by default is http://localhost:8080.

Open your browser to this URL, and you'll see the window that displays the message "Hello World". Modify the text of the message in main.js, and Webpack will automatically rebuild the bundle, and the server will reload the fresh content.

RESOLVING FILENAMES

This is all good, but we've been writing code in TypeScript, which means that we need to let Webpack know that our modules can be located not only in .js files, but in .ts files as well. Earlier in the webpack.config.js file we specified the filename with the extension: main.js. But you can specify just the filenames without any extensions as long the webpack.config.js file has the `resolve` section. The next code snippet shows how we can let Webpack know that our modules can be located in files with extensions .js or .ts, or with no extensions:

```
resolve: {
  extensions: ['.js', '.ts', '']
}
```

The TypeScript files also have to be preprocessed (transpiled). We need to tell Webpack to transpile our application's .ts files into .js files before creating bundles, and you'll see how to do this in the next section.

Usually build-automation tools provide developers with a way to specify additional tasks that need to be performed during the build process, and Webpack offers *loaders* and *plugins* that allow you to customize builds.

10.1.2 How to use loaders

Loaders are transformers that take a source file as input and produce another file as output (in memory or on disk), one at a time. A loader is a small JavaScript module with an exported function that performs a certain transformation. For example, the `json-loader` takes an input file and parses it as JSON. The `base64-loader` converts its input into a base64-encoded string. Loaders play a similar role to *tasks* in other build tools. Some loaders are included with Webpack so you don't need to install them separately, and others can be installed from public repositories. Check the "list of loaders" in the Webpack docs on GitHub (http://mng.bz/U0Yv) to see how to install and use the loaders you need.

In essence, a loader is a function written in Node-compatible JavaScript. To use a loader that's not included with the Webpack distribution, you'll need to install it using npm and include it in the package.json file of your project. You can either manually add the required loader to the `devDependencies` section of your package.json, or run the `npm install` command with the `--save-dev` option. In the case of ts-loader, the command would look like this:

```
npm install ts-loader --save-dev
```

Loaders are listed in the webpack.config.js file in the `module` section. For example, you can add the ts-loader as follows:

```
module: {
  loaders: [
    {
      test: /\.ts$/,
      exclude: /node_modules/,
      loader: 'ts-loader'
    },
  ]
}
```

The preceding configuration tells Webpack to check (test) each filename, and if it matches the regular expression `\.ts$`, to preprocess it with ts-loader. In the syntax of regular expressions, the dollar sign at the end indicates that we're interested only in files having names that end with .ts. Because we don't want to include Angular's .ts files in our bundle, we've excluded the node_modules directory. You can either reference loaders by their full name (such as `ts-loader`), or by their shorthand name, omitting the `-loader` suffix (for example, `ts`).

> **NOTE** **No SystemJS in this chapter**
> The SystemJS loader isn't used in any of the projects presented in this chapter. Webpack loads and transforms all project files using one or more loaders configured in webpack.config.js based on the file type.

USING LOADERS FOR HTML AND CSS FILES

In the previous chapters of the book, the Angular components that stored HTML and CSS in separate files were specified in the `@Component` annotation as `templateUrl` and `styleUrls` respectively. Here's an example:

```
@Component({
  selector: 'my-home',
  styleUrls: ['app/components/home.css')],
  templateUrl: 'app/components/home.html'
})
```

We usually keep the HTML and CSS files in the same directory where the component code is located. Can we specify the path relative to the current directory?

Webpack allows you to do this:

```
@Component({
  selector: 'my-home',
  styles: [home.css'],
  templateUrl: home.html
})
```

While creating bundles, Webpack will automatically add the `require()` statements for loading loading CSS and HTML files, replacing the preceding code with the following:

```
@Component({
  selector: 'my-home',
  styles: [require('./home.css')],
  templateUrl: require('./home.html')
})
```

Then Webpack will check every `require()` statement and will replace it with the content of the required file, applying the loaders specified for the respective file types. The `require()` statement we use here isn't the one from CommonJS, but it's the internal Webpack function that makes Webpack aware that these files are dependencies. Webpack's `require()` not just loads the files, but can reload them when modified (if you run it in watch mode or use webpack-dev-server).

SIDEBAR **Relative paths in templates**

It’s great that Webpack supports relative paths, but what if you want to be able to load the same app either with SystemJS or with Webpack?

By default, in Angular you have to use the full path to external files, starting from the app root directory. This would require code changes if you decide to move the component into a different directory.

But if you use SystemJS and keep the component’s code and its HTML and CSS files in the same directory, you can use a special `moduleId` property. If you assign to this property a special `__moduleName` binding, SystemJS will load files relative to the current module without the need to specify the full path.

```
declare var __moduleName: string;
@Component({
  selector: 'my-home',
  moduleId:__moduleName,
  templateUrl: './home.html',
  styleUrls: ['./home.css']
})
```

So if you want to create a component that uses relative paths and can be loaded by both SystemJS and Webpack, use `moduleId` with `__moduleName`.

You can read more about relative paths in the Angular documentation in the “Component-relative Paths” section at http://mng.bz/47w0.

In dev mode, for HTML processing, we’ll use the `raw-loader`, which simply transforms .html files into strings. To install this loader and save it in the `devDependencies` section of package.json, run the following command:

```
npm install raw-loader --save-dev
```

In prod, we’ll use the `html-loader`, which will remove extra spaces, newline characters, and comments from HTML files:

```
npm install html-loader --save-dev
```

For CSS processing we use the loaders `css-loader` and `style-loader`, and during the building process all related CSS files will be inlined. The `css-loader` will find and resolve all the `url()` expressions in a CSS file (such as `background-image: url("flowers.gif");`). The `style-loader` will insert the CSS into the `<style>` tag of your HTML template. To install these loaders and save them in the `devDependencies` section of package.json, run the following command:

```
npm install css-loader style-loader --save-dev
```

You can chain the loaders using an exclamation point as a piping symbol. The following fragment is from a webpack-config.js file that includes an array of loaders. When loaders are specified as an array, they'll be executed from the bottom to the top (so the `ts` loader will be executed first in this example). This extract is from a sample project in the next section, where CSS files are located in two folders: src and node_modules.

```
loaders: [
  {test: /\.css$/,  loader: 'to-string!css', exclude: /node_modules/},   ❶
  {test: /\.css$/,  loader: 'style!css', exclude: /src/},   ❷
  {test: /\.html$/, loader: 'raw'},   ❸
  {test: /\.ts$/,   loader: 'ts'}   ❹
]
```

❶ Excludes CSS files located in the node_modules directory.

❷ Inlines the third-party CSS files located in node_modules.

❸ Transforms the content of each .html file into a string.

❹ Transpiles each .ts file using ts-loader.

First we excluded the CSS files located in the node_modules directory, so this transformation will apply only to our application components. We chain the `to-string` and `css` loaders here. The `css` loader is executed first, turning the CSS into a JavaScript module, and then its output is piped to the `to-string` loader to extract the string from the generated JavaScript. The resulting string will be inlined into the corresponding components inside the `@Component` annotation, in place of `require()`, so Angular can apply the proper `ViewEncapsulation` strategy.

Then we want Webpack to inline the third-party CSS files located in node_modules (not in src). The `css-loader` will read the CSS, generate a JavaScript module, and pass it to the `style-loader`, which will generate `<style>` tags with the loaded CSS and insert them into the `<head>` section of the HTML document.

Finally, we turn HTML files into strings and transpile the TypeScript code.

NOTE **Bundling CSS**
In Angular we want the CSS to be encapsulated inside the components to gain the benefits of `ViewEncapsulation`, explained in chapter 6. That's why we inline CSS into the JavaScript code. But there is a way to build a separate bundle that contains just the CSS by using the ExtractTextPlugin plugin. If you use CSS preprocessors, install and use the sass-loader or less-loader.

WHAT PRELOADERS AND POSTLOADERS ARE FOR

Sometimes you may want to perform additional file processing even before the loaders start their transformations. For example, you may want to run your TypeScript files through a TSLint tool to check your code for readability, maintainability, and functional errors. For that, you'd need to add the `preLoaders` section to the Webpack configuration file:

```
preLoaders: [
  {
    test: /\.ts$/,
    exclude: /node_modules/,
    loader: "tslint"
  }
]
```

Preloaders always run before the loaders, and if they run into any errors, those will be reported on the command line. You can also configure some postprocessing by adding a `postLoaders` section to webpack.config.js.

10.1.3 How to use plugins

If Webpack loaders transform files one at a time, plugins have access to all files, and they can process them before or after the loaders kick in. For example, the CommonChunksPlugin plugin allows you to create a separate bundle for common modules required by various scripts in your application. The CopyWebpackPlugin plugin can copy either individual files or entire directories to the build directory. The UglifyJSPlugin plugin performs code minification of all transpiled files.

Say you want to split your application code into two bundles, `main` and `admin`, and each of these modules uses the Angular framework. If you just specify two entry points (`main` and `admin`), each bundle would include the application code as well as its own copy of Angular. To prevent this from happening, you can process the code with the CommonsChunkPlugin. With this plugin, Webpack won't include any of the Angular code in the `main` and `admin` bundles; it will create a separate shareable bundle with the Angular code only. This will lower the total size of your application because it includes only one copy of Angular shared between two application modules. In this case, your HTML file should include the vendor bundle first, followed by the application bundle.

The UglifyJSPlugin is a wrapper for the UglifyJS minifier, which takes the JavaScript code and performs various optimizations. For example, it compresses the code by joining consecutive `var` statements, removes unused variables and unreachable code, and optimizes `if` statements. Its mangler tool renames local variables to single letters. For a full description of UglifyJS visit its GitHub page (https://github.com/mishoo/UglifyJS).

We'll use these and other plugins in the following sections.

10.2 Creating a basic Webpack configuration for Angular

Now that we've covered the Webpack basics, let's see how we can bundle a simple Angular application written in TypeScript. We've created a small application that consists of Home and About components and doesn't use external templates or CSS files. This project is located in the basic-webpack-starter directory, and its structure is shown in figure 10.4.

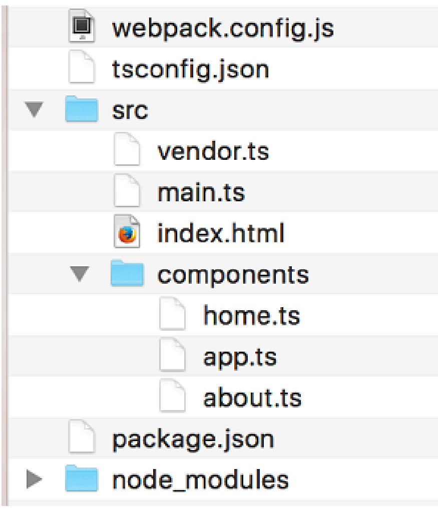


Figure 10.4 The basic-webpack-starter project

The main.ts script bootstraps the `AppModule` and `MyApp` components, which configure the router and have two links for navigating to either `HomeComponent` or `AboutComponent`. Each of these components displays a simple message—the actual functionality is irrelevant in the context of this chapter. We'll focus on creating two bundles—one for Angular and its dependencies, and the other for the application code.

The vendor.ts file is quite small—we just used the `import` statements required by Angular. We did this to create a situation where there are two entry points (main.ts and vendor.ts) that contain common Angular code, which we'll put into a separate bundle.

```
import 'zone.js/dist/zone';
import 'reflect-metadata/Reflect.js';
import '@angular/http';
import '@angular/platform-browser-dynamic';
import '@angular/router';
```

Because the preceding `import` statements can also be used in main.ts, we'll use the CommonChunksPlugin to avoid including Angular code in both bundles. Instead we'll build a separate Angular bundle that's shared by the main entry point and any other entry point if we decide to split the application code into smaller chunks.

> **NOTE** **What to place in vendor.ts**
> The vendor.ts file should import all the modules that we want included in the common bundle and removed from the application code. Webpack will inline into the common bundle all the code required for the imported modules.

The content of the webpack.config.js configuration file is shown here:

```
const path               = require('path');
const CommonsChunkPlugin = require('webpack/lib/optimize/CommonsChunkPlugin');
const CopyWebpackPlugin  = require('copy-webpack-plugin');

module.exports = {
  entry: {
    'main'  : './src/main.ts',
    'vendor': './src/vendor.ts'
  },
  output: {
    path    : './dist',
    filename: 'bundle.js'
  },
  plugins: [
    new CommonsChunkPlugin({ name: 'vendor', filename: 'vendor.bundle.js' }),
    new CopyWebpackPlugin([{from: './src/index.html', to: 'index.html'}])
  ],
  resolve: {
    extensions: ['', '.ts', '.js']
  },
  module: {
    loaders: [
      {test: /\.ts$/, loader: 'ts-loader'}
    ],
    noParse: [path.join(__dirname, 'node_modules', 'angular2', 'bundles')]
  },
  devServer: {
    contentBase: 'src',
    historyApiFallback: true
  },
  devtool: 'source-map'
};
```

1. We use require to bring the path modules in to resolve the paths to files. Then we require two plugins: CommonsChunkPlugin and copy-webpack-plugin.
2. Because the value for the entry property is specified as an object, this tells Webpack to build two bundles: one for the main.ts entry and another for vendor.ts.
3. The output bundles will be saved in the dist directory, and the name of the main entry point will go to the bundle.js file. The output for the second entry point will be configured in the plugins section.
4. This line instructs Webpack to create a common vendor.bundle.js bundle with the content that can be shared by all application bundles.

5. Copies the index.html file into the dist directory.
6. To speed up the build process, don't parse Angular minified files located in the node_modules/angular2/bundles directory
7. Lets the dev server know that the application code is located in the src directory.
8. Generates source maps.

Because CommonsChunkPlugin comes with Webpack, there's no need to install it separately. After we install the copy-webpack-plugin, Webpack will find it in the node_modules directory.

In the preceding config file we have two entry points: main.ts contains our app code plus Angular, and vendor.ts has only the Angular code. So the Angular code is common to both of these entry points, and this plugin will extract it from main and will keep it only in vendor.bundle.js.

Although it's nice to bundle all your app code into one JavaScript file for deployment, it's easier to debug code in its original form of separate files. By adding source-map to webpack.config.js, Webpack will generate source maps so you can see the sources of the JavaScript, CSS, and HTML files, even though the browser executes the code from bundle.js.

We use the option `"sourceMap": true` in the tsconfig.json file so the TypeScript source maps are generated. Web browsers load the source map files only if you have the developer console open, so generating source maps is a very good idea even for production deployments. Keep in mind that `ts-loader` will perform the code transpilation, so we turn off tsc code generation by setting `"noEmit": true` in tsconfig.json.

Now let's see see how npm's package.json file will change to include the Webpack-related content. In the basic version of package.json we'll just add two lines in the `scripts` section and the `devDependencies` section will include `webpack`, `webpack-sev-server`, and the required loaders and plugins:

```
{
  "name": "basic-webpack-starter",
  "version": "1.0.0",
  "description": "A basic Webpack-based starter project for an Angular 2 application",
  "homepage": "https://www.manning.com/books/angular-2-development-with-typescript",
  "private": true,
  "scripts": {
    "build": "webpack",    ❶
    "start": "webpack-dev-server --inline --progress --port 8080"    ❷
  },
  "dependencies": {
    "@angular/common": "2.0.0-rc.6",
    "@angular/compiler": "2.0.0-rc.6",
    "@angular/core": "2.0.0-rc.6",
    "@angular/http": "2.0.0-rc.6",
    "@angular/platform-browser": "2.0.0-rc.6",
```

```
    "@angular/platform-browser-dynamic": "2.0.0-rc.6",
    "@angular/router": "3.0.0-rc.2",
    "reflect-metadata": "^0.1.8",
    "rxjs": "5.0.0-beta.11",
    "systemjs": "^0.19.37",
    "zone.js": "0.6.17"
  },
  "devDependencies": {
    "@types/es6-shim": "0.0.31",         ❸
    "copy-webpack-plugin": "^3.0.1",     ❹
    "ts-loader": "^0.8.2",               ❺
    "typescript": "^2.0.0",
    "webpack": "^2.1.0-beta.21",         ❻
    "webpack-dev-server": "^2.1.0-beta.0"   ❼
  }
}
```

❶ Causes Webpack to write the bundles in the dist output directory.

❷ Creates the bundles in memory and will serve them to the browser using webpack-dev-server.

❸ Installs type definitions to support ES6 features. We'll also add the compiler option "types":["es6-shim"], in tsconfig.json.

❹ Adds copy-webpack-plugin as a development dependency. Note that we didn't need to add CommonsChunkPlugin, because it comes with Webpack.

❺ Adds the loaded ts-loader as a development dependency.

❻ Includes Webpack as a development dependency.

❼ Adds Webpack development server as a development dependency.

NOTE	**Use TypeScript 2.0 or newer** We use NPM packages from the `@types` namespace and the TypeScript compiler option `@types` to handle type definition files. You need TypeScript 2.0. or later installed to use the `@types` option.

Both the `start` and `build` scripts use the same Webpack configuration from the webpack.config.js file. Let's see how these scripts differ.

NPM RUN BUILD

After running `npm run build`, the command window looks like what you see in figure 10.5.

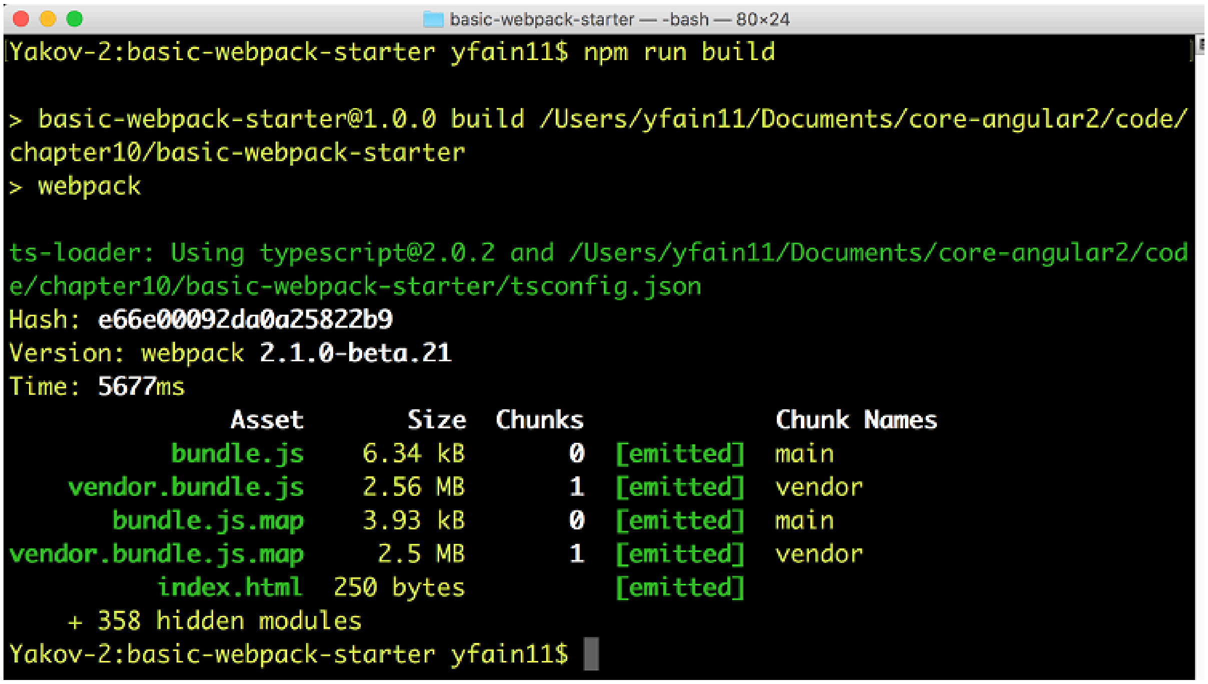


Figure 10.5 Running npm run build

The application weighs 2.5 MB and makes just three network requests to load. Webpack built two bundles (bundle.js and vendor.bundle.js), two corresponding source map files (bundle.js.map and vendor.bundle.js.map), and copied index.html into the dist output directory shown in figure 10.6.

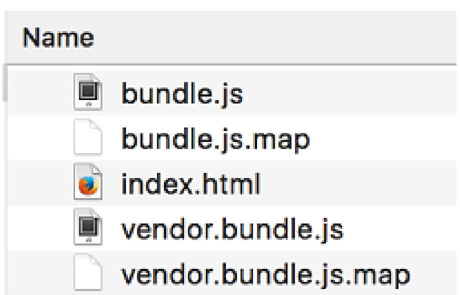


Figure 10.6 The content of the dist directory

The index.html file doesn't include any `<script>` tags for loading Angular. Everything that our application needs is located in two bundles included in two `<script>` tags:

```
<!DOCTYPE html>
<html>
<head>
  <meta charset=UTF-8>
  <title>Basic Webpack Starter</title>
  <base href="/">
</head>
<body>
  <my-app>Loading...</my-app>
  <script src="vendor.bundle.js"></script>
```

```
  <script src="bundle.js"></script>
</body>
</html>
```

You can open the command window in the dist directory and run the familiar live-server from there to see this simple application running. We took the screenshot in figure 10.7 after the application stopped at the breakpoint in main.ts to illustrate source maps in action. Even though the browser executes code from JavaScript bundles, you can still debug the code of the specific TypeScript module thanks to generated source maps.

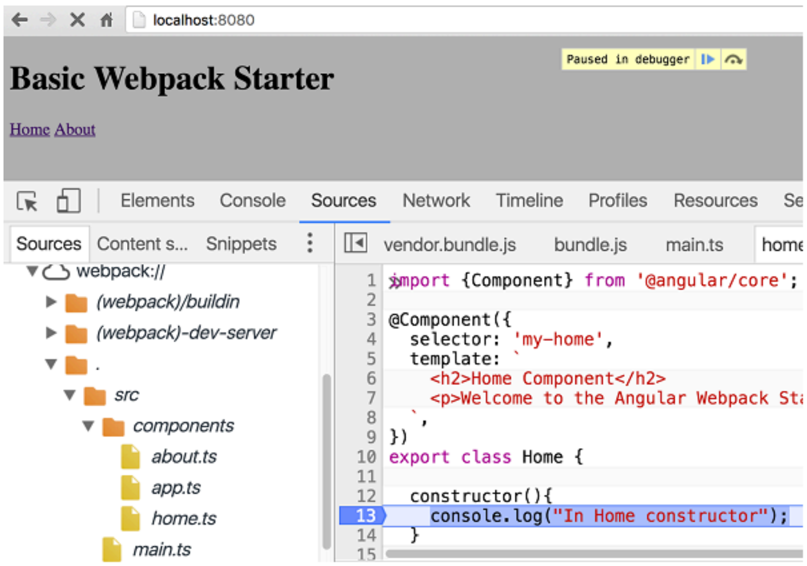


Figure 10.7 Placing a breakpoint in the TypeScript module

NPM START

If instead of `npm run build` you run the `npm start` command, the dist directory won't be created, and webpack-dev-server will do the build (including source map generation) and serve the application from memory. Just open your browser to localhost://8080 and your app will be served. The application weighs 2.7 MB, but we'll do a lot better by the end of this chapter.

The basic Webpack project presented in this section is good for demo purposes, but real-world applications require more advanced work with Webpack, which we'll discuss in the next section.

10.3 Creating development and production configurations

In this section we'll show you two versions of Webpack configuration files (one for development and one for production) that you can use as a starting point in your real-world Angular projects. All the code shown in this section is located in the angular2-webpack-starter directory. The application is the same as in the previous section and consists of two components: Home and About.

This project has more npm scripts in package.json and includes two configuration files: webpack.config.js for the development build and webpack.prod.config.js for production.

DEVELOPMENT CONFIGURATION

Let’s start with the development configuration file, webpack.config.js, which gets some minor additions compared to the file in the previous section. We just added one new plugin, DefinePlugin, that allows you to create variables that are visible from your application code and can be used by Webpack during the build:

```
const path               = require('path');
const CommonsChunkPlugin = require('webpack/lib/optimize/CommonsChunkPlugin');
const CopyWebpackPlugin  = require('copy-webpack-plugin');
const DefinePlugin       = require('webpack/lib/DefinePlugin');   ❶

const ENV  = process.env.NODE_ENV = 'development';   ❷
const HOST = process.env.HOST || 'localhost';
const PORT = process.env.PORT || 8080;

const metadata = {   ❸
  env : ENV,
  host: HOST,
  port: PORT
};

module.exports = {
  debug: true,
  devServer: {
    contentBase: 'src',
    historyApiFallback: true,
    host: metadata.host,   ❹
    port: metadata.port
  },
  devtool: 'source-map',
  entry: {
    'main'  : './src/main.ts',
    'vendor': './src/vendor.ts'
  },
  module: {
    loaders: [
      {test: /\.css$/,  loader: 'raw', exclude: /node_modules/},   ❺
      {test: /\.css$/,  loader: 'style!css?-minimize', exclude: /src/},
      {test: /\.html$/, loader: 'raw'},   ❻
      {test: /\.ts$/,   loader: 'ts'}
    ],
    noParse: [path.join(__dirname, 'node_modules', 'angular2', 'bundles')]
  },
  output: {
    path    : './dist',
    filename: 'bundle.js'
  },
  plugins: [
    new CommonsChunkPlugin({name: 'vendor', filename: 'vendor.bundle.js', minChunks: Infinity}),
    new CopyWebpackPlugin([{from: './src/index.html', to: 'index.html'}]),
    new DefinePlugin({'webpack': {'ENV': JSON.stringify(metadata.env)}})   ❼
  ],
  resolve: { extensions: ['', '.ts', '.js']}
};
```

❶ Loads the DefinePlugin that allows us to define variables.

❷ Node.js uses a NODE_ENV environment variable, which you can set on your server; for example, export NODE_ENV=production on Linux.

❸ The dev server will start on the specified host and port. The metadata constant is visible from index.html as well, so you can define the baseURL property there if your application isn't deployed in the root directory of your web server.

❹ The raw-loader doesn't transform the files but inlines them as strings in the templates. We use it for CSS and HTML files.

❺ Defines the ENV variable to be used in the application code.

The `NODE_ENV` variable is used by Node.js. To access the value of `NODE_ENV` from JavaScript, you use a special `process.env.NODE_ENV` variable. In the preceding config file we set the value of the `ENV` constant to the value of the `NODE_ENV` environment variable if defined, or to `development` if not. The use of the constants `HOST` and `PORT` is similar, and the `metadata` object will store all these values.

The `ENV` variable is used in main.ts to invoke the Angular function `if (webpack.ENV === 'production') enableProdMode();`. When production mode is enabled, Angular's change-detection module doesn't perform an additional pass to ensure that the UI isn't modified in the lifecycle hooks of the components.

NOTE **Default value of `NODE_ENV`**
Even if you don't set the Node environment variable in the command window, it will have a default value of `development`, set in the webpack.config.js file.

PRODUCTION CONFIGURATION

Now let's take a look at the webpack.prod.config.js production configuration file, which uses additional plugins: CompressionPlugin, DedupePlugin, OccurrenceOrderPlugin, and UglifyJsPlugin:

```
const path = require('path');

const CommonsChunkPlugin   = require('webpack/lib/optimize/CommonsChunkPlugin');
const CompressionPlugin    = require('compression-webpack-plugin');
const CopyWebpackPlugin    = require('copy-webpack-plugin');
const DedupePlugin         = require('webpack/lib/optimize/DedupePlugin');
const DefinePlugin         = require('webpack/lib/DefinePlugin');
const OccurrenceOrderPlugin = require('webpack/lib/optimize/OccurrenceOrderPlugin');
const UglifyJsPlugin       = require('webpack/lib/optimize/UglifyJsPlugin');


const ENV = process.env.NODE_ENV = 'production';    ❶
const metadata = {env: ENV};

module.exports = {
```

```
  debug: false,     ❷
  devtool: 'source-map',
  entry: {
    'main'  : './src/main.ts',
    'vendor': './src/vendor.ts'
  },
  metadata: metadata,
  module: {
    loaders: [
      {test: /\.css$/,  loader: 'to-string!css', exclude: /node_modules/},
      {test: /\.css$/,  loader: 'style!css', exclude: /src/},
      {test: /\.html$/, loader: 'html?caseSensitive=true'},     ❸
      {test: /\.ts$/,   loader: 'ts'}
    ],
    noParse: [path.join(__dirname, 'node_modules', 'angular2', 'bundles')]
  },
  output: {
    path    : './dist',
    filename: 'bundle.js'
  },
  plugins: [
    new CommonsChunkPlugin({name: 'vendor', filename: 'vendor.bundle.js', minChunks: Infinity}),
    new CompressionPlugin({regExp: /\.css$|\.html$|\.js$|\.map$/}),     ❹
    new CopyWebpackPlugin([{from: './src/index.html', to: 'index.html'}]),
    new DedupePlugin(),     ❺
    new DefinePlugin({'webpack': {'ENV': JSON.stringify(metadata.env)}}),
    new OccurrenceOrderPlugin(true),     ❻
    new UglifyJsPlugin({     ❼
      compress: {screw_ie8 : true},
      mangle: {screw_ie8 : true}
      }
    })
  ],
  resolve: {extensions: ['', '.ts', '.js']}
};
```

❶ Sets the value of the ENV constant to the value of the NODE_ENV environment variable if defined, or to "production" if not.

❷ Turns off Webpack's debug mode (some loaders print additional information in debug mode). In development mode it was on.

❸ The html-loader turns the HTML file into a string replacing the corresponding require() call.

❹ CompressionPlugin uses the gzip utility to prepare compressed versions of assets that match this regular expression.

❺ DedupePlugin searches for equal or similar files and deduplicates them in the output.

❻ For optimization reasons, Webpack replaces the names of the modules with numeric IDs, and OccurrenceOrderPlugin gives the shortest IDs to the most frequently used modules.

❼ UglifyJsPlugin minifies the JavaScript and uses the mangler tool to rename local variables into single letters.

We'll be starting the build process using the npm script commands included in the package.json file, which has more commands than those we discussed in section 10.2. Note that the `build` command explicitly specifies the webpack.prod.config.js file with the production configuration, and the `start` command will use the development configuration from webpack.config.js, which is a default name used by the Webpack development server:

```
"scripts": {
  "clean": "rimraf dist",  ❶
  "prebuild": "npm run clean && npm run test",  ❷
  "build": "webpack --config webpack.prod.config.js --progress --profile --colors",  ❸
  "start": "webpack-dev-server --inline --progress --port 8080",  ❹
  "preserve:dist": "npm run build",  ❺
  "serve:dist": "static dist -H '{\"Cache-Control\": \"no-cache, must-revalidate\"}' -z",  ❻
  "test": "karma start karma.conf.js"  ❼
}
```

❶ Removes all the content from the dist directory. We use an npm package, rimraf, which is the equivalent of the rm -rf Linux command but works on all platforms.

❷ npm automatically runs the prebuild command (if present) right before the npm run build command; this is the right time to clean the dist directory and run tests.

❸ The npm run build command will run the Webpack build with the specified command-line options and configuration file. In this case we use the file webpack.prod.config.js.

❹ The npm start command will perform the build in memory and will serve the application using webpack-dev-server.

❺ The preserve command runs before serve and will create the build.

❻ The serve:dist command serves the bundled app using the static web server.

❼ This is a command for running tests with Karma.

Typically after running `npm install`, you'll be using the following two commands (we won't be setting the `NODE_ENV` environment variable in the command line):

- `npm start`—Starts the Webpack development server in development mode and serves a non-optimized application. If you open the Developer Tools in the browser, you'll see that the application started in development mode because the variable `ENV` has the value `development`, as set in webpack.config.js.
- `npm run serve:dist`—Runs `npm run build` to create optimized bundles in the dist directory, and starts a static web server and serves the optimized version of the application. If you open the Developer Tools in the browser, you won't see a message saying that the application started in development mode because it runs in production mode; the `ENV` variable has the value `production`, as set in webpack.prod.config.js.

> **NOTE** **Separating dev and prod configurations**
> We keep development and production scripts in separate files, even though it’s possible to reuse the same file by selectively applying certain sections of the configuration based on the value of the environment variable. Some people define two files and reuse the development configuration in the production one (for example, `var devWebpackConfig = require('./webpack.config.js';)`). In our experience, this hurts the readability of the configuration script, so we keep complete build configurations in the separate files.

> **NOTE** **Webpack’s config files are short**
> Our webpack.config.js file has only 50 lines, and webpack.prod.config.js has 55. If we were to use Gulp for preparing a similar build configuration, it would include a couple of hundred lines of code.

A CUSTOM TYPE DEFINITIONS FILE

We need to add a custom type definition file to our app to prevent tsc compiler errors. There are two reasons that that we may get compilation errors in our app:

- Webpack will load and transform all of our CSS and HTML files. During the transformation, Webpack will replace all occurrences like the following ones,

  ```
  styles: ['home.css'],
  template: require('./home.html')
  ```

  with the transformed content:

  ```
  styles: [require('./home.css')],
  template: require('./home.html')
  ```

  This is Webpack’s own `require()` function, not the one from Node.js. If you’ll be running the tsc compiler, the preceding code will result in compilation errors because it doesn’t recognize the `require()` function with such a signature.
- Our app uses the `ENV` constant defined in the Webpack configuration files:

  ```
  if (webpack.ENV === 'production') {
    enableProdMode();
  }
  ```

  To make sure the compiler won’t complain about this variable, we created a custom typings.d.ts type definitions file with the following content:

  ```
  declare function require(path: string);

  declare const webpack: {
    ENV: string
  };
  ```

  Type definitions that start with the `declare` keyword don’t have a direct link to the actual implementations of the variables (such as the `require()` function and the `ENV` constant), and it's our responsibility to update the preceding file if the code changes (for example, if we decide to rename `ENV` as `ENVIRONMENT`).

Figure 10.8 shows the screen shot taken after we ran the command `npm run serve:dist` and opened the app in the browser. Note that this version of the application made just three requests to the server and the total size of the application is 180KB. This application is a little smaller than the Auction, but you can still compare the number of the server requests and the size shown on figure 10.1 to see the difference and appreciate the job done by Webpack.

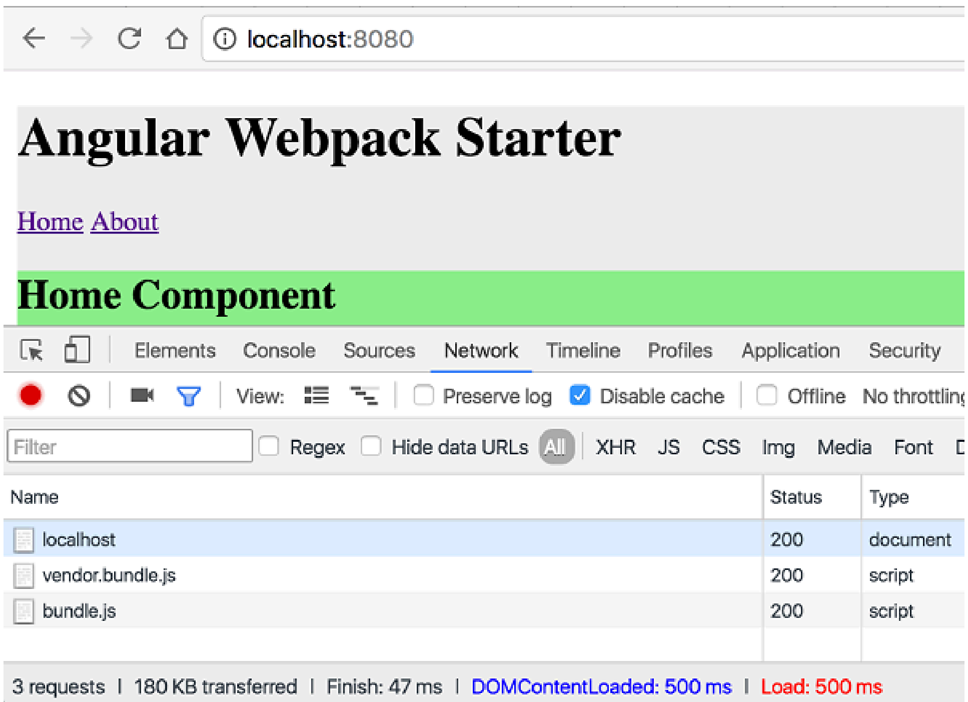


Figure 10.8 After running npm run serve:dist

NOTE	**Splitting the code into modules** If you're building a large application with megabytes worth of JavaScript code, you may want to split your application code into multiple modules (entry points), and turn each of them into a bundle. Say your web application has a user profile module that's not used very often. Removing the code that implements the user profile will lower the initial size of the home page of your app, and the code for the user profile will only be loaded when needed. A popular Instagram web application defines more than a dozen entry points.

SIDEBAR **Establishing continuity**

If you're a project manager, you need to make sure that the main processes of your project are automated. The biggest mistake a project manager can make is to allow John Smith, an expert developer, to manually build and deploy your applications on request. John is a human being, and he can get sick, take a vacation, or even quit one day. Automating the build and deployment processes serves as a guarantee of continuity for the business of software development. The following processes have to be established during the early stages of your project.

- *Continuous integration (CI)*—This is an established process that runs build scripts multiple times a day, such as after each code merge in the source code repository. The build scripts include unit tests, minification, and bundling. You need to install and configure a CI server to guarantee that the master branch of the application code is always in a working condition, and you'll never hear the question, "Who broke the build?"
- *Continuous delivery (CD)*—This is a process that prepares your application for deployment. Continuous delivery is about offering your users additional features and bug fixes.
- *Continuous deployment*—This is the process of actually deploying the new version of an application that was prepared during the continuous delivery phase. Continuous delivery allows you to get frequent feedback from your users, ensuring that your team is working on something that users really need.

Front-end developers often work in collaboration with a team that works on the server side of your application. That team may already have CI and CD processes in place, and you'll need to learn how to integrate your build with whatever tools are used for the server side.

If you still believe that manual deployment isn't a crime, read about what happened to Knight Capital Group, which went bankrupt in 45 minutes because of a human error during deployment. Doug Seven wrote an article, "Knightmare: A DevOps Cautionary Tale," describing this incident (http://mng.bz/1kDr).

The bottom line is that the build and deployment process should be automated and repeatable, and it can't depend on any single technician.

10.4 What's Angular CLI

The entry barrier into the world of Angular development is pretty high. Even to get started with a simple application, you need to know and use the TypeScript language, the TypeScript compiler, ES6 modules, SystemJS, npm, and a development web server. To work on a real-world project, you also need to learn how to test and bundle your app.

To jumpstart the development process, the Angular team is working on a tool called Angular CLI (see https://github.com/angular/angular-cli), which is a command-line tool that covers all the stages of the Angular application lifecycle, from scaffolding and generating an initial app to generating boilerplate for your components, routes, and so on. The generated code also includes preconfigured files for unit tests and bundling with Webpack.

You can install Angular CLI globally by using following command:

```
npm install -g angular-cli@webpack
```

At the time of this writing, Angular CLI is still changing, and adding the suffix `@webpack` is required to install the proper version of this tool. This suffix may not be needed by the time you read this book.

SIDEBAR **Angular CLI and Webpack**

Angular CLI is powered by Webpack. Internally, the CLI-generated project includes Webpack configuration files similar to the ones discussed in this chapter.

Even though CLI uses Webpack internally, it doesn't allow you to modify the Webpack configuration, which may prevent you from implementing specific build requirements (such as a custom bundling strategy) using the CLI. In that case, you can configure your project manually (without CLI) using the knowledge gained in this chapter.

10.4.1 Starting a new project with CLI

After the CLI is installed, the executable binary `ng` becomes available on your PATH. You'll use the `ng` command to invoke Angular CLI commands.

To create the initial application boilerplate, use the `new` command:

```
ng new basic-cli
```

CLI will generate a new directory called basic-cli, which will include all the files required for a simple app that renders the message "app works!" CLI automatically installs all the required dependencies and creates a local git repository in the folder. Figure 10.12 shows what the generated project structure looks like.

Figure 10.9 CLI project structure

Let’s take a quick look at the main project files and directories:

- *e2e*—The directory for end-to-end tests.
- *src/app*—The main directory for the application code. For routes and child components we usually create subdirectories here, but the CLI doesn’t mandate this.
- *src/app/shared*—Components and services shared among several components are put here. This is a just convention, not a strict CLI requirement.
- *src/assets*—Everything in this folder will be copied as-is in the dist during the build process.
- *src/environments*—Here you specify environment-specific settings. You can create an arbitrary number of custom environments, such as QA, staging, and production.
- *angular-cli.json*—The main Angular CLI configuration file. Here you can customize the locations for files and directories that CLI relies on.

10.4.2 CLI commands

CLI provides a few commands that you can use to manage an Angular application. Table 10.1 the most commonly used commands that come in handy while developing and preparing a production version of an application.

Table 10.1 Frequently used CLI commands

Command	Description
`ng serve`	Starts the included dev web server with live-reload capabilities. Optionally specify the `-prod` flag to serve your app bundled and highly optimized.
`ng generate`	This command is used for generating various artifacts for your project. To list all the available options, invoke `ng help generate`. Here are some examples: • `ng generate component <component-name>`—Generates four files for the component: a TypeScript file for the source code, a TypeScript file for the component unit tests, an HTML file for the template, and the CSS file for styling the component's view. • `ng generate service <service-name>`—Generates two TypeScript files: one for the source code and another one for the unit tests.
`ng test`	Runs unit tests using the Karma test runner.
`ng build`	Produces JavaScript bundles with the transpiled application code and all the dependencies inlined. Saves the bundles in the dist directory. Optionally, you can specify `-prod` to build a highly optimized ready-to-deploy production version of your app.

The assets generated by the `ng build -prod` command can be deployed in the production environment. Figure 10.10 shows a bundled app running. With the minimum effort, you'll get a decent result out of the box—the total size of the payload is 222 KB, and all the application code and dependencies are bundled in the minimized JavaScript files:

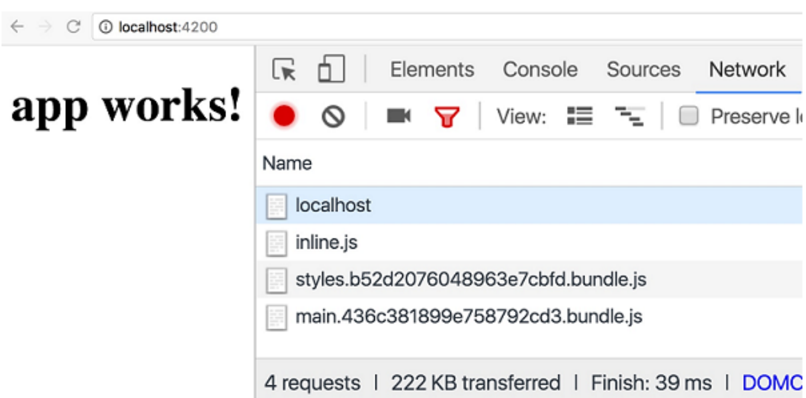


Figure 10.10 Hosted production build

NOTE	In one of the upcoming releases, `angular-cli` will be able to generate a separate bundle for each lazy-loaded route.

This concludes our brief overview of Angular CLI. You can find a detailed description of all its commands on GitHub at http://mng.bz/ILbW.

10.5 Hands-on: Deploying the online auction with Webpack

In this exercise you won't be developing any new application code. The goal is to use Webpack to build and deploy an optimized version of the online auction. You'll also integrate the Karma test runner into the build process.

For this chapter we refactored the auction project from chapter 8, which used the same package.json file between the client and server portions of the application. Now the client and server will be separate applications with their own package.json files. Keeping the client and the server code separate simplifies build automation.

SIDEBAR **Angular and security**

Angular has built-in protection against common web application vulnerabilities and attacks. In particular, to prevent cross-site scripting attacks, it blocks malicious code from entering the DOM. With images, an attacker can replace the image with malicious code in the `src` attribute of an `<img>` tag.

Our auction application uses images from the http://placehold.it website, which will be blocked during bundling unless we specifically write that we trust this site. In this chapter's auction, we added code stating that we trust the images from http://placehold.it, and that they don't need to be blocked.

That's why we added the code to prevent image sanitizing in the auction components that use images coming from a third-party server. For example, a constructor for `ProductItemComponent` looks like this:

```
constructor(private sanitizer: DomSanitizer) {
  this.imgHtml = sanitizer.bypassSecurityTrustHtml(`
    <img src="http://placehold.it/320x150">`);
}
```

You can find more details about Angular security in the security section of the Angular documentation at http://mng.bz/pk57.

The package.json file from the client directory will have the npm scripts required to build the production bundle as well as run webpack-dev-server in development mode. The server directory has its own package.json with npm scripts to start the auction's Node server—no bundling is needed there. Technically we have two independent applications with their own dependencies configured separately.

We'll start this hands-on project using the source code located in the auction directory from chapter 10.

STARTING THE NODE SERVER

The server's package.json file looks like this:

```
{
  "name": "ng2-webpack-starter",
  "description": "Angular 2 Webpack starter project suitable for a production grade application",
```

```
  "homepage": "https://www.manning.com/books/angular-2-development-with-typescript",
  "private": true,
  "scripts": {
    "tsc": "tsc",
    "startServer": "node build/auction.js",
    "dev": "nodemon build/auction.js"
  },
  "dependencies": {
    "express": "^4.13.3",
    "ws": "^1.0.1"
  },
  "devDependencies": {
    "@types/compression": "0.0.29",
    "@types/es6-shim": "0.0.27-alpha",
    "@types/express": "^4.0.28-alpha",
    "@types/ws": "0.0.26-alpha",
    "compression": "^1.6.1",
    "nodemon": "^1.8.1",
    "typescript": "^2.0.0"
  }
}
```

Note that we defined the `tsc` script here to ensure that the local version of TypeScript 2.0 will be used even if you have an older version of the compiler installed globally.

In the command line, change to the server directory and run `npm install` to get all the required dependencies for the server's portion of the application.

To use the local compiler, run the command `npm run tsc`, which will transpile the server's code and create auction.js and model.js (and their source maps) in the build directory, as configured in tsconfig.json. This is the code for the auction's server.

Start the server by running the command `npm run startServer`. It'll print the message "Listening on 127.0.0.1:8000" on the console.

STARTING THE AUCTION CLIENT

You can start the auction client either in development or production mode using different npm script commands. The npm scripts section of the client's package.json has the following commands:

```
"scripts": {
  "clean": "rimraf dist",
  "prebuild": "npm run clean && npm run test",
  "build": "webpack --config webpack.prod.config.js --progress --profile",
  "startWebpackDevServer": "webpack-dev-server --inline --progress --port 8080",
  "test": "karma start karma.conf.js",
  "predeploy": "npm run build && rimraf ../server/build/public && mkdirp ../server/build/public",
  "deploy": "copyup dist/* ../server/build/public"
}
```

Most of the commands should look familiar to you, as we used them in webpack.prod.config.js in section 10.3. We've added a new `deploy` command, which uses the `copyup` command to copy files from the client's dist directory to the server's build/public directory. Here we use the `copyup` command from the copyfiles npm package (https://www.npmjs.com/package/copyfiles). We use this package for cross-platform compatibility when it comes to copying files. We also added the `test` command to run tests with Karma (see section 10.56).

Because there's a `predeploy` command, it'll run automatically each time we run `npm run deploy`. In turn, the `predeploy` will run the `build` command, which will automatically run `prebuild`. The latter will run `clean` and `test`, and only after all these commands succeed will the `build` command do the build. Finally, the `copyup` command will copy the bundles from the dist directory into the server/build/public directory.

Before starting the client portion of the auction, you need to open a separate command window, change to the client directory, and run the command `npm install`.

Then start the auction app in development mode by running `npm run startWebpackDevServer`. The webpack-dev-server will bundle your Angular app and will start listening for the browser's requests on port 8080. Enter http://localhost:8080 in your browser, and you'll see the familiar UI of the auction app.

NOTE	**Bundling is done in memory** The development build is done in memory, and the auction application is available on port 8080, which is the port configured in the webpack.config.js file.

Open the Network tab in Chrome Developer Tools. You'll see the application load the freshly built bundles, and the size of the application is pretty large.

Check Webpack's log on the console, and you'll see which files went to which bundle (or *chunk*). In our case we built two chunks: bundle.js and vendor.js. Figure 10.11 shows a small fragment of the Webpack log, but you can see see the size of each file. Our bundled application (bundle.js) weighs 285 KB, whereas the vendor code (vendor.bundle.js) is 3.81 MB.

```
Version: webpack 2.1.0-beta.21
Time: 25082ms
                                   Asset       Size  Chunks             Chunk Names
  f4769f9bdb7466be65088239c12046d1.eot    20.1 kB          [emitted]
 fa2772327f55d8198301fdb8bcfc8158.woff    23.4 kB          [emitted]
448c34a56d699c29117adc64c43affeb.woff2      18 kB          [emitted]
  e18bbf611f2a2e43afc071aa2f4e1512.ttf    45.4 kB          [emitted]
  89889688147bd7575d6327160d64e760.svg     109 kB          [emitted]
                             bundle.js     285 kB       0  [emitted]  main
                      vendor.bundle.js    3.81 MB       1  [emitted]  vendor
                         bundle.js.map     275 kB       0  [emitted]  main
                  vendor.bundle.js.map    4.05 MB       1  [emitted]  vendor
                            index.html  315 bytes          [emitted]
```

Figure 10.11 The console output fragment

On the top, you'll see some font files that weren't bundled, because in the webpack.config.js file we specified the `limit` parameters to avoid inlining large fonts into the bundle.

```
{test: /\.woff$/,  loader: "url?limit=10000&minetype=application/font-woff"},
{test: /\.woff2$/, loader: "url?limit=10000&minetype=application/font-woff"},
{test: /\.ttf$/,   loader: "url?limit=10000&minetype=application/octet-stream"},
{test: /\.svg$/,   loader: "url?limit=10000&minetype=image/svg+xml"},
{test: /\.eot$/,   loader: "file"}
```

The last line instructs the file-loader to copy the fonts with the .eot extension into the build directory. If you scroll the console output, you'll see that all the application code went to chunk `{0}`, and the vendor-related code went to chunk `{1}`.

IMPORTANT **Dev mode and server deployment**
In development mode we didn't deploy the Angular app under the Node server. The Node server was running on port 8000, and the auction client was served on port 8080 and was communicating with the Node server using the HTTP and WebSocket protocols. We'll deploy the Angular app under our Node server next.

Now stop the webpack-dev-server (not the Node server) by pressing Ctrl-C in the command window that you started the client from. Start the *production build* by running the command `npm run deploy`. This command will prepare the optimized build and will copy its files into the ../server/build/public directory, which is where all the static content of the Node server belongs.

There's no need to restart the Node server because we only deployed the static code there. But to see the production version of the auction, you need to use port 8000, where the Node server runs.

Open your browser to the URL http://localhost:8000. You'll see the auction application served by the Node server. Open the Chrome Developer Tools panel in the Network tab and refresh the application. You'll see that the size of the optimized application is drastically smaller. Figure 10.12 shows that the total size of the application is 349 KB (compared with 5.5 MB in the unbundled version shown earlier in figure 10.1).

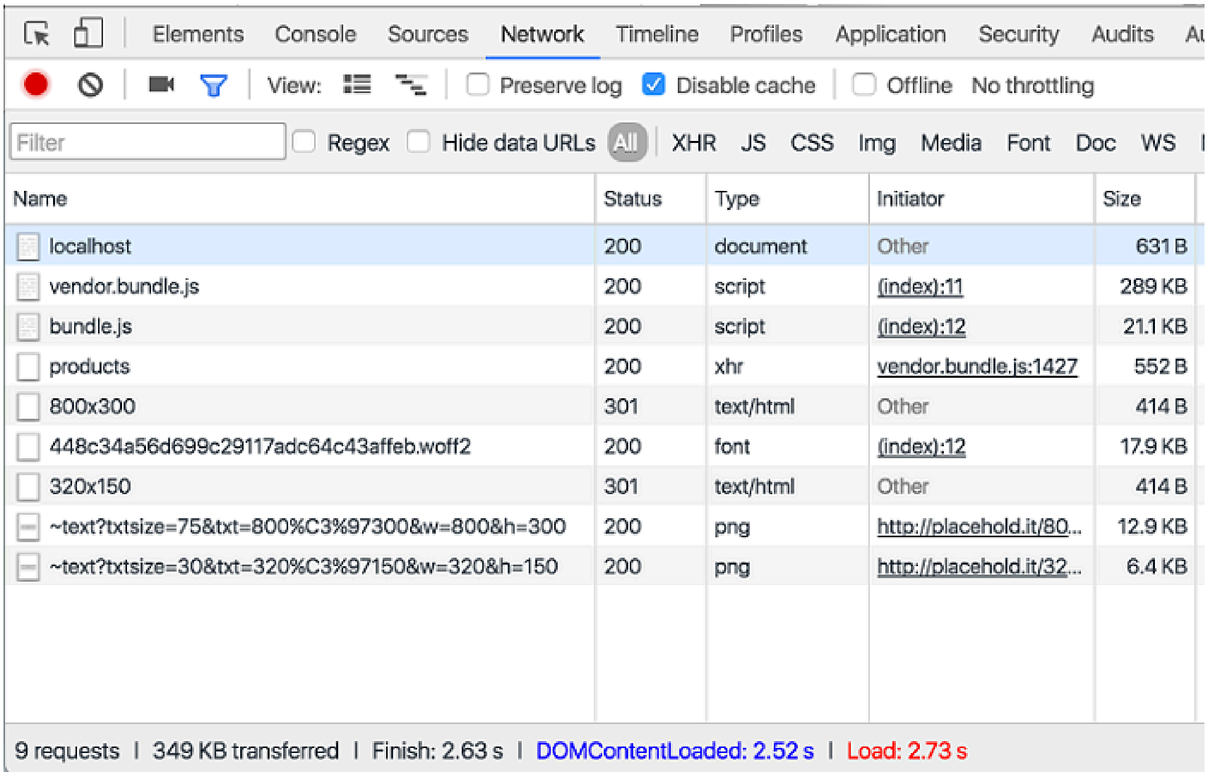


Figure 10.12 What's loaded in the prod version of the auction

The browser made nine requests to the server to load index.html, two bundles, and those gray images that represent products. You can also see the request for data about products that the client made using Angular's `Http` request. The line that ends with `.woff2` is the font loaded by Twitter's Bootstrap framework.

The url-loader works like file-loader, but it can inline files smaller than the specified limit into the CSS where they are defined. We specified 10,000 bytes as a limit for the files with names ending with .woff, .woff2, .ttf, and .svg. One larger file (17.9 KB) wasn't inlined.

Each font is represented in multiple formats, such as .eot, .woff, .woff2, .ttf, .svg, and there are several non-exclusive options for dealing with fonts:

- Inline all of them into the bundle, and let the browser choose which one it wants to use.
- Inline the font format supported by the oldest browser you want your app to support. This means newer browsers will download files two to three times larger than they need to.
- Inline none of them, and let the browser choose and download the one it supports best.

Our strategy was to inline only the selected fonts that meet certain criteria, and to simply copy the others into the build folder, which can be considered a combination of options 1 and 3.

RUNNING TESTS WITH KARMA

In chapter 9 we developed three specs for unit testing `ApplicationComponent`, `StarsComponent`, and `ProductService`. We'll reuse the same specs here, but we'll run them with Karma as a part of the building process.

Because the client and server are separate npm projects now, the karma configuration files karma.conf.js and karma-test-runner.js are located in the client directory.

```
module.exports = function (config) {
  config.set({
    browsers     : ['Chrome', 'Firefox'],
    frameworks   : ['jasmine'],
    reporters    : ['mocha'],        ❶
    singleRun    : true,
    preprocessors: {'./karma-test-runner.js': ['webpack']},        ❷
    files        : [{pattern: './karma-test-runner.js', watched: false}],        ❷
    webpack      : require('./webpack.test.config.js'),        ❸
    webpackServer: {noInfo: true}        ❹
  });
};
```

❶ In chapter 9 we used dots for reporting progress, but here we use the more descriptive mocha reporter that prints messages from specs rather than dots (see figure).

❷ Specifies when the script to run Karma tests should be preprocessed by the karma-webpack plugin.

❸ Loads the test specs included in the karma-test-runner.js file.

❹ Specifies the Webpack config file that Karma should use.

❺ Turns off Webpack logging so its messages won't clutter Karma's output.

The karma.conf.js file is a lot shorter than the one from chapter 9, because we don't need to configure files for SystemJS anymore—Webpack is the loader now, and the files are already configured in webpack.test.config.js.

This is the karma-test-runner.js script for running Karma:

```
Error.stackTraceLimit = Infinity;

require('reflect-metadata/Reflect.js');
require('zone.js/dist/zone.js');
require('zone.js/dist/long-stack-trace-zone.js');
require('zone.js/dist/proxy.js');
require('zone.js/dist/sync-test.js');
require('zone.js/dist/jasmine-patch.js');
require('zone.js/dist/async-test.js');
require('zone.js/dist/fake-async-test.js');

var testing = require('@angular/core/testing');
var browser = require('@angular/platform-browser-dynamic/testing');
```

```
testing.TestBed.initTestEnvironment(
    browser.BrowserDynamicTestingModule,
    browser.platformBrowserDynamicTesting());

Object.assign(global, testing);


var testContext = require.context('./src', true, /\.spec\.ts/);

function requireAll(requireContext) {
  return requireContext.keys().map(requireContext);
}

var modules = requireAll(testContext);
```

The webpack.test.config.js file is shown next. It's simplified for testing as we don't need to create bundles during testing. The Webpack dev server isn't needed because Karma acts as a server.

```
const path         = require('path');
const DefinePlugin = require('webpack/lib/DefinePlugin');

const ENV  = process.env.NODE_ENV = 'development';
const HOST = process.env.HOST || 'localhost';
const PORT = process.env.PORT || 8080;

const metadata = {
  env : ENV,
  host: HOST,
  port: PORT
};

module.exports = {
  debug: true,
  devtool: 'source-map',
  module: {
    loaders: [
      {test: /\.css$/,  loader: 'raw', exclude: /node_modules/},
      {test: /\.css$/,  loader: 'style!css?-minimize', exclude: /src/},
      {test: /\.html$/, loader: 'raw'},
      {test: /\.ts$/,   loaders: [
        {loader: 'ts', query: {compilerOptions: {noEmit: false}}},
        {loader: 'angular2-template'}
      ]}
    ]
  },
  plugins: [
    new DefinePlugin({'webpack': {'ENV': JSON.stringify(metadata.env)}})
  ],
  resolve: {
    extensions: ['', '.ts', '.js']
  }
};
```

The client/package.json file has the following Karma-related content:

```
"scripts": {
...
"test": "karma start karma.conf.js"
}
...
"devDependencies": {
...
```

```
    "karma": "^1.2.0",
    "karma-chrome-launcher": "^2.0.0",
    "karma-firefox-launcher": "^1.0.0",
    "karma-jasmine": "^1.0.2",
    "karma-mocha-reporter": "^2.1.0",
    "karma-webpack": "^1.8.0",
}
```

To run the tests manually, just run the `npm test` command in the command window from the client directory. You'll see output like that shown in figure 10.13.

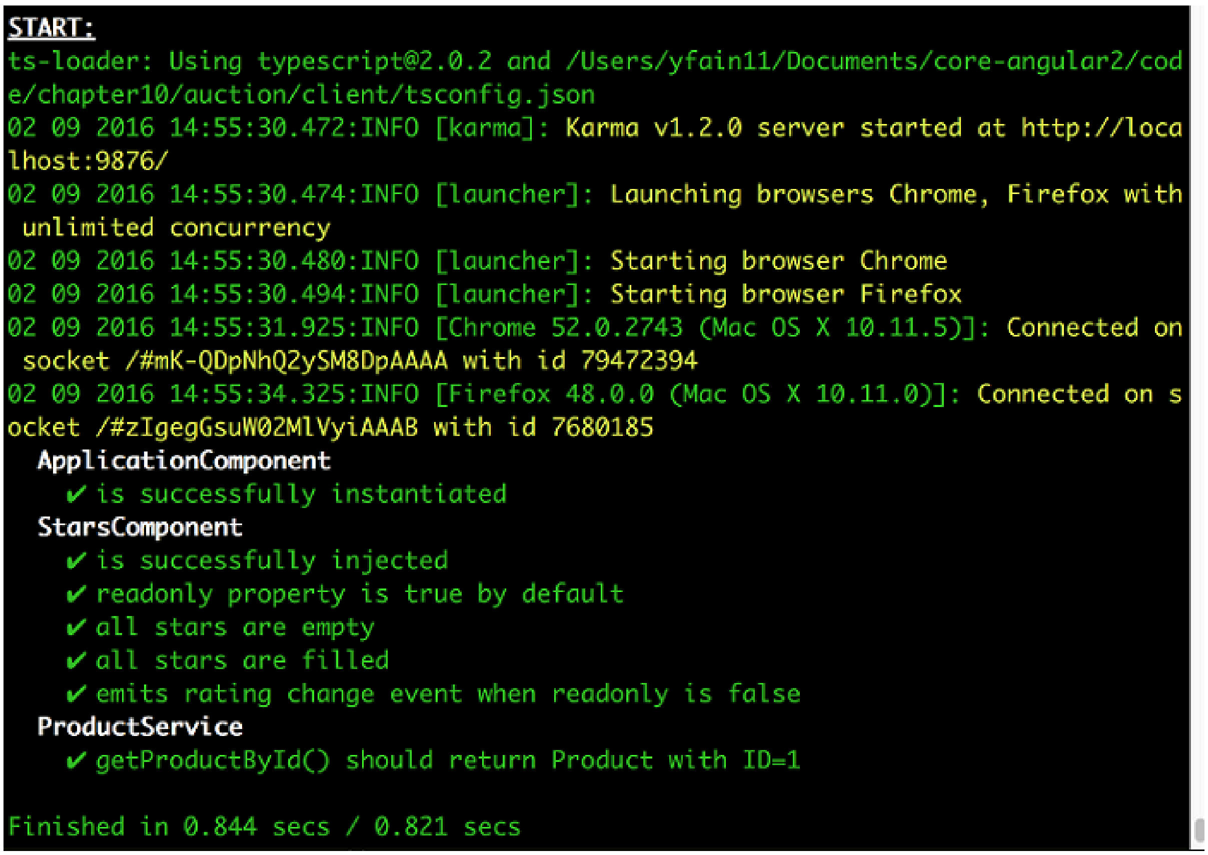


Figure 10.13 Running Karma

To integrate the Karma run into the build process, you can modify the npm `prebuild` command to look like this:

```
"prebuild": "npm run clean && npm run test"
"build": "webpack ...",
```

Now if you run the command `npm run build`, it'll run the `prebuild`, which will clean the output directory, run the tests, and then do the build. If any of the tests fail, the `build` command won't run.

We're done with the final hands-on project for this book. If this was a real-world application, we'd continue fine-tuning our build configuration, cherry-picking the files that we want to include or exclude from the build. Webpack is a very sophisticated tool, and it offers endless possibilities for optimizing the bundles.

The Angular team is working on an optimization of the Angular code using the ahead-of-time compilation, and we wouldn't be surprised if the Angular framework will add only 50 KB to your application's code.

10.6 Summary

This chapter wasn't about writing code. Our goal was to optimize and bundle code for deployment. The JavaScript community has a few popular tools for build automation and bundling of web applications. Our choice is the combination of Webpack and npm scripts.

Webpack is a very intelligent and sophisticated tool, but we presented a small combination of loaders and plugins that work for us. We published the n2-webpack-starter project from this chapter on GitHub (http://mng.bz/2toG) and you're welcome to contribute to this project. If you're looking for a more complete Webpack configuration, try angular2-webpack-starter (http://mng.bz/fS4T).

These are the main takeaways from this chapter:

- The process of preparing deployment bundles and running builds should be automated in the early phases of development.
- To minimize the number of requests that the browser makes for loading your application, combine the code into a small number of bundles for deployment.
- Avoid packaging the same code into more than one bundle. Keep third-party frameworks in a separate bundle so other bundles of your application can share them.
- Always generate source maps, as they allow you to debug the source code in TypeScript. Source maps don't increase the size of the application code and are generated only if your browser has the developer tools open, so using source maps even for production builds is encouraged.
- For running build and deployment tasks, use npm scripts because they're simple to write and you already have npm installed. If you're working on preparing a build for a large and complex project, and you feel the need for a scripting language to describe various build scenarios, introduce Gulp into your project workflow.
- To quickly start your development in Angular and TypeScript, generate your first projects with Angular CLI.

A An overview of ECMAScript 6

This appendix covers

- How ES6 and JavaScript are related
- The role of transpilers
- Overview of the new syntax of ES6
- How to split code into modules

ECMAScript is a standard for client-side scripting languages. The first edition of the ECMAScript specification was released in 1997, and the sixth edition was finalized in 2015. The seventh edition is already in the works. The ECMAScript standard is implemented in several languages, and the most popular implementation is JavaScript. In this appendix we'll look at the JavaScript implementation of ECMAScript 6 (ES6), also known as ECMAScript 2015.

At the time of writing, not all web browsers fully support the ES6 specification; you can visit the ECMAScript compatibility site at http://mng.bz/ao59 to see the current state of ES6 support. The good news is that you can and should develop in ES6 today, and use transpilers like Traceur (https://github.com/google/traceur-compiler) or Babel (https://babeljs.io) to turn the ES6 code into an ES5 version supported by all web browsers.

> **NOTE** **Testing ES6 code in the latest browsers**
> If you'd like to test your ES6 code in upcoming versions of popular web browsers, download the latest nightly build of Firefox at https://nightly.mozilla.org or use the remote version of Internet Explorer at https://remote.modern.ie. You can also get the Canary build of Chrome at http://mng.bz/9rub. You may need to enable experimental JavaScript features by visiting the URL chrome://flags (for Chrome) or about://flags (for IE).

We assume you're familiar with the ES5 syntax and APIs, and we'll cover only selected new features introduced in ES6. If your JavaScript skills are a little rusty, read the online appendix from *Enterprise Web Development* by Yakov Fain et al. (O'Reilly, 2014), which is available on GitHub at http://mng.bz/EIlI. To find out what's coming in future versions of ECMAScript, check out the proposals for the Harmony project at http://mng.bz/5r7B. Harmony is an umbrella name for all new features being considered for ECMAScript.

In this appendix we'll often show code snippets in ES5 and their ES6 equivalents, but ES6 doesn't deprecate any old syntax, so you'll be able to safely run the legacy ES5 or ES3 code in future web browsers or standalone JavaScript engines.

A.1 How to run code samples

The code samples for this appendix come in the form of simple HTML files that include scripts in ES6, so you can run and debug them in your browser's developer tools if your browser fully supports ES6. What if it doesn't? There are several options:

- Use the ES6 Fiddle website (http://www.es6fiddle.net), which allows you to copy and paste a fragment of ES6 code into the field on the left, press the play button, and see the console output on the right, as shown in figure A.1:

Figure A.1 Using ES6 Fiddle

- Use the Traceur or Babel transpilers, which convert code from ES6 to ES5. Interactive tools that allow you to quickly run code fragments are called REPLs (Read-Eval-Print-Loop). You can use REPLs from Traceur (http://mng.bz/bI91) or Babel (http://babeljs.io/repl). The screenshot in figure A.2 shows Babel's REPL. On the left side you can see the code written in ES6; the right side has the generated ES5 equivalent. The console output produced by the code sample (if any) is shown at the bottom right.

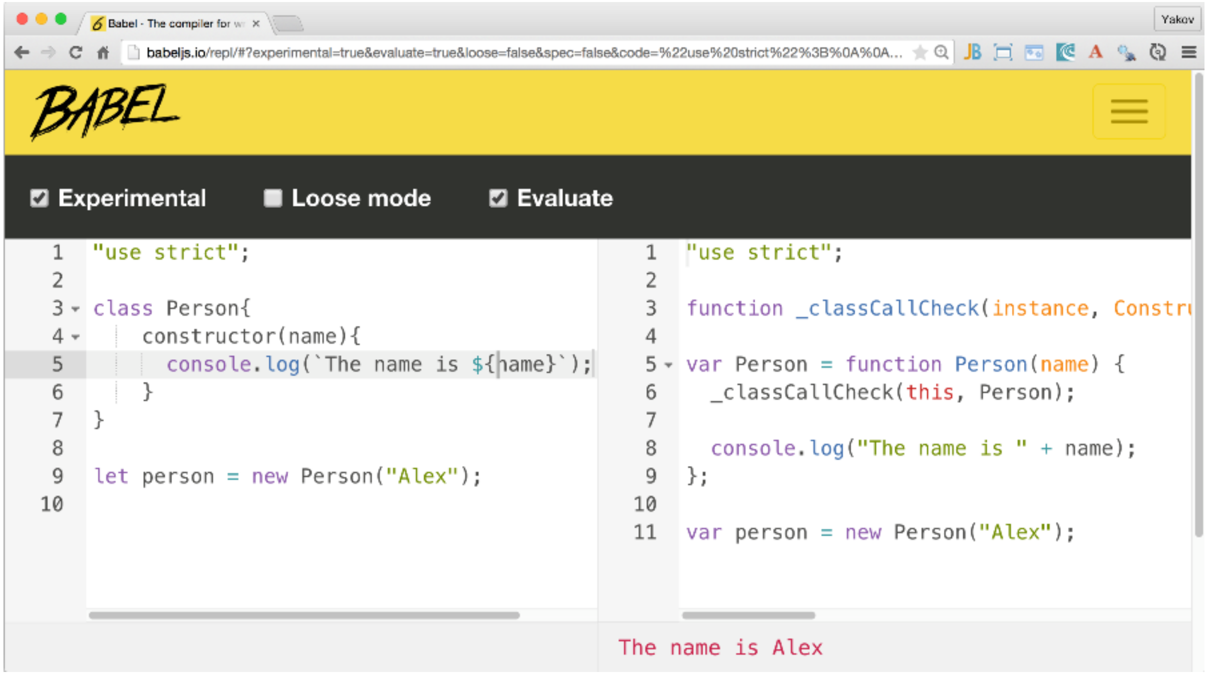


Figure A.2 Using the Babel REPL

A.2 Template literals

ES6 introduces a new syntax for working with string literals, which can contain embedded expressions. This feature is known as *string interpolation*.

In ES5 you'd use concatenation to create a string that contains string literals mixed in with the values of variables:

```
var customerName = "John Smith";
console.log("Hello" + customerName);
```

In ES6, template literals are surrounded with back-tick symbols, and you can embed expressions right inside the literal by placing them between curly braces prefixed with a dollar sign. In the next code snippet, the value of the variable `customerName` is embedded in the string literal:

```
var customerName = "John Smith";
console.log(`Hello ${customerName}`);

function getCustomer(){
  return "Allan Lou";
}
console.log(`Hello ${getCustomer()}`);
```

The output of this code is

```
Hello John Smith
Hello Allan Lou
```

In the preceding example we embedded the value of the variable `customerName` into the template literal and then embedded the value returned by the `getCustomer()` function. You can use any valid JavaScript expression between the curly braces.

A.2.1 Multiline strings

Strings can span multiple lines in your code. Using back-ticks you can write multiline strings without the need to concatenate them or use the backslash character:

```
var message = `Please enter a password that
               has at least 8 characters and
               includes a capital letter`;

console.log(message);
```

The resulting string will treat all spaces as part of the string, so the output will look like this:

```
Please enter a password that
               has at least 8 characters and
               includes a capital letter
```

A.2.2 Tagged template strings

If a template string is preceded with a function name, the string is evaluated first and then passed to the function for further processing. The string parts of a template are given as an array, and all the expressions that were evaluated in the template are passed as separate arguments. The syntax looks a little unusual, because you don't use parentheses as in regular function calls:

```
mytag`Hello ${name}`;
```

Let's see how it works by printing an amount with a currency sign that depends on the `region` variable. If the value of the `region` is 1, we keep the amount unchanged and prepend it with a dollar sign. If the value of the `region` is 2, we need to convert the amount, applying 0.9 as an exchange rate, and prepend it with a euro sign. Our template string will look like this:

```
`You've earned ${region} ${amount}!`
```

Let's call the tag function `currencyAdjustment`. The tagged template string will look like this:

```
currencyAdjustment`You've earned ${region} ${amount}!`
```

Our `currencyAdjustment` function will take three arguments: the first will represent all string parts from our template string, the second will get the region, and the third is for the amount. You can add any number of arguments after the first one. The complete example follows.

```
function currencyAdjustment(stringParts, region, amount) {
    console.log( stringParts);
    console.log( region );
    console.log( amount );

  var sign;
  if (region==1){
    sign="$"
  } else{
    sign='\u20AC';      // the euro sign
    amount=0.9*amount;  // convert to euros using 0.9 as exchange rate
  }
  return `${stringParts[0]}${sign}${amount}${stringParts[2]}`;
}

var amount = 100;
var region = 2;  // Europe: 2, USA: 1

var message = currencyAdjustment`You've earned ${region} ${amount}!`
console.log(message);
```

The `currencyAdjustment` function will get a string with embedded `region` and `amount`, and it will parse the template, separating the string parts from these values (blank spaces are also considered string parts). We'll print these values first for illustration. Then this function will check the region, apply the conversion, and return a new string template. Running the preceding code will produce the following output:

```
["You've earned "," ","!"]
2
100
You've earned €90!
```

For more details on tagged templates, refer to the "Template Literals" chapter in *Exploring ES6* by Axel Rauschmayer, available at http://exploringjs.com.

A.3 Optional parameters and default values

In ES6 you can specify default values for function parameters (arguments) that will be used if no value is provided during function invocation. Say you're writing a function to calculate tax that takes two arguments: the annual income and the state where the person lives. If the state value isn't provided, we want to use Florida.

In ES5 we'd need to start the function body by checking if the state value was provided, otherwise we'd use Florida:

```
function calcTaxES5(income, state){
```

```
    state = state || "Florida";

    console.log("ES5. Calculating tax for the resident of " + state +
                                      " with the income " + income);
}

calcTaxES5(50000);
```

Here’s what this code prints:

```
"ES5. Calculating tax for the resident of Florida with the income 50000"
```

In ES6 you can specify the default value right in the function signature:

```
function calcTaxES6(income, state = "Florida") {

  console.log("ES6. Calculating tax for the resident of " + state +
                                  " with the income " + income);
}

calcTaxES6(50000);
```

The output looks similar:

```
"ES6. Calculating tax for the resident of Florida with the income 50000"
```

Rather than providing a hard-coded value for an optional parameter, you can even invoke a function that returns one:

```
function calcTaxES6(income, state = getDefaultState()) {
  console.log("ES6. Calculating tax for the resident of " + state + " with the income " + income);
}

function getDefaultState(){
  return "Florida";
}
```

Just keep in mind that the `getDefaultState()` function will be invoked each time you invoke `calcTaxES6()`, which may have performance consequences.

This new syntax for optional parameters allows you to write less code and makes the code easier to understand.

A.4 Scope of variables

The scoping mechanism in ES5 is rather confusing. Regardless of where you declare a variable with the keyword `var`, the declaration is moved to the top of the scope. This is called *hoisting*. The use of the keyword `this` is also not as straightforward as in languages like Java or C#.

ES6 eliminates this hoisting confusion (discussed in the next section) by introducing the keyword `let`, and the `this` confusion is cured by using arrow functions. Let's look closer at the hoisting and `this` problems.

A.4.1 Variable hoisting

In JavaScript, all variable declarations are moved to the top and there's no block scope. Look at the following simple example where we declare the variable `i` inside the `for` loop but use it outside as well.

```
function foo(){

   for(var i=0;i<10;i++){

   }

  console.log("i=" + i);
}

foo();
```

Running this code will print `i=10`. The variable `i` is still available outside the loop, even though it seems like it was meant to be used only inside. JavaScript automatically hoists the variable declaration to the top.

In the preceding example hoisting didn't cause any harm, because there was only one variable named `i`. If two variables with the same name are declared inside and outside the function, however, this may result in confusing behavior. Consider the following example, which declares the variable `customer` on the global scope. A bit later we'll introduce another `customer` variable in the local scope, but for now it's commented out.

```
<!DOCTYPE html>
<html>
<head>
    <title>hoisting.html</title>
</head>
<body>

<script>
    "use strict";

    var customer = "Joe";

    (function (){
        console.log("The name of the customer inside the function is "  + customer);

       /*  if (2 > 1) {
             var customer = "Mary";
         }*/

    })();

    console.log("The name of the customer outside the function is "  + customer);
</script>

</body>
</html>
```

Open this file in the Chrome browser and look at the console output in Chrome Developer Tools. As expected, the global variable `customer` is visible inside and outside the function, as shown in figure A.3.

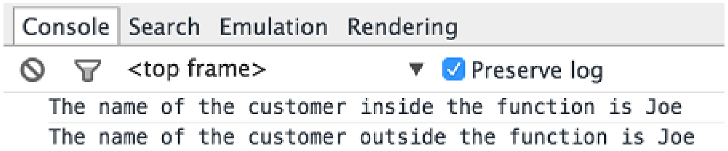


Figure A.3 Declaration is hoisted

Now uncomment the `if` statement that declares and initializes the `customer` variable inside the curly braces. Now we have two variables with the same name—one on the global scope and another on the function scope. Refresh the page in the web browser. The console output is different now—the function's `customer` variable has the value `undefined`, as seen in figure A.4.

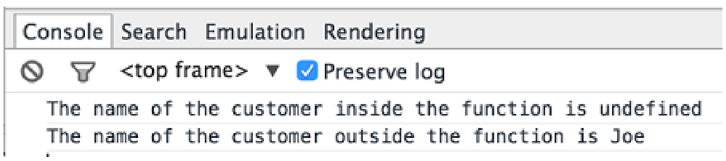


Figure A.4 Variable initialization is not hoisted

The reason for this behavior is that in ES5 the variable declarations are hoisted to the top of the scope, but the variable initializations aren't. So the declaration of the second uninitialized `customer` variable was hoisted to the top of the function, and `console.log()` printed the value defined inside the function, which has shadowed the value of the global variable `customer`.

Function declarations are hoisted too, so you can invoke a function before it's declared:

```
doSomething();

function doSomething(){
   console.log("I'm doing something");
}
```

On the other hand, function expressions are considered variable initializations, so they aren't hoisted. The following code snippet will produce `undefined` for the `doSomething` variable:

```
doSomething();
```

```
var doSomething = function(){
   console.log("I'm doing something");
}
```

Let's see what ES6 changes in terms of scoping.

A.4.2 Block scoping with let and const

Declaring variables with the ES6 keyword `let` instead of `var` allows variables to have block scoping. Here's an example:

```
<!DOCTYPE html>
<html>
<head>
    <title>let.html</title>
</head>
<body>


<script>
    "use strict";

    let customer = "Joe";

    (function (){
        console.log("The name of the customer inside the function is "  + customer);

        if (2 > 1) {
         let customer = "Mary";
         console.log("The name of the customer inside the block is "  + customer);
        }

    })();

    for (let i=0; i<5; i++){
        console.log("i=" + i);
    }

    console.log("i=" + i);   // prints Uncaught ReferenceError: i is not defined

</script>

</body>
</html>
```

Now two `customer` variables have different scopes and values, as shown in figure A.5.

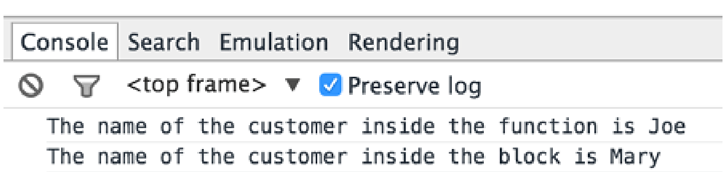


Figure A.5 Block scoping with let

SIDEBAR **Testing the `let` keyword in the Traceur REPL**

To get an idea what the transpiled code might look like, visit Traceur's Transcoding Demo web page (http://mng.bz/bI91), which allows you to enter ES6 syntax and convert (transcode) it into ES5 in interactive mode. Paste the preceding code sample into the left text box and you'll see its ES5 version on the right side, as shown in figure A.6.

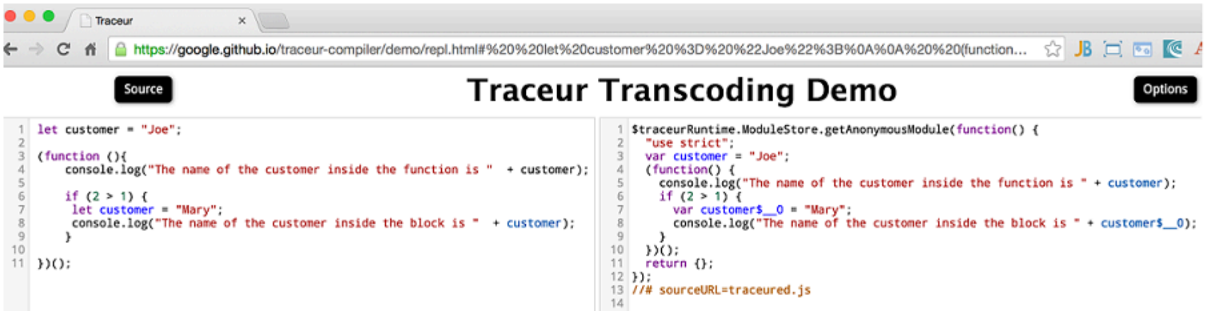


Figure A.6 Transpiling ES6 to ES5 with the Traceur REPL

SIDEBAR As you see, Traceur introduced a separate `customer$_0` variable to distinguish it from the `customer` variable.

Open the web console in your browser while working with the Traceur REPL, and you'll see the results of your code execution immediately.

If you declare a variable with `let` in a loop, it'll be available only inside the loop:

```
for (let i=0; i<5; i++){
  console.log("i=" + i);
}

console.log("i=" + i);   // ReferenceError: i is not defined
```

To put it simply, if you're developing a new application, don't use `var`. Use `let` instead. The `let` keyword allows you to assign and reassign a value to a variable as many times as you want.

If you want to declare a variable that can't change its value after it's assigned, declare it with the keyword `const`. Constants also support block scope.

NOTE **`let` vs. `const`**

The only difference between `let` and `const` is that the latter won't allow the assigned value to be changed. The best practice is to use `const` in your programs, and if you see that this value needs to change, replace `const` with `let`.

A.4.3 Block scope for functions

If you declare a function inside a block (within curly braces), it won't be visible from outside the block. The following code will throw an error saying "doSomething is not defined":

```
{
  function doSomething(){
    console.log("In doSomething");
  }
}

doSomething();
```

In ES5, the `doSomething()` declaration would be hoisted, and it would print `"In doSomething"`. Declaring a function inside a block wasn't recommended in ES5 (see "ES5 Implementation Best Practice" at http://mng.bz/Bvym), because doing so may produce inconsistent results across the browsers, which may parse this syntax differently.

A.5 Arrow function expressions, this, and that

ES6 introduced arrow function expressions, which provide a shorter notation for anonymous functions and add lexical scope for the `this` variable. In some other programming languages (such as C# and Java) a similar syntax is called *lambda expressions*.

The syntax of arrow function expressions consists of arguments, the fat arrow sign (), and the function body. If the function body is just one expression, you don't even need curly braces. If a single-expression function returns a value, there's no need to write the `return` statement—the result is returned implicitly:

```
let sum = (arg1, arg2) => arg1 + arg2;
```

The body of a multiline arrow function expression should be enclosed in curly braces and use the explicit `return` statement:

```
(arg1, arg2) => {
  // do something
  return someResult;
}
```

If an arrow function doesn't have any arguments, use empty parentheses:

```
() => {
  // do something
  return someResult;
}
```

If the function has just one argument, no parentheses are required:

```
arg1 => {
  // do something
}
```

In the following code snippet, we pass arrow function expressions as arguments to array's `reduce()` method to calculate a sum, and to `filter()` to print the even numbers.

```
var myArray = [1,2,3,4,5];
console.log( "The sum of myArray elements is " +
                 myArray.reduce((a,b) => a+b));  // prints 15
console.log( "The even numbers in myArray are " +
                 myArray.filter( value => value % 2 == 0)); // prints 2 4
```

Now that you're familiar with the syntax of arrow functions, let's see how they streamline working with the `this` object.

In ES5, figuring out which object is referred to by the keyword `this` isn't always a simple task. Search online for "JavaScript this and that" and you'll find multiple posts where people complain about `this` pointing to the "wrong" object. The `this` reference can have different values depending on how the function is invoked and on whether strict mode was used (see the documentation for "Strict Mode" on the Mozilla Developer Network at http://mng.bz/VNVL). We'll illustrate the problem first, and then we'll show you the solution offered by ES6.

Consider the code in the thisAndThat.html file, which invokes the `getQuote()` function every second. The `getQuote()` function prints random generated prices for the stock symbol provided to the `StockQuoteGenerator()` constructor function.

```
<!DOCTYPE html>
<html>
<head>
    <title>thisAndThat.html</title>
</head>
<body>

<script>

    function StockQuoteGenerator(symbol){

       // this.symbol = symbol;    // is undefined inside getQuote()

        var that = this;
        that.symbol = symbol;

        setInterval(function getQuote(){
            console.log("The price quote for " + that.symbol
                    + " is " + Math.random());
        }, 1000);
    }

    var stockQuoteGenerator = new StockQuoteGenerator("IBM");
```

```
</script>

</body>
</html>
```

The line that's commented out in the preceding code illustrates the wrong ways of using `this` when a value is needed in a function that seemingly has the same `this` reference but doesn't. If we hadn't saved the value of the variable `this` in `that`, the value of `this.symbol` would be `undefined` inside the `getQuote()` function invoked inside `setInterval()` or another callback. Inside `getQuote()`, `this` points at the global object, which is not the same as `this` defined by the `StockQuoteGenerator()` constructor function.

The other possible solution for ensuring that a function runs in a particular `this` object is to use the JavaScript `call()`, `apply()`, or `bind()` functions.

NOTE	**More on the `this` issue** If you're not familiar with the `this` problem in JavaScript, Richard Bovell's article, "Understand JavaScript's 'this' with Clarity and Master It" (http://mng.bz/ZQfz).

The fatArrow.html file illustrates the arrow function solution that eliminates the need to store `this` in `that`, as we did in thisAndThat.html.

```
<!DOCTYPE html>
<html>
<head>
    <title>fatArrow.html</title>
</head>
<body>

<script>

  "use strict";

  function StockQuoteGenerator(symbol){

      this.symbol = symbol;

      setInterval(() => {
                 console.log("The price quote for " + this.symbol
                         + " is " + Math.random());
              }, 1000);
  }

  var stockQuoteGenerator = new StockQuoteGenerator("IBM");

</script>

</body>
</html>
```

The arrow function that's given as an argument to `setInterval()` uses the `this` value of the enclosing context, so it will recognize IBM as the value of `this.symbol`.

A.5.1 Rest and spread operators

In ES5, writing a function with a variable number of parameters required using a special `arguments` object. This object is *similar* to an array, and it contains values corresponding to the arguments passed to a function. The implicit `arguments` variable could be treated as a local variable in any function.

ES6 has rest and spread operators, and both are represented by three dots (…). The rest operator is used to pass a variable number of arguments to a function, and it has to be the last one in the arguments list. If the name of the function argument starts with the three dots, the function will get the rest of the arguments in an array.

For example, you can pass multiple customers to a function using a single variable name with a rest operator:

```
function processCustomers(...customers){
  // implementation of the function goes here
}
```

Inside this function, you can handle the `customers` data the same way you'd handle any array. Imagine that you need to write a function to calculate taxes that must be invoked with the first argument, `income`, followed by any number of arguments representing the names of the customers. The following code shows how you could process a variable number of arguments using first the old and then the new syntax. The `calcTaxES5()` function uses the object named `arguments`, and the function `calcTaxES6()` uses the ES6 rest operator:

```
<!DOCTYPE html>
<html>
<head>
    <title>rest.html</title>
</head>
<body>

<script>

  "use strict";

// ES5 and arguments object
  function calcTaxES5(){

      console.log("ES5. Calculating tax for customers with the income ",
                             arguments[0]);   // income is the first element

      // extract an array starting from 2nd element
      var customers = [].slice.call(arguments, 1);

      customers.forEach(function (customer) {
          console.log("Processing ", customer);
      });
  }
```

```
  calcTaxES5(50000, "Smith", "Johnson", "McDonald");
  calcTaxES5(750000, "Olson", "Clinton");

// ES6 and rest operator
  function calcTaxES6(income, ...customers) {
      console.log("ES6. Calculating tax for customers with the income ", income);

      customers.forEach(function (customer) {
          console.log("Processing ", customer);
      });
  }

  calcTaxES6(50000, "Smith", "Johnson", "McDonald");
  calcTaxES6(750000, "Olson", "Clinton");

</script>

</body>
</html>
```

Both functions, `calcTaxES5()` and `calcTaxES6()`, produce the same results:

```
ES5. Calculating tax for customers with the income 50000
Processing Smith
Processing Johnson
Processing McDonald
ES5. Calculating tax for customers with the income 750000
Processing Olson
Processing Clinton
ES6. Calculating tax for customers with the income 50000
Processing Smith
Processing Johnson
Processing McDonald
ES6. Calculating tax for customers with the income 750000
Processing Olson
Processing Clinton
```

There's a difference in handling customers though. Because the `arguments` object isn't a real array, we had to create an array in the ES5 version by using the `slice()` and `call()` methods to extract the names of the customers starting from the second element in `arguments`. The ES6 version doesn't require us to use these tricks because the rest operator gives you a regular array of customers. Using the rest arguments made the code simpler and more readable.

If the rest operator can turn a variable number of parameters into an array, the spread operator can do the opposite: turn an array into a list of arguments. Say you need to write a function that will calculate tax for three customers with a given income. This time the number of arguments is fixed, but the customers are located in an array. You can use the spread operator, the three dots (…), to turn the array into a list of separate arguments, as follows:

```
<!DOCTYPE html>
<html>
<head>
    <title>rest.html</title>
</head>
```

```
<body>

<script>

  "use strict";

  function calcTaxSpread( customer1, customer2, customer3, income) {
      console.log("ES6. Calculating tax for customers with the income ", income);

      console.log("Processing ", customer1, customer2, customer3);
  }

  var customers = ["Smith", "Johnson", "McDonald"];

  // spread operator
  calcTaxSpread(...customers, 50000);

</script>

</body>
</html>
```

In this example, instead of extracting the values from the `customers` array and then providing these values as function arguments, we use an array with the spread operator as if we're saying to the function, "You need three arguments, but I'm giving you an array. Spread it out."

Note that as opposed to the rest operator, the spread operator doesn't have to be the last one in the argument list.

A.5.2 Generators

When a browser executes a regular JavaScript function, it runs without interrupting its own flow to the end. But the execution of a *generator function* can be paused and resumed multiple times. A generator function can yield control to the calling script, which runs on the same thread.

As soon as the code in a generator function reaches the keyword `yield`, it gets suspended, and the calling script can resume the function's execution by calling `next()` on the generator.

To turn a regular function into a generator, you need to place an asterisk between the keyword `function` and the function name. Here's an example:

```
function* doSomething(){

  console.log("Started processing");

  yield;

  console.log("Resumed processing");
}
```

When you invoke this function, it doesn't immediately execute the function code but returns a special `Generator` object, which serves as an iterator. The following line won't print anything:

```
var iterator = doSomething();
```

To start executing the body of the function, you need to call the method `next()` on the generator:

```
iterator.next();
```

After the preceding line, the `doSomething()` function will print “Started processing” and will be suspended because of the `yield` operator. Calling `next()` again will print “Resumed processing”.

Generator functions are useful when you need to write a function that produces a stream of data. Imagine that you need a function to retrieve and produce stock prices for a specified symbol (IBM, MSFT, and so on). If a stock price falls below a specified value (the limit price) you want to purchase this stock.

The following generator function, `getStockPrice()`, emulates this scenario, but for simplicity it doesn’t retrieve prices from the stock exchange, but instead generates random numbers using `Math.random()`.

```
function* getStockPrice(symbol){

  while(true){
    yield Math.random()*100;

    console.log(`resuming for ${symbol}`);
  }
}
```

If there’s a value after `yield`, it’s returned to the caller, but the function isn’t completed yet. Even though the `getStockPrice()` function has an infinite loop, it will yield (return) the price only if the script that invoked `getStockPrice()` calls `next()` on this generator, as follows:

```
let priceGenerator = getStockPrice("IBM");

const limitPrice = 15;
let price = 100;

while ( price > limitPrice){

   price = priceGenerator.next().value;
   console.log (`The generator returned ${price}`);
}

console.log(`buying at ${price} !!!`);
```

1. Creates the Generator object but doesn't execute the body of the getStockPrice() function that will provide a stream of prices for IBM.
2. Sets the limit price to 15 and the initial price to 100 dollars.
3. Requests stock prices until they falls below 15 dollars.
4. Requests the next price and prints it to the console.
5. If the price falls below 15 dollars, the loop is over and the program prints a message about buying the stock and its price.

Running this code sample will print something similar to the following on the browser's console:

```
The generator returned 61.63144460879266
resuming for IBM
The generator returned 96.60782956052572
resuming for IBM
The generator returned 31.163037824444473
resuming for IBM
The generator returned 18.416578718461096
resuming for IBM
The generator returned 55.80756475683302
resuming for IBM
The generator returned 14.203652134165168
buying at 14.203652134165168 !!!
```

Note the order of the messages. When you call the `next()` method on the `priceGenerator`, the execution of the suspended `getStockPrice()` method resumes at the line below `yield`, which prints "resuming for IBM". Even though the control flow went outside the function and then came back, `getStockPrice()` remembers that the value of `symbol` was "IBM". When the `yield` operator returns control to the outside script, it creates a snapshot of the stack so it can remember all the values of the local variables. When execution of the generator function is resumed, these values haven't been lost.

With generators you can separate the implementation of certain operations (such as getting a price quote) and the consumption of the data produced by these operations. The consumer of the data lazily evaluates the results and decides if requesting more data is necessary.

A.5.3 Destructuring

Creating instances of objects means constructing them in memory. Destructuring means taking objects apart. In ES5 you could deconstruct any object or a collection by writing a function to do it. ES6 introduces the destructuring assignment syntax that allows you to extract data from an object's properties or an array in a simple expression by specifying a *matching pattern*.

A destructuring expression consists of a matching pattern, the equal sign, and the object or array that you want to pull apart. It's easier to explain by example, which we'll do next.

DESTRUCTURING OF OBJECTS

Let's say that a `getStock()` function returns a `Stock` object that has the attributes `symbol` and `price`. In ES5, if you wanted to assign the values of these attributes to separate variables, you'd need to create a variable to store the `Stock` object first, and then write two statements assigning the object attributes to corresponding variables:

```
var stock = getStock();
var symbol = stock.symbol;
var price = stock.price;
```

In ES6 you just need to write a matching pattern on the left, and assign the `Stock` object to it:

```
let {symbol, price} = getStock();
```

It's a little unusual to see curly braces on the left of the equal sign, but this is part of the syntax of a matching expression. When you see curly braces on the left side, think of them as a block of code and not the object literal.

The following script demonstrates getting the `Stock` object from the `getStock()` function and destructuring it into two variables:

```
function getStock(){

    return {
        symbol: "IBM",
        price: 100.00
    };
}

let {symbol, price} = getStock();

console.log(`The price of ${symbol} is ${price}`);
```

Running this script will print the following:

```
The price of IBM is 100
```

In other words, we bind a set of data (object attributes, in this case) to a set of variables (`symbol` and `price`) in one assignment expression. Even if the `Stock` object would have had more than two attributes, the preceding destructuring expression would still work because `symbol` and `price` would have matched the pattern. The matching expression lists only the variables for the object attributes you're interested in.

The previous code sample works because the names of the variables are the same as the names of the `Stock` attributes. Let's change `symbol` to `sym`:

```
let {sym, price} = getStock();
```

Now the output will change because JavaScript doesn't know that the object's `symbol` attribute should be assigned to the variable `sym`:

```
The price of undefined is 100
```

This is an example of a wrong matching pattern. If you really want to map the variable named `sym` to the `symbol` attribute, introduce an alias name for `symbol`:

```
let {symbol: sym, price} = getStock();
```

If you provide more variables on the left than the number of attributes the object has, the extra variables will get the value `undefined`. If you add a `stockExchange` variable on the left, it will be initialized with `undefined`, because there's no such attribute in the object returned by `getStock()`:

```
let {sym, price, stockExchange} = getStock();
console.log(`The price of ${symbol} is ${price} ${stockExchange}`);
```

If you apply the preceding destructuring assignment to the same `Stock` object, the console output will look like this:

```
The price of IBM is 100 undefined
```

If you want the `stockExchange` variable to have a default value, such as “NASDAQ”, you could rewrite the destructuring expression like this:

```
let {sym, price, stockExchange="NASDAQ"} = getStock();
```

You can also destructure nested objects. The next code sample creates a nested object that represents the Microsoft stock and passes it to the `printStockInfo()` function, which pulls the stock symbol and name of the stock exchange from this object.

```
let msft = {symbol: "MSFT",
```

```
    lastPrice: 50.00,
    exchange: {
        name: "NASDAQ",
        tradingHours: "9:30am-4pm"
    }
};

function printStockInfo(stock){
    let {symbol, exchange:{name}} = stock;
    console.log(`The ${symbol} stock is traded at ${name}`);
}

printStockInfo(msft);
```

Running the preceding script will print the following:

```
The MSFT stock is traded at NASDAQ
```

DESTRUCTURING OF ARRAYS

Array destructuring works much like object destructuring, but instead of curly brackets you’ll need to use square ones. Whereas in destructuring objects you need to specify variables that match attributes, with arrays you specify variables that match indexes. The following code extracts the values of two array elements into two variables:

```
let [name1, name2] = ["Smith", "Clinton"];
console.log(`name1 = ${name1}, name2 = ${name2}`);
```

The output will look like this:

```
name1 = Smith, name2 = Clinton
```

If you just wanted to extract the second element of this array, the matching pattern would look like this:

```
let [, name2] = ["Smith", "Clinton"];
```

If a function returns an array, the destructuring syntax turns it into a function with a multiple-value return, as shown in the `getCustomers()` function:

```
function getCustomers(){
    return ["Smith", , , "Gonzales"];
}

let [firstCustomer,,,lastCustomer] = getCustomers();
console.log(`The first customer is ${firstCustomer} and the last one is ${lastCustomer}`);
```

Now let’s combine array destructuring with rest parameters. Let’s say we have an array of multiple customers but we want to process only the first two. The following code snippet shows how to do it:

```
let customers = ["Smith", "Clinton", "Lou", "Gonzales"];

let [firstCust, secondCust, ...otherCust] = customers;

console.log(`The first customer is ${firstCust} and the second one is ${secondCust}`);
console.log(`Other customers are ${otherCust}`);
```

Here’s the console output produced by this code:

```
The first customer is Smith and the second one is Clinton
Other customers are Lou,Gonzales
```

On a similar note, you can pass the matching pattern with a rest parameter to a function:

```
var customers = ["Smith", "Clinton", "Lou", "Gonzales"];

function processFirstTwoCustomers([firstCust, secondCust, ...otherCust]) {

  console.log(`The first customer is ${firstCust} and the second one is ${secondCust}`);
  console.log(`Other customers are ${otherCust}`);

}

processFirstTwoCustomers(customers);
```

The output will be the same:

```
The first customer is Smith and the second one is Clinton
Other customers are Lou,Gonzales
```

To summarize, the benefit of destructuring is that you can write less code when you need to initialize some variables with data that’s located in object properties or arrays.

A.6 Iterating with forEach(), for-in, and for-of

Looping through a collection of objects can be done using different JavaScript keywords and APIs. In this section we’ll show you how to use the new `for-of` loop. We’ll compare it with `for-in` loops and the `forEach()` function.

A.6.1 Using the forEach() method

Consider the following code, which iterates through an array of four numbers. This array also has an additional `description` property, which is ignored by `forEach()`.

```
var numbersArray = [1, 2, 3, 4];
numbersArray.description = "four numbers";

numbersArray.forEach((n) => console.log(n));
```

The output of the preceding script looks like this:

```
1
2
3
4
```

The `forEach()` method takes a function as an argument and properly prints four numbers from the array, ignoring the `description` property. Another limitation of `forEach()` is that it doesn't allow you to break the loop prematurely. You'd need to use the `every()` method instead of `forEach()`, or come up with some other hack to do that. Let's see how the `for-in` loop can help.

A.6.2 Using the for-in loop

The `for-in` loop iterates over the *property names* of objects and data collections. In JavaScript, any object is a collection of key-value pairs, where a key is a property name and a value is the property value. Our array has five properties: four for the numbers and `description`. Let's iterate through the properties of this array.

```
var numbersArray = [1, 2, 3, 4];
numbersArray.description = "four numbers";

for (let n in numbersArray) {
  console.log(n);
}
```

The output of the preceding code will look like this:

```
0
1
2
3
description
```

Running this code through a debugger shows that each of these properties is a `string`. To see the actual values of the properties, we should print the array elements using the `numbersArray[n]` notation:

```
var numbersArray = [1, 2, 3, 4];
numbersArray.description = "four numbers";

for (let n in numbersArray) {
  console.log(numbersArray[n]);
}
```

Now the output will look like this:

```
1
2
3
4
four numbers
```

As you can see, the `for-in` loop iterated through all the properties, not only the data, which may not be what we need. Let's try the new `for-of` syntax.

A.6.3 Using for-of

ES6 introduced the `for-of` loop, which allows you to iterate over data regardless of what other properties the data collection has. You can break out of this loop if need be by using the `break` keyword.

```
var numbersArray = [1, 2, 3, 4];
numbersArray.description = "four numbers";

console.log("Running for of for the entire array");
for (let n of numbersArray) {
  console.log(n);
}

console.log("Running for of with a break");
for (let n of numbersArray) {
  if (n >2) break;

  console.log(n);
}
```

This script will produce the following output:

```
Running for of for the entire array
1
2
3
4
Running for of with a break
1
2
```

The `for of` loop works with any iterable object, including `Array`, `Map`, `Set`, and others. Strings are iterable as well. The following code will print the content of the string "John" one character at a time:

```
for (let char of "John") {
  console.log(char);
}
```

A.7 Classes and inheritance

Both ES3 and ES5 support object-oriented programming and inheritance. But with ES6 classes, the code is easier to read and write.

In ES5, objects could be created either from scratch or by inheriting from other objects. By default, all JavaScript objects are inherited from `Object`. This object inheritance is implemented via a special property called `prototype`, which points at this object's ancestor. This is called *prototypal inheritance*. For example, to create an `NJTax` object that inherits from the object `Tax`, you'd write something like this:

```
function Tax() {
  // The code of the tax object goes here
}

function NJTax() {
  // The code of New Jersey tax object goes here
}

NJTax.prototype = new Tax(); // Inheriting NJTax from Tax

var njTax = new NJTax();
```

ES6 introduced the keywords `class` and `extends` to bring the syntax in line with other object-oriented languages such as Java and C#. The ES6 equivalent of the preceding code is shown next:

```
class Tax {
  // The code of the tax class goes here
}

class NJTax extends Tax {
  // The code of New Jersey tax object goes here
}

var njTax = new NJTax();
```

In this example, the `Tax` class is an ancestor or superclass, and `NJTax` is a descendant or subclass. We can also say that the `NJTax` class has the "is a" relation with the class `Tax` . In other words, `NJTax` is a `Tax`. You can implement additional functionality in `NJTax`, but `NJTax` still "is a" or "is a kind of" `Tax`. Similarly, if you created an `Employee` class that inherits from `Person`, you could say that `Employee` is a `Person`.

A class serves as a blueprint that can be used to create one or more instances of the objects, just like this:

```
var tax1 = new Tax();  // the first instance of the Tax object
var tax2 = new Tax();  // the second instance of the Tax object
```

NOTE	**Hoisting and classes** Class declarations are not hoisted. You need to declare the class first and then work with it.

Each of these objects will have properties and methods that exist in the `Tax` class, but they will have different *state*; for example, the first instance could be created for a customer with an annual income of $50,000, and the second for a customer who earned $75,000. Each instance will share the same copy of the methods declared in the `Tax` class, so there's no duplication of code.

In ES5 you could also avoid code duplication by declaring methods not inside the objects, but on their prototypes:

```
function Tax() {
  // The code of the tax object goes here
}

Tax.prototype = {
  calcTax: function() {
    // code to calculate tax goes here
  }
}
```

ES6 does the same thing but behind the scenes, which allows you to write more elegant code:

```
class Tax(){

  calcTax(){
    // code to calculate tax goes here
  }
}
```

SIDEBAR

Class member variables are not supported

The ES6 syntax doesn't allow you to declare class member variables as in Java, C#, or TypeScript. The following syntax is *not* supported:

```
class Tax {
  var income;
}
```

A.7.1 Constructors

During instantiation, classes execute the code placed in special methods called *constructors*. In languages such as Java and C#, the name of the constructor must be the same as the name of the class, but in ES6 you specify the class's constructor by using the keyword `constructor`:

```
class Tax{

  constructor (income){
    this.income = income;
  }
```

```
}

var myTax = new Tax(50000);
```

A constructor is a special method that’s executed only once, when the object is created. If you’re familiar with the syntax of Java or C#, the preceding code still may look a little unusual, because it doesn’t declare a separate class-level `income` variable, but creates it dynamically on the `this` object, initializing `this.income` with the values of the constructor’s argument. The `this` variable points at the instance of the current object.

The next code sample shows how you can create an instance of an `NJTax` subclass, providing the income of 50,000 to its constructor.

```
class Tax{
    constructor(income){
       this.income = income;
    }
}

class NJTax extends Tax{
    // The code of New Jersey tax object goes here
}

var njTax = new NJTax(50000);

console.log(`The income in njTax instance is ${njTax.income}`);
```

The output of this code snippet is as follows:

```
The income in njTax instance is 50000
```

Because the `NJTax` subclass didn’t define its own constructor, the one from the `Tax` superclass was automatically invoked during the instantiation of `NJTax`. This wouldn’t be the case if a subclass defined its own constructor. You’ll see such an example in section A.7.4.

Note that we were able to access the value of `income` from outside of the class via the `njTax` reference variable. Can we hide `income` so it’s not visible from outside the object? We’ll discuss this in section A.9.

A.7.2 Static variables

If you need a class property that’s shared by multiple instances of the object, you need to create it outside of the class declaration. In the following example, the `counter` variable is shared by both instances of the object `A`.

```
class A{
}
```

```
A.counter = 0;

var a1 = new A();
A.counter++;
console.log(A.counter);

var a2 = new A();
A.counter++;
console.log(A.counter);
```

The preceding code produces this output:

```
1
2
```

A.7.3 Getters, setters, and method definitions

The syntax for the object's getter and setter methods isn't new in ES6, but let's review it before going on to the new syntax for defining methods. Setters and getters bind functions to object properties. Consider the declaration and the use of the object literal `Tax`:

```
var Tax = {
  taxableIncome:0,
  get income() {return this.taxableIncome;},
  set income(value){ this.taxableIncome=value}
};

Tax.income=50000;
console.log("Income: " + Tax.income); // prints Income: 50000
```

Note that we've assigned and retrieved the value of `income` using dot notation, as if it were a declared property of the `Tax` object.

In ES5 we'd need to use the `function` keyword, such as `calculateTax = function(){…}`. ES6 allows us to skip the `function` keyword in any method definition.

```
var Tax = {
    taxableIncome:0,
    get income() {return this.taxableIncome;},
    set income(value){ this.taxableIncome=value},
    calculateTax(){ return this.taxableIncome*0.13}
};

Tax.income=50000;
console.log(`For the income ${Tax.income} your tax is ${Tax.calculateTax()}`);
```

The output of this code comes next:

```
For the income 50000 your tax is 6500
```

Getters and setters offer a convenient syntax for working with properties. For example, if you decide to add some validation code to the `income` getter, the scripts using the `Tax.income` notation won't need to be changed. The bad part is that ES6 doesn't support private variables in classes, so nothing stops programmers from accessing the variable used in a getter or setter (such as `taxableIncome`) directly. We'll talk about hiding (encapsulating) variables in section A.9.

A.7.4 The super keyword and the super function

The `super()` function allows a subclass (descendant) to invoke a constructor from a superclass (ancestor). The `super` keyword is used to call a method defined in a superclass. The following code illustrates both `super()` and `super`. The `Tax` class has a `calculateFederalTax()` method, and its `NJTax `` subclass adds the ``calculateStateTax()` method. Both of these classes have their own versions of the `calcMinTax()` method.

```
"use strict";

 class Tax{
     constructor(income){
        this.income = income;
     }

     calculateFederalTax(){
         console.log(`Calculating federal tax for income ${this.income}`);
     }

     calcMinTax(){
         console.log("In Tax. Calculating min tax");
         return 123;
     }
 }

 class NJTax extends Tax{
    constructor(income, stateTaxPercent){
        super(income);
        this.stateTaxPercent=stateTaxPercent;
    }

    calculateStateTax(){
        console.log(`Calculating state tax for income ${this.income}`);
    }

     calcMinTax(){
         super.calcMinTax();
         console.log("In NJTax. Adjusting min tax");
     }
 }

 var theTax = new NJTax(50000, 6);

 theTax.calculateFederalTax();
 theTax.calculateStateTax();

 theTax.calcMinTax();
```

Running this code produces the following output:

```
Calculating federal tax for income 50000
Calculating state tax for income 50000
In Tax. Calculating min tax
In NJTax. Adjusting min tax
```

The `NJTax` class has its own explicitly defined constructor with two arguments, `income` and `stateTaxPercent`, which we provide while instantiating `NJTax`. To make sure that the constructor of `Tax` is invoked (it sets the `income` attribute on the object), we explicitly call it from the subclass's constructor: `super("50000");`. Without this line, the preceding code would report an error, and even if it didn't, the code in `Tax` wouldn't see the value of `income`.

If you need to invoke the constructor of a superclass, it has to be done in the subclass's constructor by calling the function `super()`.

The other way of invoking code in superclasses is by using the `super` keyword. Both `Tax` and `NJTax` have a `calcMinTax()` method. The one in the `Tax` superclass calculates the base minimum amount according to federal tax laws, whereas the subclass's version of this method uses the base value and adjusts it. Both methods have the same signature, so we have a case for *method overriding*.

By calling `super.calcMinTax()`, we ensure that the base federal tax is taken into account for calculating state tax. If we didn't call `super.calcMinTax()`, the method overriding would kick in, and the subclass's version of the `calcMinTax()` method would apply. Method overriding is often used to replace the functionality of the method in the superclass without changing its code.

SIDEBAR **A warning about classes and inheritance**

ES6 classes are just syntactic sugar that increases code readability. Under the hood, JavaScript still uses prototypal inheritance, which allows you to replace the ancestor dynamically at runtime, whereas a class can have only one ancestor. Try to avoid creating deep inheritance hierarchies, as they reduce the flexibility of your code and complicate refactoring if it's needed.

Although using the `super` keyword or `super()` function allows you to invoke code in the ancestor, you should try to avoid using them, as they introduce tight coupling between the descendant and ancestor objects. The less the descendant knows about its ancestor, the better. If the ancestor of the object changes, the new one may not have the method you're trying to invoke with `super()`.

A.8 Asynchronous processing with promises

To arrange asynchronous processing in previous implementations of ECMAScript, we had to use callbacks, which are functions that are given as arguments to another function for invocation. Callbacks can be called synchronously or asynchronously.

In section A.6 we passed a callback to the `forEach()` function for synchronous invocation. In making AJAX requests to the server, we're passing a callback function to be invoked asynchronously, when the result arrives from the server.

A.8.1 A callback hell

Let's consider an example of getting data about some ordered products from the server. It starts with an asynchronous call to the server to get the information about the customers, and then for each customer we'll need to make another call to get the orders. For each order, we need to get products. The final call will get the products' details.

In asynchronous processing you don't know when each of these operation will complete, so you need to write callback functions that are invoked when the previous one is complete. Let's use the `setTimeout()` function to emulate delays, as if each of these operations requires one second to complete:

```
function getProductDetails() {

   setTimeout(function () {
      console.log('Getting customers');
      setTimeout(function () {
         console.log('Getting orders');
         setTimeout(function () {
            console.log('Getting products');
            setTimeout(function () {
               console.log('Getting product details')
            }, 1000);
         }, 1000);
      }, 1000);
   }, 1000);
};

getProductDetails();
```

Running this code will print the following messages with one-second delays:

```
Getting customers
Getting orders
Getting products
Getting product details
```

The level of nesting in the preceding code already makes it difficult to read. Now imagine if we were to add application logic and error processing to it. Writing the code this way is often referred to as "callback hell" or "triangle of doom" (the empty spaces in the code take the shape of a triangle).

A.8.2 ES6 promises

ES6 introduced *promises*, which allow you to eliminate this nesting and make the code more readable, while maintaining the same functionality as with callbacks. The `Promise` objects waits and listens for the result of an asynchronous operation and lets you know if it succeeded or failed so you can proceed with the next steps accordingly. The `Promise` object represents the future result of an operation, and it can be in one of these states:

- *Fulfilled*—The operation successfully completed.
- *Rejected*—The operation failed and returned an error.
- *Pending*—The operation is in progress, neither fulfilled nor rejected.

You instantiate a `Promise` by providing two functions to its constructor: the function to call if the operation is fulfilled, and the function to call if the operation is rejected. Consider a script with a `getCustomers()` function:

```
function getCustomers(){

  return new Promise(
     function (resolve, reject){

      console.log("Getting customers");
        // Emulate an async server call here
      setTimeout(function(){
        var success = true;
        if (success){
          resolve( "John Smith"); // got the customer
        }else{
          reject("Can't get customers");
        }
      },1000);

     }
  );
}

let promise = getCustomers()
  .then((cust) => console.log(cust))
  .catch((err) => console.log(err));
console.log("Invoked getCustomers. Waiting for results");
```

The `getCustomers()` function returns a `Promise` object, which was instantiated with a function that had `resolve` and `reject` as the constructor's arguments. In the code we invoke `resolve()` if we receive the customer information. For simplicity, `setTimeout()` emulates an asynchronous call that lasts 1 second. We've also hardcoded the `success` flag to be true. In a real-world scenario, you could make a request with the `XMLHttpRequest` object and invoke `resolve()` if the result is successfully retrieved or `reject()` if an error occurs.

At the bottom of this script, we attached `then()` and `catch()` methods to the `Promise()` instance. Only one of these two will be invoked. When we call `resolve("John Smith")` from inside the function, it results in the invocation of the `then()` that received “John Smith” as its argument. If we changed the value of `success` to `false`, the `catch()` method would be called with the argument “Can’t get customers”.

Running the preceding code prints the following messages on the console:

```
Getting customers
Invoked getCustomers. Waiting for results
John Smith
```

Note that the message “Invoked getCustomers. Waiting for results” was printed before “John Smith”. This proves that the `getCustomers()` function worked asynchronously.

Each promise represents one asynchronous operation, and you can chain them up to guarantee a particular order of execution. Let’s add a `getOrders()` function that can find the orders for a specific customer, and chain it with `getCustomers()`.

```
'use strict';

function getCustomers(){

  let promise = new Promise(
     function (resolve, reject){

      console.log("Getting customers");
        // Emulate an async server call here
      setTimeout(function(){
        let success = true;
        if (success){
          resolve( "John Smith"); // got the customer
        }else{
          reject("Can't get customers");
        }
      },1000);

     }
  );
  return promise;
}

function getOrders(customer){

  let promise =  new Promise(
     function (resolve, reject){

        // Emulate an async server call here
      setTimeout(function(){
        let success = true;
        if (success){
          resolve( `Found the order 123 for ${customer}`); // got the order
        }else{
          reject("Can't get orders");
        }
      },1000);

     }
  );
  return promise;
}
```

```
getCustomers()
.then((cust) => {console.log(cust);return cust;})
  .then((cust) => getOrders(cust))
  .then((order) => console.log(order))
  .catch((err) => console.error(err));
console.log("Chained getCustomers and getOrders. Waiting for results");
```

This code not only declares and chains two functions, but it also demonstrates how you can print intermediate results on the console. The output of the preceding script follows (note that the customer returned from `getCustomers()` was properly passed to `getOrders()`):

```
Getting customers
Chained getCustomers and getOrders. Waiting for results
John Smith
Found the order 123 for John Smith
```

You can chain multiple function calls using `then()` and have just one error-handling script for all chained invocations. If an error occurs, it will be propagated through the entire chain of “thens” until it finds an error handler. No “thens” will be invoked after the error.

Changing the value of the `success` variable to `false` will result in it printing the message “Can’t get customers”, and the `getOrders()` method won’t be called. If we remove these console prints, the code that retrieves customers and orders will look clean and is easy to understand:

```
getCustomers()
  .then((cust) => getOrders(cust))
  .catch((err) => console.error(err));
```

Adding more “thens” doesn’t make this code less readable (compare it with the triangle of doom from the beginning of this section).

A.8.3 Resolving several promises at once

Another case to consider is asynchronous functions that don’t depend on each other. Say you need to invoke two functions in no particular order, but you need to perform some action only *after* both of them are complete. `Promise` has an `all()` method that takes an iterable collection of promises and executes (resolves) all of them. Because the `all()` method returns a promise, you can add `then()` or `catch()` (or both) to the result.

Let’s see what happens if we use `all()` with our `getCustomers()` and `getOrders()` functions:

```
Promise.all([getCustomers(), getOrders()])
.then((order) => console.log(order));
```

This code produces the following output:

```
Getting customers
Getting orders for undefined
["John Smith","Order 123"]
```

Note the “Getting orders for undefined” message. This happens because we haven’t resolved promises in an orderly fashion, so the `getOrders()` function hasn’t received the customer as its argument. Certainly, using `Promise.all()` isn’t a good idea in our scenario, but there are situations when it makes perfect sense. Imagine a web portal that needs to make several asynchronous calls to get the weather, stock market news, and traffic information. If you want to display the portal page when all of these calls have completed, `Promise.all()` is what you need:

```
Promise.all([getWeather(), getStockMarketNews(), getTraffic()])
.then(renderGUI);
```

Compared to callbacks, promises make your code more linear and easier to read, and they represent multiple states of an application. On the negative side, promises aren’t cancellable. Imagine an impatient user who makes clicks a button several times to get some data from the server. Each click creates a promise and initiates an HTTP request. There’s no way to keep only the last request and cancel the uncompleted ones. The next step in the evolution of a `Promise` is an `Observable` object, which may be introduced in ES7, but in chapter 5 we explained how to use it today.

NOTE	**The Fetch API** The new Fetch API for getting resources over the network may become a replacement for the `XMLHttpRequest` object soon. The Fetch API is based on promises—see the Mozilla Developer Network documentation of the “Fetch API” for details (http://mng.bz/mbMe).

A.9 Modules

In any programming language, splitting code into modules helps in organizing the application into logical and possibly reusable units. Modularized applications allows programming tasks to be split between software developers more efficiently. Developers get to decide which API should be exposed by the module for external use, and which should be used internally.

ES5 didn’t have any language constructs for creating modules, and we had to resort to one of these options:

- Manually implement a module design pattern as an immediately initialized function (see

Todd Motto's "Mastering the Module Pattern" article at https://toddmotto.com/mastering-the-module-pattern/).

- Use third-party implementations of the AMD (http://mng.bz/JKVc) or CommonJS (http://mng.bz/7Lld) standards.

CommonJS was created for modularizing JavaScript applications that run outside the web browser (such as those written in Node.js and deployed under Google's V8 engine). AMD is primarily used for applications that run inside a web browser.

In any decent-sized web application, you should minimize the amount of JavaScript code loaded to the client. Imagine a typical online store. Do you need to load the code for processing payments when users open the application's home page? What if they never click on the Place Order button? It would be nice to modularize the application so the code is loaded on an as-needed basis. RequireJS is probably the most popular third-party library that implements the AMD standard. It allows you to define dependencies between modules and load them into the browser on demand.

Starting with ES6, modules have become a part of the language, which means that developers will stop using third party-libraries to implement various standards. Even though web browsers don't support ES6 modules natively, there are polyfills that allow you to start using JavaScript modules today. We use the polyfill called SystemJS in this book.

A.9.1 Imports and exports

Typically a module is just a file with JavaScript code that implements certain functionality and provides a public API so other JavaScript programs can use it. There's no special keyword to declare that the code in a particular file is a module. But inside the script you can use the keywords `import` and `export`, which turn this script into an ES6 module.

The `import` keyword allows one script to declare that it needs to use some variables or functions defined in another script file. Similarly, the `export` keyword allows the module creator to declare variables, functions, or classes that the module should expose to other scripts. In other words, by using the `export` keyword, you can make selected APIs available to other modules. The module's functions, variables, and classes that are not explicitly exported remain encapsulated inside the module.

> **NOTE** **How modules differ from regular scripts**
> The main difference between a module and a regular JavaScript file is that when you add a file to a page with a `<script>` tag, it become part of a global context, whereas the declarations in modules are local and never become a part of the global namespace. Even the exported members are available only to those modules that import them.

ES6 offers two types of `export` usage: named and default. With named exports, you can use the `export` keyword in front of multiple members of the module (such as classes, functions, or variables). The code in the following file (tax.js) exports the variable `taxCode` and the function `calcTaxes()`, but the `doSomethingElse()` function remains hidden to external scripts:

```
export var taxCode;

export function calcTaxes() { // the code goes here }

function doSomethingElse() { // the code goes here}
```

When a script imports named exported module members, their names must be placed in curly braces. The main.js file illustrates this:

```
import {taxCode, calcTaxes} from 'tax';

if (taxCode === 1) { // do something }

calcTaxes();
```

Here `tax` refers to the filename of the module, minus the file extension.

One of the exported module members can be marked as `default`, which means that this is an anonymous export, and another module can give it any name in its `import` statement. The my_module.js file that exports a function may look like this:

```
export default function() { // do something } // no semicolon

export var taxCode;
```

The main.js file imports both named and default exports while assigning the name `coolFunction` to the default one:

```
import coolFunction, {taxCode} from 'my_module';

coolFunction();
```

Note that we didn't use curly braces around `coolFunction` but we did around `taxCode`. The script that imports a class, variable, or function that was exported with the `default` keyword can give them new names without using any special keywords.

```
import aVeryCoolFunction, {taxCode} from 'my_module';

aVeryCoolFunction();
```

But to give an alias name to a named export, you'd need to write something like this:

```
import coolFunction, {taxCode as taxCode2016} from 'my_module';
```

The import statements don't result in copying the exported code. Imports serve as references. The script that imports modules or members can't modify them, and if the values in the imported modules change, the new values are immediately reflected in all places where they were imported.

A.9.2 Loading modules dynamically with the ES6 module loader

The early drafts of the ES6 specification defined a dynamic module loader named `System`, but it didn't make it into the final version of the spec. In the future, the `System` object will be natively implemented by browsers as a promise-based loader that can be used as follows:

```
System.import('someModule')
      .then (function(module){
          module.doSomething();
        })
      .catch (function(error){
          // handle error here
        })
        ;
```

Because no browser implements the `System` object yet, developers use polyfills. One of the `System` polyfills is the ES6 Module Loader, and another is SystemJS.

NOTE	**The SystemJS module loader** Although es6-module-loader.js is a polyfill for the `System` object that loads *only* ES6 modules, there's a universal SystemJS loader that supports not only ES6 modules, but AMD and CommonJS modules as well. We use SystemJS throughout this book starting from chapter 3. With SystemJS you can dynamically download not only the JavaScript code, but CSS and HTML files as well.

The polyfill for the ES6 Module Loader is available on GitHub at http://mng.bz/MD8w. You can download and unzip this loader, copy the es6-module-loader.js file to your project directory, and include it in your HTML file before your application scripts:

```
<script src="es6-module-loader.js"></script>
<script src="my_app.js"></script>
```

To make sure that your ES6 script works in all browsers, you'll need to transpile it to ES5. This can be done either upfront as a part of your build process or on the fly in a browser. We'll show you the latter scenario using the Traceur compiler.

You'll need to include the transpiler, the module loader, and your script(s) in the HTML file. You can either download the Traceur script to your local directory or provide a direct link to it, like this:

```
<script src="https://google.github.io/traceur-compiler/bin/traceur.js"></script>
<script src="es6-module-loader.js"></script>
<script src="my-es6-app.js"></script>
```

Let's consider a simple application for an online store that has shipping and billing modules loaded on demand. Our application will consist of one HTML file and two modules. The HTML file will have one button titled "Load the Shipping Module". When the user clicks on this button, the application should load and use the shipping module, which in turn depends on the billing module.

The shipping module will look like this:

```
import {processPayment} from 'billing';

export function ship() {
    processPayment();
    console.log("Shipping products...");
}

function calculateShippingCost(){
    console.log("Calculating shipping cost");
}
```

The `ship()` function can be invoked by external scripts, and `calculateShippingCost()` is private. The shipping module starts with the `import` statement so it can invoke the `processPayment()` function from the `billing` module that's shown next:

```
function validateBillingInfo() {
    console.log("Validating billing info...");
}

export function processPayment(){
    console.log("processing payment...");
}
```

The billing module also has a public `processPayment()` function and a private one called `validateBillingInfo()`.

The HTML file includes one button with a click event handler that loads the shipping module using `System.import()` from es6-module-loader.

```
<!DOCTYPE html>
<html>
<head>
    <title>modules.html</title>
    <script src="https://google.github.io/traceur-compiler/bin/traceur.js"></script>
```

```
    <script src="es6-module-loader.js"></script>
</head>
<body>

  <button id="shippingBtn">Load the Shipping Module</button>

<script type="module">

let btn = document.querySelector('#shippingBtn');
btn.addEventListener('click', () => {

     System.import('shipping')
         .then(function(module) {
             console.log("Shipping module Loaded. ", module);

             module.ship();

             module.calculateShippingCost();  // will throw an error
         })
         .catch(function(err){
             console.log("In error handler", err);
         });
});

</script>

</body>
</html>
```

`System.import()` returns an ES6 `Promise` object, and when the module is loaded, the function specified in `then()` will be executed. In case of an error, control goes to the `catch()` function.

Inside the `then()`, we print the message to the console and invoke the `ship()` function from the shipping module, which invokes `processPayment()` from billing. After that, we try to invoke the module's `calculateShippingCost()` function, which will result in an error because this function wasn't exported and remains private.

> **NOTE** **Traceur and modules**
> If you use Traceur and have an inline script in the HTML file, use `type="module"` to make sure that Traceur transpiles it to ES5. Without it, this script wouldn't work in browsers that don't support the `let` keyword and arrow functions.

To run this example on your computer, you'll need to have node.js with npm installed. Then download and install es6-module loader in any directory by running the following npm command:

```
npm install es6-module-loader
```

After that, create an application folder and copy the es6-module-loader.js file there (this is a minimized version of the loader that was downloaded by npm). Our sample application will have three additional files, shown above: moduleLoader.html, shipping.js, and billing.js. For simplicity, we'll keep all these files in the same folder.

NOTE	**Running the module loader example** To see this code in action, you need to serve it using a web server. You can install a basic HTTP server like live-server as explained in "Launching Applications" section in chapter 2.

We ran moduleLoader.html in Google Chrome and opened Chrome Developer Tools. Figure A.7 shows what the Chrome browser looks like after clicking on the Load the Shipping Module button:

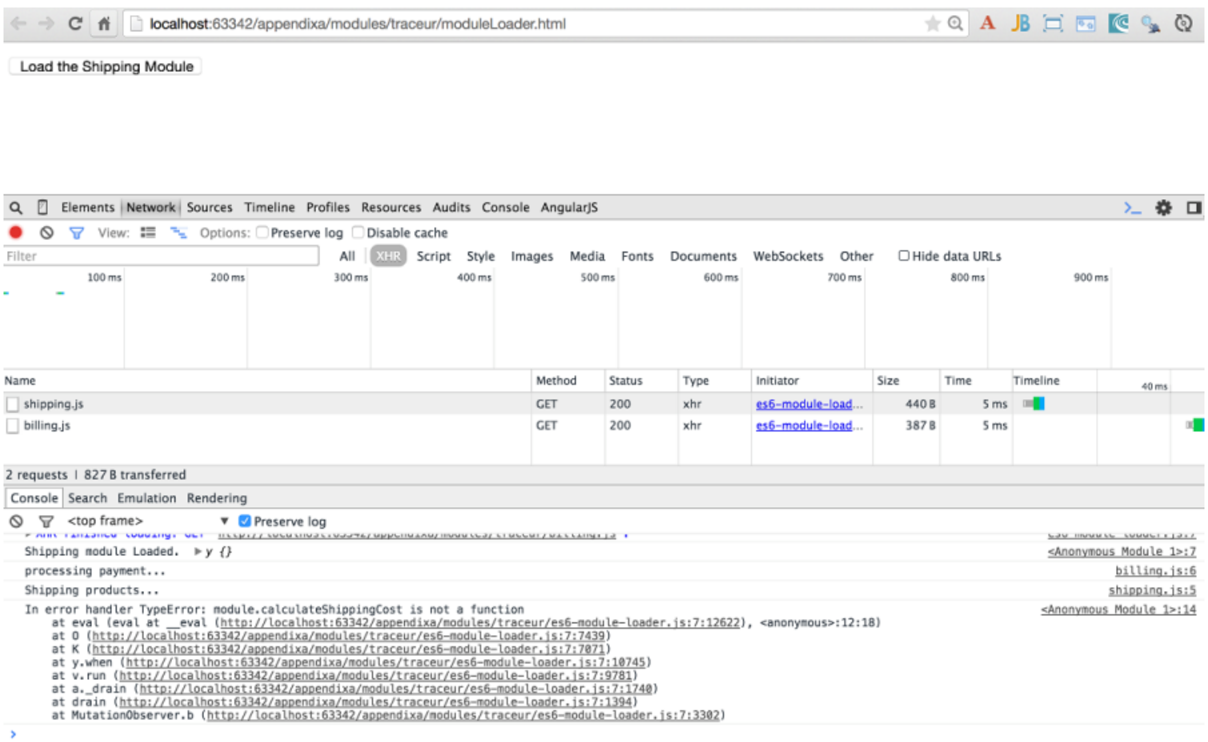


Figure A.7 Using es6-module-loader

Look at the XHR tab in the middle of the window. The HTML page loads shipping.js and billing.js only after the user clicks on the button. These files are small (440 and 387 bytes including HTTP response objects), and making an additional network call to get them seems like overkill. But if the application consists of 10 modules of 500 KB each, modularization with lazy loading makes sense.

At the bottom of the figure, on the Console tab, you can see the message from the script in `moduleLoader` indicating that the shipping module was loaded. Then it calls the function from `ship()` from the shipping module and generates an error trying to call the `calculateShippingCost()` function, as expected.

A.10 Summary

Although many people criticize JavaScript for not being as robust and well-designed as some other languages, there is no other language that allows you to write programs that work on so many different software and hardware platforms. Isn't it amazing that 20-year-old JavaScript code written for websites rendered by the Netscape browser on PCs running Windows 3.1 still work in 2016 on the latest versions of iOS or Android? JavaScript has proven to be an important player in web development, and it deserves to get a new life implementing ES6, ES7, and future specifications.

These are the main takeaways from this appendix:

- You can and should start developing in ES6 today.
- Switching from ES5 to ES6 is easy: you'll keep using the same language and tooling that you always did, but ES6 allows you to write code in a more declarative way.
- Using transpilers is a new trend in web development that allows you to write in ES6 without waiting for browsers to support it.
- ES6 modules will change the way web applications are designed by replacing HTML imports with loadable code blocks.
- Writing in ES6 makes your code easier to read and write.
- ES6 introduced classes that are just syntactic sugar, making the code easier to read. You shouldn't change the style of your JavaScript programming by introducing deep inheritance hierarchies.

The goal of this appendix was to get you familiar with the ES6 syntax, but for in-depth coverage, read the book *Exploring ES6* by Axel Rauschmayer (http://exploringjs.com/es6/). Eric Douglas maintains a compilation of various ES6 learning resources on GitHub at http://mng.bz/cZfX.

B TypeScript as a language for Angular applications

This appendix covers

- Benefits of writing Angular apps in TypeScript
- How the TypeScript transpiler works
- A brief overview of the TypeScript syntax
- The TypeScript/Angular development process

You may be wondering, why not just develop in JavaScript? Why do we need to use other programming languages if JavaScript is already a language? You wouldn't find any article about languages for developing Java or C# applications, would you?

The reason is that developing in JavaScript isn't overly productive. Say a function expects a string value as an argument, but the developer mistakenly invokes it by passing a numeric value. With JavaScript, this error can be caught only at runtime. Java or C# compilers wouldn't even compile code that has mismatching types, but JavaScript is very forgiving because it's a dynamically typed language.

Although JavaScript runtime engines do a good job of guessing the types of variables by their values, development tools have a limited ability to help you without knowing the types. In mid- or large-size applications, this JavaScript shortcoming lowers the productivity of software developers.

On larger projects, good IDE context-sensitive help and support for refactoring are very important. Renaming all occurrences of a variable or function name in statically typed languages is done by IDEs in a split second, even in projects that have thousands of lines of code, but this isn't the case in JavaScript, which doesn't support types. IDEs can help with refactoring a lot better when the types of the variables are known.

To be more productive, you may consider developing in a statically typed language, and then convert the code to JavaScript for deployment.

Currently there are dozens of languages that compile to JavaScript (see the "List of languages that compile to JS” on GitHub, http://mng.bz/vjzi). The most popular are TypeScript (www.typescriptlang.org/), CoffeeScript (http://coffeescript.org/), and Dart (www.dartlang.org/).

SIDEBAR **Why not the Dart language**

We spent quite a bit of time working with Dart, and we like the language, but it has some drawbacks: * Interoperability with third-party JavaScript libraries isn’t that great. * Development in Dart can be done only in a specialized version of the Chrome browser (Dartium) that comes with the Dart VM. No other web browsers have it. * The generated JavaScript isn’t easily readable by a human.

The Angular framework is written in TypeScript, and in this appendix we’ll cover its syntax. All of the the code samples in this book are written in TypeScript. We’ll also show you how to turn TypeScript code into its JavaScript version so it can be executed by any web browser or a standalone JavaScript engine.

B.1 Why write Angular apps in TypeScript?

You can write your applications in ES6 (and even in ES5), but we use TypeScript as a substantially more productive way for writing JavaScript, and here’s why:

- TypeScript supports types. This allows the TypeScript compiler to help developers by finding and fixing lots of errors during development before even running the app.
- Great IDE support is one of TypeScript’s main advantages. If you make a mistake in a function or a variable name, it’s displayed in red. If you pass the wrong number of parameters (or wrong types) to a function, the wrong ones show in red. IDEs also offer great context-sensitive help. TypeScript code can be refactored by IDEs, whereas JavaScript has to be refactored manually. If you need to explore a new library, just install its type definitions file, and the IDE will prompt you with available APIs, so you don’t need to read its documentation elsewhere.
- Angular is bundled with type definitions files, so IDEs perform type checking while using the Angular API and they offer context-sensitive help right out of the box.
- TypeScript follows the ECMAScript 6 standard and adds to it types, interfaces, decorators, class member variables (fields), generics, and the keywords `public` and `private`. Future releases of TypeScript will support the missing ES6 features and implement the features of ES7 (see the TypeScript “Roadmap” on GitHub at http://mng.bz/Ri29).
- TypeScript interfaces allow you to declare custom types that will be used in your application. Interfaces help in preventing compile-time errors caused by using objects of the wrong types in your application.
- The generated JavaScript code is easy to read, and it looks like hand-written code.
- Most of the code samples in the Angular documentation are given in TypeScript (see https://angular.io/docs).

B.2 The role of transpilers

Web browsers don't understand any other language but JavaScript. If the source code is written in TypeScript, it has to be *transpiled* into JavaScript before you can run it in the browser's or a standalone JavaScript engine.

Transpiling means converting the source code of a program in one language into source code in another language. Many developers prefer using the word *compiling*, so phrases like "TypeScript compiler" or "compile TypeScript into JavaScript" are also valid.

Figure B.1 shows a screenshot with TypeScript code on the left and its equivalent in an ES5 version of JavaScript generated by the TypeScript transpiler.

```
var foo: string;

class Bar{

}
```

```
var foo;
var Bar = (function () {
    function Bar() {
    }
    return Bar;
})();
```

Figure B.1 Transpiling TypeScript into ES5

In TypeScript we declared a variable `foo` of type `string`, but the transpiled version doesn't have the type information. In TypeScript we declared a class `Bar`, which was transpiled in a class-like pattern in the ES5 syntax. If we had specified ES6 as a target for transpiling, the generated JavaScript code would look different.

A combination of Angular with statically typed TypeScript simplifies the development of medium and large web applications. Good tooling and the static type analyzer substantially decrease the number of runtime errors and will shorten the time to market. When complete, your Angular application will have lots of JavaScript code, and although developing in TypeScript will require you to write more code, you'll reap the benefits by saving time on testing, refactoring, and minimizing the number of runtime errors.

B.3 Getting started with TypeScript

Microsoft has open-sourced TypeScript, and it hosts the TypeScript repository on GitHub at http://mng.bz/Ri29. You can install the TypeScript compiler using npm or download it from www.typescriptlang.org/. The TypeScript site also has a web-hosted TypeScript compiler (a playground), where you can enter TypeScript code and compile it to JavaScript interactively, as shown in figure B.2:

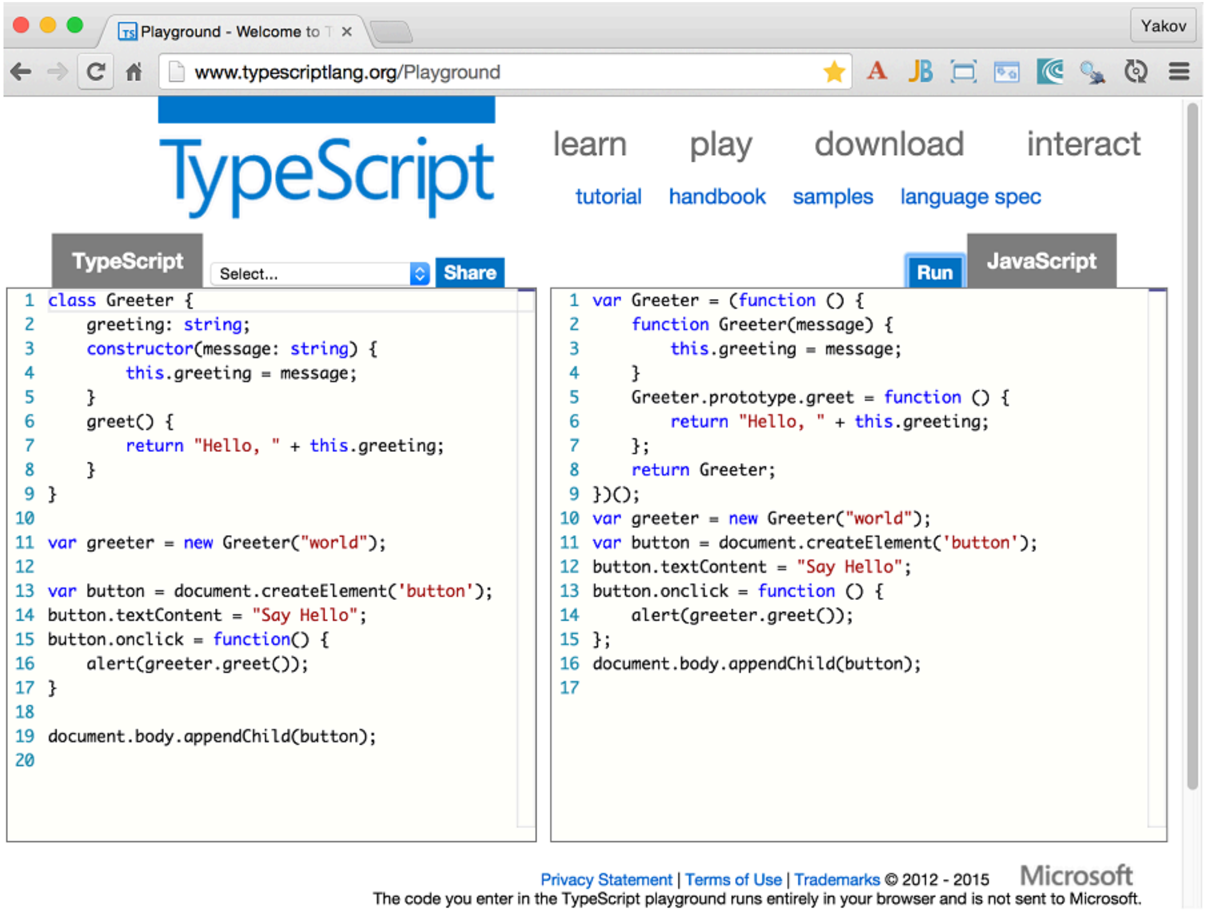


Figure B.2 Using TypeScript Playground

In the TypeScript playground you enter TypeScript code on the left, and its JavaScript version will be displayed on the right. Click on the Run button to execute the transpiled code (open the browser's developer tools to see the console output produced by your code, if any).

Interactive tools will suffice for learning the language's syntax, but for real-world development you'll need to use the right tooling to be productive. You may decide to use an IDE or a text editor, but having the TypeScript compiler installed locally is a must for development.

B.3.1 Installing and using the TypeScript compiler

The TypeScript compiler is itself written in TypeScript. We'll use Node.js's npm package manager to install the compiler. If you don't have Node, download and install it from http://nodejs.org. Node.js comes with npm, which we'll use for installing not only the TypeScript compiler, but many other development tools throughout the book.

To install the TypeScript compiler globally, run the following npm command in the command or terminal window:

```
npm install -g typescript
```

The `-g` option installs the TypeScript compiler globally on your computer, so it's available from the command prompt for all of your projects. To develop Angular 2 applications, download the latest version of the TypeScript compiler (we use version 2.0 in this book). To check the version of your TypeScript compiler, run the following command:

```
tsc --version
```

Code written in TypeScript has to be transpiled into JavaScript so web browsers can execute it. TypeScript code is saved in files with the .ts extension. Say you wrote a script and saved it in the file main.ts. The following command will transpile main.ts into main.js.

```
tsc main.ts
```

You can also generate source map files that map the source code in TypeScript to the generated JavaScript. With source maps you can place breakpoints in your TypeScript code while running it in the browser, even though it executes JavaScript. To compile main.ts into main.js while also generating the main.map source map file, you'd run the following command:

```
tsc --sourcemap main.ts
```

Figure B.3 shows a screenshot that was made while debugging in Chrome Developer Tools.

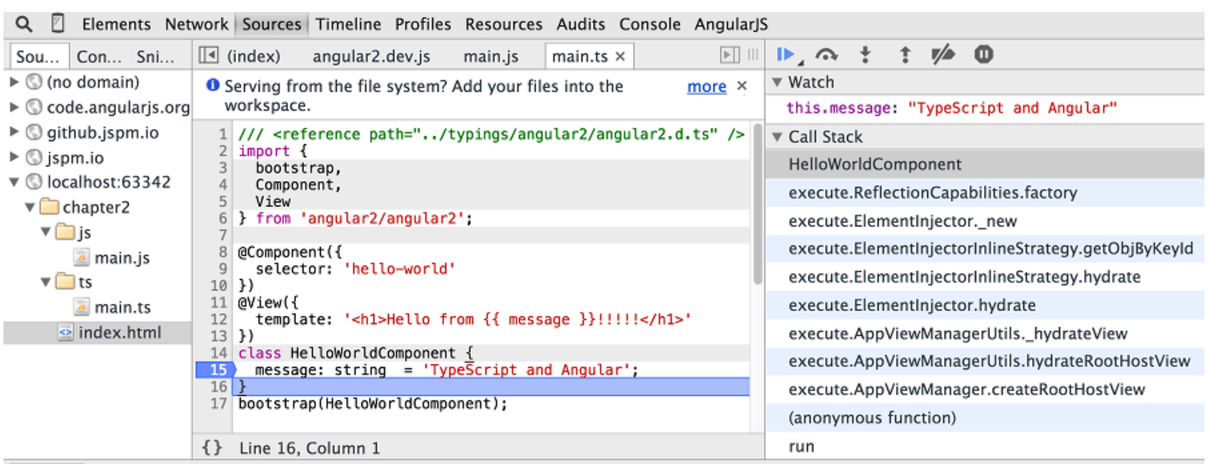


Figure B.3 Debugging TypeScript in Chrome Developer Tools

Note the breakpoint at line 15. You can find your TypeScript file in the Sources tab of the Developer Tools panel, place the breakpoint in the code, and watch the values of the variables on the right.

SIDEBAR **Transpiling TypeScript in the web browser**

During development we use tsc installed locally, but transpiling can also be done either on the server during deployment or on the fly when the web browser loads your application. In this book we use the SystemJS library, which internally uses tsc to transpile and dynamically load modules of your app.

Keep in mind that transpiling on the fly in the browser may introduce delays in displaying your app's content on the user's device.

If you use SystemJS to load and transpile your code in the browser, source maps will be generated by default.

During the compilation, TypeScript's compiler removes all TypeScript types, interfaces, and keywords from the generated code to produce valid JavaScript. By providing compiler options, you can generate JavaScript compliant with ES3, ES5, or ES6 syntax. Currently ES3 is the default. Here's how to transpile the code to ES5-compatible syntax:

```
tsc --t ES5 main.ts
```

If you want to compile your code in memory without generating output .js files, run tsc with the `--noEmit` option. We often use this option in development mode because we just need to have executable JavaScript code in the browser's memory.

You can start your TypeScript compiler in watch mode by providing the `-w` option. In this mode, whenever you modify and save your code, it is automatically transpiled into the corresponding JavaScript files. To compile and watch all .ts files, run the following command:

```
tsc -w *.ts
```

The compiler will compile all the TypeScript files, print error messages (if any) on the console, and continue watching the files for changes. As soon as the file changes, tsc will immediately recompile it.

NOTE **Compiling in the IDE**

Typically, we don't use the IDE for compiling TypeScript. We use either SystemJS with its in-browser compiler or a bundler (Webpack) that uses a special TypeScript loader for compilation. We use the TypeScript code analyzer provided by the IDEs to highlight errors, and the browser for debugging TypeScript.

The TypeScript compiler allows you to preconfigure the process of compilation (specifying the source and destination directories, source map generation, and so on). The presence of the tsconfig.json configuration file in the project directory allows you to simply enter `tsc` on the command line. The compiler will read all the options from tsconfig.json. A sample tsconfig.json file is shown here:

```
{
  "compilerOptions": {
      "target": "es5",
      "module": "commonjs",
      "emitDecoratorMetadata": true,
      "experimentalDecorators": true,
      "rootDir": ".",
      "outDir": "./js"
   }
}
```

This config file instructs tsc to transpile the code into ES5 syntax, and the generated JavaScript files will be located in the js directory. The tsconfig.json file may include the `files` section that lists the files that have to be compiled by TypeScript. Our example doesn't include this list because we use the `rootDir` option to request the compilation of all files starting from the root directory of our project.

If you want to exclude some of your project's files from compilation, add the `exclude` property to your tsconfig.json file. This is how you can exclude the entire content of the node_modules directory:

```
"exclude": [
  "node_modules"
]
```

You can read more about configuring the compilation process and the TypeScript compiler's options at in the TypeScript documentation (http://mng.bz/rf14).

NOTE	**Metadata in TypeScript** Most of the Angular examples in this book use *annotations* (a.k.a. *decorators*) with classes or class members (such as `@Component` and `@Input`). Annotations are a way to add metadata to the annotated classes or their members. See the "What's metadata?" sidebar in chapter 2 for more details.

B.4 TypeScript as a superset of JavaScript

TypeScript fully supports ES5 and most of the ES6 syntax. Just change the name extension of a file with JavaScript code from .js to .ts, and it'll become valid TypeScript code. The only two exceptions we've seen so far are handling optional function parameters and assigning a value to an object literal.

In JavaScript, even if a function is declared with two parameters, you can invoke it by providing only one, whereas in TypeScript you need to append a question mark to the parameter name to make it optional. In JavaScript you can initialize a variable with an empty object literal and immediately attach a property using dot notation, whereas in TypeScript you'd need to use square brackets.

But these differences are really minor. What's more important is that because it's a superset of JavaScript, TypeScript adds a number of useful features to JavaScript, and we'll review them next.

NOTE **Converting JavaScript to TypeScript with tsc**
If you're in the middle of converting your JavaScript project to TypeScript, you can use the tsc compiler's `--allowJs` option. The TypeScript compiler will check the input .js files for syntax errors and will emit valid output based on the `--target` and `--module` options of tsc. The output can be combined with other .ts files as well. Source maps are still generated for .js files, just like with .ts files.

B.5 Optional types

You can declare variables and provide types either for all or some of them. The following two lines are valid TypeScript syntax:

```
var name1 = 'John Smith';

var name2: string = 'John Smith';
```

If you use types, TypeScript's transpiler can detect mismatched types during development, and IDEs will offer code completion and refactoring support. This will increase your productivity on any decent sized project. Even if you don't use types in declarations, TypeScript will guess the type based on the assigned value, and will still do type checking afterward. This is called *type inference*.

The following fragment of TypeScript code shows that you can't assign a numeric value to a `name1` variable that was meant to be a `string`, even though it was initially declared without a type (JavaScript syntax). After initializing this variable with a `string` value, the inferred typing won't let you assign the numeric value to `name1`. The same rule applies to the variable `name2`, which was declared with an explicit type:

```
var name1 = 'John Smith';
name1 = 123;        ❶

var name2: string = 'John Smith';
name2 = 123;        ❷
```

❶ Assigning a value of a different type to a variable is valid in JavaScript but invalid in TypeScript because of the inferred type.

❷ Assigning a value of a different type to a variable is valid in JavaScript but invalid in TypeScript because of the explicitly declared type.

In TypeScript you can declare typed variables, function parameters, and return values. There are four keywords for declaring basic types: `number`, `boolean`, `string`, and `void`. The latter indicates the absence of a return value in a function declaration. A variable can have a value of type `null` or `undefined`, similar to JavaScript.

Here are some examples of variables declared with explicit types:

```
var salary: number;
var name: string = "Alex";
var isValid: boolean;
var customerName: string = null;
```

All these types are subtypes of the `any` type. If you don't specify a type while declaring a variable or a function argument, TypeScript's compiler will assume that it has the type `any`, which will allow you to assign any value to this variable or function argument. You may as well explicitly declare a variable, specifying `any` as its type. In this case, inferred typing isn't applied:

```
var name2: any = 'John Smith';  // valid
name2 = 123;                    // valid
```

If the variables are declared with explicit types, the compiler will check their values to ensure they match the declarations.

TypeScript includes other types that are used in interactions with the web browser, such as `HTMLElement` or `Document`.

If a programmer defines a class or an interface, it can be used as a custom type in variable declarations. We'll introduce classes and interfaces a bit later, but first let's get familiar with TypeScript functions, which are the most used constructs in JavaScript.

B.5.1 Functions

TypeScript functions (and function expressions) are similar to JavaScript functions, but you can explicitly declare parameter types and return values.

Let's write a JavaScript function that calculates tax. It'll have three parameters and will calculate tax based on the state, income, and number of dependents. For each dependent, the person is entitled to a $500 or $300 tax deduction depending on the state the person lives in.

```
function calcTax(state, income, dependents) {
```

```
    if (state == 'NY') {
        return income * 0.06 - dependents * 500;
    } else if (state == 'NJ') {
        return income * 0.05 - dependents * 300;
    }
}
```

Say a person with an income of 50,000 lives in the state of New Jersey and has two dependents. Let's invoke `calcTax()`:

```
var tax = calcTax('NJ', 50000, 2);
```

The `tax` variable will get the value of 1,900, which is correct. Even though the function `calcTax()` didn't declare any types for the function parameters, you can guess them based on the parameter names.

Now let's invoke it the wrong way, passing a `string` value for a number of dependents:

```
var tax = calcTax('NJ', 50000, 'two');
```

We won't know that there's a problem until we invoke this function. The `tax` variable will have a `NaN` value (not a number). A bug sneaked in just because we didn't have a chance to explicitly specify the types of the parameters.

Let's rewrite this function in TypeScript, declaring types for parameters and the return value:

```
function calcTax(state: string, income: number, dependents: number): number{

    if (state == 'NY'){
        return income*0.06 - dependents*500;
    } else if (state=='NJ'){
        return income*0.05 - dependents*300;
    }
}
```

Now there's no way to make the same mistake and pass a string value as the number of dependents.

```
var tax: number = calcTax('NJ', 50000, 'two');
```

The TypeScript compiler will display an error saying "Argument of type 'string' is not assignable to parameter of type 'number'." Moreover, the return value of the function was declared as `number`, which stops you from making another mistake and assigning the result of the tax calculations to a non-numeric variable.

```
var tax: string = calcTax('NJ', 50000, 'two');
```

The compiler will catch this, producing the error “The type 'number' is not assignable to type 'string': var tax: string.” This kind of type checking during the compilation can save you a lot of time on any project.

B.5.2 Default parameters

While declaring a function, you can specify default parameter values. The only limitation is that parameters with default values can’t be followed by required parameters. In our tax calculation function, to provide `NY` as a default value for the `state` parameter, you *can’t* declare it as follows:

```
function calcTax(state: string = 'NY', income: number, dependents: number): number{
    // the code goes here
}
```

You’d need to change the order of the parameters to ensure that there are no required parameters after the default one:

```
function calcTax(income: number, dependents: number, state: string = 'NY'): number{
    // the code goes here
}
```

There’s no need to change even one line of code in the body of the `calcTax()` function. You now have the freedom to invoke it with either two or three parameters:

```
var tax: number = calcTax(50000, 2);
// or
var tax: number = calcTax(50000, 2, 'NY');
```

The results of both invocations will be the same.

B.5.3 Optional parameters

In TypeScript you can easily mark function parameters as optional by appending a question mark to the parameter name. The only restriction is that optional parameters must come last in the function declaration. When you write code for functions with optional parameters, you need to provide application logic that handles the cases when the optional parameters are not provided.

Let’s modify our tax calculation function: if no dependents are specified, it won’t apply any deduction to the calculated tax.

```
function calcTax(income: number, state: string = 'NY', dependents?: number): number{

    var deduction: number;

    if (dependents) {  // handle the optional value in dependents
```

```
        deduction = dependents*500;
    }else {
      deduction = 0;
    }

    if (state == 'NY'){
        return income*0.06 - deduction;
    } else if (state=='NJ'){
        return income*0.05  - deduction;
    }
}

var tax: number = calcTax(50000, 'NJ', 3);
console.log("Your tax is " + tax);

var tax: number = calcTax(50000);
console.log("Your tax is " + tax);
```

Note the question mark in `dependents?: number`. Now our function checks whether the value for `dependents` was provided. If it wasn't, we assign 0 to the `deduction` variable; otherwise we deduct 500 for each dependent.

Running the preceding code will produce the following output:

```
Your tax is 1000
Your tax is 3000
```

B.5.4 Arrow function expressions

TypeScript supports simplified syntax for using anonymous functions in expressions. There's no need to use the `function` keyword, and the fat arrow symbol () is used to separate function parameters from the body. TypeScript supports the ES6 syntax for arrow functions (appendix A has more details on arrow functions). In some other programming languages, arrow functions are known as *lambda expressions*.

Let's look at the simplest example of the arrow function with a single-line body:

```
var getName = () => 'John Smith';
console.log(getName());
```

The empty parentheses denote that the preceding arrow function has no parameters. A single-line arrow expression doesn't need curly braces or an explicit `return` statement, and the preceding code fragment will print "John Smith" on the console. If you try that code in TypeScript's playground, it'll convert it to the following ES5 code:

```
var getName = function () { return 'John Smith'; };
console.log(getName());
```

If the body of your arrow function consists of multiple lines, you'll have to enclose it in curly braces and use the `return` statement. The following code snippet converts a hard-coded string value to uppercase and prints “PETER LUGER” on the console:

```
var getNameUpper = () => {
    var name = 'Peter Luger'.toUpperCase();
    return name;
}
console.log(getNameUpper());
```

Besides providing a shorter syntax, arrow function expressions remove the infamous confusion with the `this` keyword. In JavaScript, if you use the `this` keyword in a function, it may not point at the object where the function is being invoked. That could result in runtime bugs and require additional time for debugging. Let’s look at an example.

The following TypeScript code has two functions: `StockQuoteGeneratorArrow()` and `StockQuoteGeneratorAnonymous()`. Each second, both of these functions invoke `Math.random()` to generate a random price for the stock symbol provided as a parameter. Internally, the `StockQuoteGeneratorArrow()` function uses the arrow function syntax, providing the argument for `setInterval()`, whereas the `StockQuoteGeneratorAnonymous()` function uses the anonymous function.

```
function StockQuoteGeneratorArrow(symbol: string){

    this.symbol = symbol;   ❶

    setInterval(() => {   ❷
        console.log("StockQuoteGeneratorArrow. The price quote for " + this.symbol
            + " is " + Math.random());
    }, 1000);

}

var stockQuoteGeneratorArrow = new StockQuoteGeneratorArrow("IBM");

function StockQuoteGeneratorAnonymous(symbol: string){

    this.symbol = symbol;   ❸

    setInterval(function () {   ❹
        console.log("   StockQuoteGeneratorAnonymous.The price quote for " + this.symbol
            + " is " + Math.random());
    }, 1000);
}

var stockQuoteGeneratorAnonymous = new StockQuoteGeneratorAnonymous("IBM");
```

❶ Assigns the the stock symbol to this.symbol.

❷ Uses the arrow function as the argument of setInterval() to invoke it every second (1,000 milliseconds).

❸ Assigns the the stock symbol to this.symbol.

❹ Uses the anonymous function as the argument of setInterval().

In both cases we assign the stock symbol ("IBM") to the `symbol` variable on the `this` object. But with the arrow function, the reference to the instance of the `StockQuoteGeneratorArrow()` constructor function was automatically saved in a separate variable, and when you refer to `this.symbol` from the arrow function, it properly finds it and uses "IBM" in the console output.

But when the anonymous function is invoked in the browser, `this` points at the global `Window` object, which doesn't have the `symbol` property. Running this code in the web browser will print something like this every second:

```
StockQuoteGeneratorArrow. The price quote for IBM is 0.2998261866159737
StockQuoteGeneratorAnonymous.The price quote for undefined is 0.9333276399411261
```

As you see, when we use the arrow function, it recognizes IBM as our stock symbol, but it's `undefined` in the anonymous function.

IMPORTANT **Arrow function expressions and the `this` keyword**

TypeScript replaces the `this` inside the arrow function expression with a reference to the outer scope's `this` by passing in the reference. This is why the code inside the arrow in `StockQuoteGeneratorArrow()` properly sees `this.symbol` from the outer scope.

SIDEBAR **Function overloading**

JavaScript doesn't support function overloading, so having several functions with the same name but different lists of arguments isn't possible there. The TypeScript creators introduced function overloading, but because the code has to be transpiled into a single JavaScript function, the syntax for overloading is not elegant.

You can declare several signatures of a function with one and only one body, where you'd need to check the number and types of the arguments and execute the appropriate portion of the code:

```
function attr(name: string): string;
function attr(name: string, value: string): void;
function attr(map: any): void;
function attr(nameOrMap: any, value?: string): any {
  if (nameOrMap && typeof nameOrMap === "string") {
      // handle string case
  } else {
      // handle map case
  }

  // handle value here
}
```

Our next topic is TypeScript classes, but let's take a brief pause and summarize what we've covered so far:

- Typescript code is compiled into JavaScript using the tsc compiler.
- TypeScript allows you to declare the, types of variables, function parameters and return values.
- Functions can have parameters with default values and optional parameters.
- Arrow function expressions offer a shorter syntax for declaring anonymous functions.
- Arrow function expressions eliminate the uncertainty in using the `this` object reference.

B.6 Classes

If you have Java or C# experience, you'll be familiar with the concepts of classes and inheritance in their classical form. In those languages, the definition of a class is loaded in memory as a separate entity (like a blueprint) and is shared by all instances of this class. If a class is inherited from another one, the object is instantiated using the combined blueprint of both classes.

TypeScript is a superset of JavaScript, which only supports *prototypal inheritance*, where you can create an inheritance hierarchy by attaching one object to the *prototype* property of another one. In this case, an inheritance (or rather, a linkage) of *objects* is created dynamically.

In TypeScript the `class` keyword is just syntactic sugar to simplify coding. In the end, your classes will be transpiled into JavaScript objects with prototypal inheritance. In JavaScript you can declare a constructor function and instantiate it with the `new` keyword. In TypeScript you can also declare a class and instantiate it with the `new` operator.

A class can include a constructor, fields (a.k.a. properties), and methods. Properties and methods declared are often referred as *class members*. We'll illustrate the syntax of TypeScript classes by showing you a series of code samples and comparing them with the equivalent ES5 syntax.

Let's create a simple `Person` class that contains four properties to store the first and last name, age, and social security number (a unique identifier assigned to every legal resident of the USA). On the left side of figure B.4 you can see the TypeScript code that declares and instantiates the `Person` class, and on the right side is a JavaScript closure generated by the tsc compiler.

```
class Person {
    firstName: string;
    lastName: string;
    age: number;
    ssn: string;
}

var p = new Person();

p.firstName = "John";
p.lastName = "Smith";
p.age = 29;
p.ssn = "123-90-4567";
```

```
var Person = (function () {
    function Person() {
    }
    return Person;
})();
var p = new Person();
p.firstName = "John";
p.lastName = "Smith";
p.age = 29;
p.ssn = "123-90-4567";
```

Figure B.4 Transpiling a TypeScript class into a JavaScript closure

By creating a closure for the `Person` function, the TypeScript compiler enables the mechanism for exposing and hiding the elements of the `Person` object.

TypeScript also supports class constructors that allow you to initialize object variables while instantiating the object. A class constructor is invoked only once during object creation. The left side of figure B.5 shows the next version of the `Person` class, which uses the `constructor` keyword that initializes the fields of the class with the values given to the constructor. The generated ES5 version is shown on the right.

```
class Person {
    firstName: string;
    lastName: string;
    age: number;
    ssn: string;

    constructor(firstName:string, lastName: string,
        age: number, ssn: string) {

        this.firstName = firstName;
        this.lastName;
        this.age = age;
        this.ssn = ssn;
    }
}

var p = new Person("John", "Smith", 29, "123-90-4567");
```

```
var Person = (function () {
    function Person(firstName, lastName, age, ssn) {
        this.firstName = firstName;
        this.lastName;
        this.age = age;
        this.ssn = ssn;
    }
    return Person;
})();
var p = new Person("John", "Smith", 29, "123-90-4567");
```

Figure B.5 Transpiling a TypeScript class with constructor

Some JavaScript developers may see little value in using classes, as they can easily program the same functionality using constructor functions and closures. But people who are just starting with JavaScript will find the syntax of classes easier to read and write, compared to constructor functions and closures.

B.6.1 Access modifiers

JavaScript doesn't have a way to declare a variable or a method as private (hidden from external code). To hide a property (or a method) within an object, you need to create a closure that neither attaches this property to the `this` variable nor returns it in the closure's `return` statement.

TypeScript provides `public`, `protected`, and `private` keywords to help you control access to the object's members during the development phase. By default, all class members have `public` access and they're visible from outside the class. If a member is declared with the `protected` modifier, it's visible within the class and its subclasses. Class members declared as `private` are visible only within the class.

Let's use the `private` keyword to hide the value of the `ssn` property so it can't be directly accessed from outside of the `Person` object. We'll show you two versions of declaring a class with properties that use access modifiers. The longer version of the class looks like this:

```
class Person {
    public firstName: string;
    public lastName: string;
    public age: number;
    private _ssn: string;

    constructor(firstName:string, lastName: string, age: number, ssn: string) {
        this.firstName = firstName;
        this.lastName = lastName;
        this.age = age;
        this._ssn = ssn;
    }
}

var p = new Person("John", "Smith", 29, "123-90-4567");
console.log("Last name: " + p.lastName + " SSN: " + p._ssn);
```

Note that the name of the private variable starts with an underscore: `_ssn`. This is just a naming convention for private properties.

The last line of the preceding example attempts to access the `_ssn` private property from outside, so the TypeScript code analyzer will give you a compilation error: "Property 'ssn' is private and is only accessible within class 'Person'". But unless you use the `--noEmitOnError` compiler option, the erroneous code will still transpile into JavaScript:

```
var Person = (function () {
    function Person(firstName, lastName, age, _ssn) {
        this.firstName = firstName;
        this.lastName = lastName;
        this.age = age;
        this._ssn = _ssn;
    }
    return Person;
})();

var p = new Person("John", "Smith", 29, "123-90-4567");
console.log("Last name: " + p.lastName + " SSN: " + p._ssn);
```

So the keyword `private` only makes it private in the TypeScript code. IDEs won't show private members in the context-sensitive help when you try to access properties of an object from outside, but the production JavaScript code will treat all properties and methods of the class as public anyway.

TypeScript allows you to provide access modifiers with the constructor's arguments, as shown in the following short version of the `Person` class.

```
class Person {

    constructor(public firstName: string,
        public lastName: string, public age: number,  private _ssn: string) {
    }
}

var p = new Person("John", "Smith", 29, "123-90-4567");
```

When you use a constructor with access modifiers, the TypeScript compiler takes it as an instruction to create and retain the class properties matching the constructor's arguments. You don't need to explicitly declare and initialize them.

Both the short and long versions of the `Person` class generate the same JavaScript.

B.6.2 Methods

When a function is declared inside a class, we call it a *method*. In JavaScript you need to declare methods on the prototype of an object, but with a class you just declare a method by specifying a name followed by parentheses and curly braces, as you would in other object-oriented languages.

The next code snippet shows how you can declare and use a `MyClass` class with a `doSomething()` method that has one argument and no return value:

```
class MyClass{

   doSomething(howManyTimes: number): void{
      // do something here
   }
}

var mc = new MyClass();
mc.doSomething(5);
```

SIDEBAR

Static and instance members

The code of the preceding code sample, as well as the class shown in figure B.4, creates an instance of the class first and then accesses its members using a reference variable that points at this instance:

```
mc.doSomething(5);
```

If a class property or method were declared with the keyword `static`, its values would be shared between all instances of the class and you wouldn't need to create an instance to access static members. Instead of using a reference variable (such as `mc`) you'd use the name of the class:

```
class MyClass{

   static doSomething(howManyTimes: number): void{
      // do something here
   }
}

MyClass.doSometing(5);
```

If you instantiate a class and need to invoke a class method from within another method declared in the same class, you must use the `this` keyword (for example, `this.doSomething(5)`). In other programming languages, using `this` inside the class code is optional, but the TypeScript compiler will complain that it can't find the method if `this` isn't explicitly used.

Let's add public setter and getter methods to the `Person` class to set and get the value of `_ssn`.

```
class Person {

    constructor(public firstName: string,

        public lastName: string, public age: number,  private _ssn?: string) {     ❶
    }

    get ssn(): string{     ❷
        return this._ssn;
    }

    set ssn(value: string){     ❸
        this._ssn = value;
    }
}

var p = new Person("John", "Smith", 29);

p.ssn = "456-70-1234";     ❹

console.log("Last name: " + p.lastName + " SSN: " + p.ssn);
```

❶ In this version, we made the last argument of the constructor optional (_ssn?).

❷ This is a getter method.

❸ This is a setter method.

❹ We've assigned the value to _ssn after creating the instance of the Person object using the ssn setter.

In the preceding example, the getter and setter don't contain any application logic, but in real-world applications these methods would perform some validation. For example, the code in the getter and setter may check if the caller is authorized to get or set the value of `_ssn`.

NOTE	**JavaScript supports getters and setters** Getters and setters are supported in JavaScript as well, starting with the ES5 specification.

Note that inside the methods, we use the `this` keyword to access the property of the object. It's mandatory in TypeScript.

B.6.3 Inheritance

JavaScript supports prototypal *object-based* inheritance, where one object can use another object as a prototype. TypeScript has the keyword `extends` for inheritance of classes, like ES6 and other object-oriented languages. But during transpiling to JavaScript, the generated code uses the syntax of the prototypal inheritance.

Figure B.6 shows how to create an `Employee` class (line 9) that extends the class `Person` (shown in a screenshot from the TypeScript Playground).

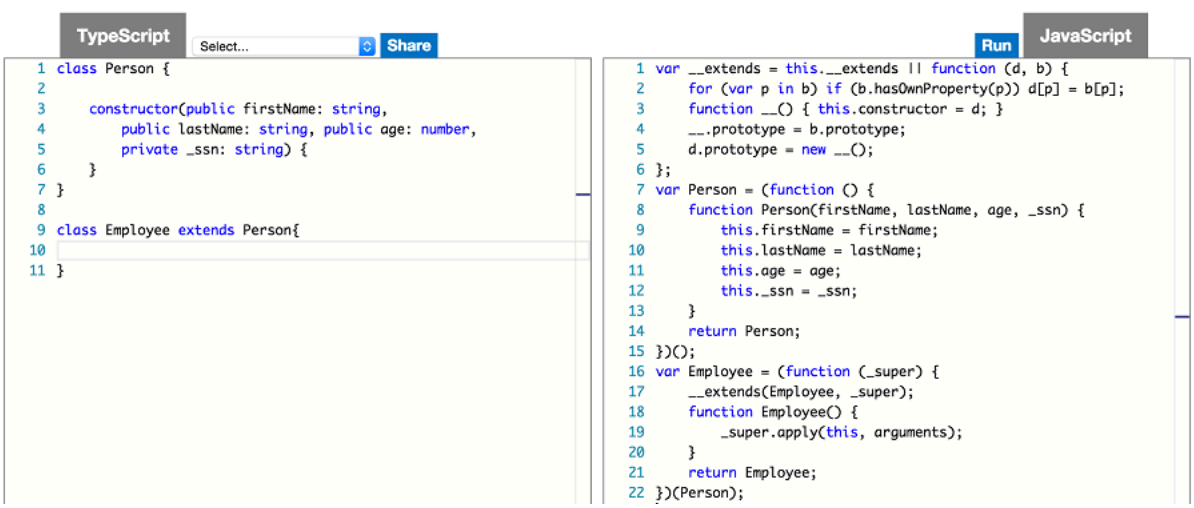


Figure B.6 Class inheritance in TypeScript

On the right side you can see the transpiled JavaScript version, which uses prototypal inheritance. The TypeScript version of the code is more concise and easier to read.

Let's add a constructor and a `department` property to the `Employee` class:

```
class Employee extends Person{
    department: string;  ❶

    constructor(firstName: string, lastName: string,
            age: number, _ssn: string, department: string){  ❷

        super(firstName, lastName, age, _ssn);  ❸

        this.department = department;
    }
}
```

❶ Declares a property department.

❷ Creates a constructor that has an additional department argument.

❸ A subclass that declares a constructor must invoke the constructor of the superclass.

If you invoke a method declared in a superclass on the object of the subclass type, you can just use the name of this method as if it were declared in the subclass. But sometimes you want to specifically call the method of the superclass, and this is when you should use the `super` keyword.

The `super` keyword can be used in two ways. In the constructor of a derived class, you invoke it as a method. You can also use the `super` keyword to specifically call a method of the superclass. It's typically used with method overriding. For example, if both a superclass and its descendant have a `doSomething()` method, the descendant can reuse the functionality programmed in the superclass and add some other functionality as well:

```
doSomething(){
    super.doSomething();

    // Add more functionality here
}
```

You can read more about the `super` keyword in appendix A in the section "The super keyword and the super function." We're halfway through this appendix, so let's take a little breather and review what we've learned so far.

- Even though you can write Angular applications using JavaScript's ES5 or ES6 syntax, using TypeScript has benefits during the development stage of your project.
- TypeScript allows you to declare the types of the primitive variables as well as to develop custom types. Transpilers erase the information about types, so your applications can be deployed in any browser that supports the syntax of ECMAScript 3, 5, or 6.

- The TypeScript compiler turns .ts files into their .js counterparts. You can start the compiler in watch mode so this transformation will be initiated on any change in any .ts file.
- TypeScript classes make the code more declarative. The concept of classes and inheritance is well known to developers who use other object-oriented languages.
- Access modifiers help in controlling access to class members during development, but they aren't as strict as they are in languages such as Java or C#.

We'll continue introducing more TypeScript syntax constructs starting in the next section, but if you're eager to see how TypeScript and Angular work together, feel free to jump to section B.9.

B.7 Generics

TypeScript supports parameterized types, also known as generics, which could be used in a variety of scenarios. For example, you can create a function that can take values of any type, but during its invocation in a particular context you can explicitly specify a concrete type.

Take another example: An array can hold objects of any type, but you can specify which particular object types (for example, instances of `Person`) are allowed in your array. If you (or someone else) were to try to add an object of a different type, the TypeScript compiler would generate an error.

The following code snippet declares a `Person` class, creates two instances of it, and stores them in the `workers` array declared with the generic type. Generic types are denoted by placing them in the angle brackets (for example, `<Person>`).

```
class Person {
    name: string;
}

class Employee extends Person{
    department: number;
}

class Animal {
    breed: string;
}

var workers: Array<Person> = [];

workers[0] = new Person();
workers[1] = new Employee();
workers[2] = new Animal();  // compile-time error
```

In this code snippet, we declare the `Person`, `Employee`, and `Animal` classes, and a `workers` array with the generic type `<Person>`. By doing this, we announce our plans to store only instances of the class `Person` or its descendants. An attempt to store an instance of an `Animal` in the same array will result in a compile-time error.

If you work in an organization that allows animal workers (such as police dogs) you can change the declaration of `workers` as follows:

```
var workers: Array<any> = [];
```

NOTE **Generics and interfaces**
You'll see another example of using generics in the section on interfaces. There we'll declare a `workers` array of the interface type.

Can you use generic types with any object or a function? No. The creator of the object or function has to allow this feature. If you open TypeScript's type definition file, lib.d.ts, on GitHub at http://mng.bz/I3V7 and search for "interface Array", you'll see the declaration of the `Array`, as shown in figure B.7. (Type definition files are explained in section B.10.)

```
1004 /////////////////////////////
1005 /// ECMAScript Array API (specially handled by compiler)
1006 /////////////////////////////
1007
1008 interface Array<T> {
1009     /**
1010       * Gets or sets the length of the array. This is a number one higher than the h
1011       */
1012     length: number;
1013     /**
1014       * Returns a string representation of an array.
1015       */
1016     toString(): string;
1017     toLocaleString(): string;
1018     /**
1019       * Appends new elements to an array, and returns the new length of the array.
1020       * @param items New elements of the Array.
1021       */
1022     push(...items: T[]): number;
1023     /**
1024       * Removes the last element from an array and returns it.
1025       */
1026     pop(): T;
1027     /**
1028       * Combines two or more arrays.
1029       * @param items Additional items to add to the end of array1.
1030       */
```

Figure B.7 The fragment of lib.d.ts describing the Array API

The `<T>` in line 1008 means that TypeScript allows you to declare a type parameter with `Array` and that the compiler will check for the specific type provided in your program. In our code example we specified this generic `<T>` parameter as `<Person>`. But because generics aren't supported in ES6, you won't see them in the code generated by the transpiler. It's just an additional safety net for developers at compile time.

You can see another `T` in line 1022 in figure B.7. When generic types are specified with function arguments, no angle brackets are needed. But there's no actual `T` type in TypeScript. The `T` here means that the `push` method allows you to push objects of a specific type into an array, as in the following example:

```
workers.push(new Person());
```

In this section we've illustrated just one use case for working with generic types with an array that already supports generics. You can create your own classes or functions that support generics as well. If somewhere in the code you try to invoke the function `saySomething()` and provide a wrong argument type, the TypeScript compiler will give you an error:

```
function saySomething<T>(data: T){

}

saySomething<string>("Hello");    ❶

saySomething<string>(123);    ❷
```

❶ Replaces T with a string

❷ Produces a compiler error because 123 is not a string

The generated JavaScript won't include any generic information, and the preceding code snippet will be transpiled into the following code:

```
function saySomething(data) {
}
saySomething("Hello");
saySomething(123);
```

If you'd like to learn about generics in depth, refer to the Generics section in the TypeScript Handbook (http://mng.bz/447K).

B.8 Interfaces

JavaScript doesn't support the concept of interfaces, which in other object-oriented languages are used to introduce a *code contract* that an API has to abide by. An example of a contact can be class X declaring that it implements interface Y. If class X won't include an implementation of the methods declared in interface Y, it's considered a violation of the contract and won't compile.

TypeScript includes the keywords `interface` and `implements` to support interfaces, but interfaces won't get transpiled into any JavaScript code. They just help you avoid using the wrong types during development.

In TypeScript there are two patterns for using interfaces:

- Declare an interface that defines a custom type containing a number of properties. Then declare a method that has an argument of such a type, and the compiler will check when this method is invoked that the object given as an argument includes all the properties declared in the interface.
- Declare an interface that includes abstract (non-implemented) methods, and when a class declares that it `implements` this interface, the class must provide an implementation for all the abstract methods.

Let's consider these two patterns by example.

B.8.1 Declaring custom types with interfaces

When you use JavaScript frameworks, you may run into an API that requires some sort of configuration object as a function parameter. To figure out which properties must be provided in this configuration object, you need to either open the documentation for the API or read the source code of the framework. In TypeScript you can simply declare an interface that includes all the properties, and their types, that must be present in a configuration object.

Let's see how this can be done in our `Person` class, which contained a constructor with four arguments: `firstName`, `lastName`, `age`, and `ssn`. This time we'll declare an `IPerson` interface that will contain the four members, and we'll modify the constructor of the `Person` class to use an object of this custom type as an argument.

```
interface IPerson {

    firstName: string;
    lastName: string;
    age: number;
    ssn?: string;     ❶
}

class Person  {


    constructor(public config: IPerson) {     ❷
    }
}


var aPerson: IPerson = {     ❸
    firstName: "John",
    lastName: "Smith",
    age: 29
}


var p = new Person(aPerson);     ❹
console.log("Last name: " + p.config.lastName );
```

❶ Declares an IPerson interface with ssn as an optional member (note the question mark).

❷ The class Person has a constructor with one argument of type IPerson.

❸ Creates an aPerson object literal with members compatible with IPerson.

4 Instantiates the Person object, providing an object of type IPerson as an argument.

TypeScript has a structural type system, which means that if two different types include the same members, the types are considered compatible. Having the same members means that the members have the same names and types. In the preceding code, even if we didn't specify the type of the `aPerson` variable, it still would be considered compatible with `IPerson` and could be used as a constructor argument while instantiating the `Person` object.

If you change the name or type of one of the members of `IPerson`, the TypeScript compiler will report an error. On the other hand, if you try to instantiate a `Person` that contains an object with all the required members of `IPerson` and some other members, it won't raise a red flag. You could use the following object as a constructor argument for a `Person`:

```
var anEmployee: IPerson = {
    firstName: "John",
    lastName: "Smith",
    age: 29,
    department: "HR"
}
```

The `department` member wasn't defined in the `IPerson` interface, but as long as the object has all other members listed in the interface, the contract terms are fulfilled.

The `IPerson` interface didn't define any methods, but TypeScript interfaces can include method signatures without implementations.

B.8.2 Using the implements keyword

The `implements` keyword can be used with a class declaration to announce that the class will implement a particular interface. Say we have an `IPayable` interface that's declared as follows:

```
interface IPayable{
  increase_cap:number;

  increasePay(percent: number): boolean
}
```

Now the `Employee` class can declare that it implements `IPayable`:

```
class Employee implements IPayable{

    // The implementation goes here
}
```

Before going into implementation details, let’s answer the question, “Why not just write all required code in the class rather than separating a portion of the code into an interface?”

Let’s say we need to write an application that will allow us to increase salaries for the employees of our organization. We can create an `Employee` class (that extends `Person`) and include the `increaseSalary()` method there. Then the business analysts may ask you to add the ability to increase pay to contractors that work for your firm. But contractors in our firm are represented by their company names and IDs; they have no notion of salary but are getting paid on an hourly basis.

You can create another class, `Contractor` (not inherited from `Person`), that includes some properties and an `increaseHourlyRate()` method. Now we have two different APIs: one for increasing the salary of employees, and another for increasing the pay for contractors.

A better solution is to create a common `IPayable` interface and have `Employee` and `Contractor` classes provide *different implementations* of `IPayable` for these classes, as illustrated in the following code sample.

```
interface IPayable{   ❶

  increasePay(percent: number): boolean
}

class Person {   ❷
    // properties are omitted for brevity

    constructor() {
    }
}

class Employee extends Person implements IPayable{   ❷

    increasePay(percent: number): boolean{   ❸

        console.log("Increasing salary by " + percent)
        return true;
    }
}

class Contractor implements IPayable{
    increaseCap:number = 20;   ❹

    increasePay(percent: number): boolean{   ❺
        if (percent < this.increaseCap) {
            console.log("Increasing hourly rate by " + percent)
            return true;
        } else {
            console.log("Sorry, the increase cap for contractors is", this.increaseCap);
            return false;
        }
    }
}
```

```
var workers: Array<IPayable> = [];
workers[0] = new Employee();
workers[1] = new Contractor();

workers.forEach(worker => worker.increasePay(30));
```

1. The IPayable interface includes the signature of the increasePay() method that will be implemented by the Employee and Contractor classes.
2. The Person class serves as a base class for Employee.
3. The Employee class inherits from Person and implements the IPayable interface. A class can implement multiple interfaces.
4. The Employee class implements the increasePay() method. The salary of an employee can be increased by any amount, so the method just prints the message on the console and returns true (allowing the increase).
5. The Contractor class includes a property that places a cap of 20% on pay increases.
6. The implementation of increasePay() in the Contractor class is different. Invoking increasePay() with an argument that's more than 20 results in the "Sorry" message and it returns false.
7. Declaring the array with the <IPayable> generic allows us to place any objects of the IPayable type there (but see the following note).
8. Now we can invoke the increasePay() method on any object in the workers array. Note that we don't use parentheses with the arrow function expression that has a single worker argument.

Running the preceding code sample produces the following output on the browser's console:

```
Increasing salary by 30
Sorry, the increase cap for contractors is 20
```

NOTE **Why declare classes with the `implements` keyword**

The preceding code sample illustrates the structural subtyping of TypeScript. If you remove `implements Payable` from the declaration of either `Employee` or `Contractor`, the code will still work and the compiler won't complain about lines that add these objects to the `workers` array. The compiler is smart enough to see that even if the class doesn't explicitly declare `implements IPayable`, it implements `increasePay()` properly. But if you remove `implements IPayable` and try to change the signature of the `increasePay()` method from any of the classes, you won't be able to place such an object into the `workers` array, because that object would not be of the `IPayable` type any longer. Also, without the `implements` keyword, the IDE support (such as for refactoring) will be broken.

B.8.3 Using callable interfaces

TypeScript has an interesting feature known as a *callable interface* that contains a bare function signature (a signature without a function name). The following example shows a bare function signature that takes one parameter of type `number` and returns a `boolean`.

```
(percent: number): boolean;
```

The bare function signature indicates that the instance of the interface is callable. In the following example we'll show you a different version of declaring `IPayable`, which will contain a bare function signature. For brevity we've removed the inheritance in this example. We'll declare separate functions that implement rules for pay increase for employees and contractors. These functions will be passed as arguments and invoked by the constructor of the `Person` class.

```
interface IPayable {    ❶
    (percent: number): boolean;
}

class Person  {

    constructor(private validator: IPayable) {    ❷
    }

    increasePay(percent: number): boolean {    ❸
        return this.validator(percent);
    }
}

var forEmployees: IPayable = (percent) => {    ❹
        console.log("Increasing salary by ", percent);
        return true;
    };
```

```
var forContractors: IPayable = (percent) => {    ❺
    var increaseCap: number = 20;

    if (percent < increaseCap) {
            console.log("Increasing hourly rate by", percent);
            return true;
        } else {
            console.log("Sorry, the increase cap for contractors is ", increaseCap);
            return false;
        }
}

var workers: Array<Person> = [];

workers[0] = new Person(forEmployees);    ❻
workers[1] = new Person(forContractors);

workers.forEach(worker => worker.increasePay(30));    ❼
```

❶ A callable interface that include a bare function signature.

❷ The constructor of the Person class takes an implementation of the callable interface IPayable as an argument.

❸ The increasePay() method invokes the bare function on the passed implementation of IPayable, supplying the pay increase value for validation.

❹ The rules for salary increases for employees are implemented using the arrow function expression.

❺ The rules for pay increases for contractors are implemented using the arrow function expression.

❻ Instantiates two Person objects, passing different rules for pay increases.

❼ Invokes increasePay() on each instance, validating the 30% pay increase.

Running the preceding code will generate the following output on the browser's console:

```
Increasing salary by 30
Sorry, the increase cap for contractors is 20
```

Interfaces support inheritance with the `extends` keyword. If a class implements interface A that's extended from interface B, the class must implement all members from A and B.

SIDEBAR **Treating classes as interfaces**

In TypeScript you can think of any class as an interface. If you declared `class A {}` and `class B {}`, it's perfectly legal to write `class A implements B {}`. You'll see an example of this syntax in chapter 4 in the "Switching injectables made easy" section.

TypeScript interfaces don't generate any output when transpiled to JavaScript, and if you place just an interface declaration into a separate file (such as ipayable.ts) and compile it with tsc, it will generate an empty ipayable.js file. If you load the code that imports the interface from a file (such as from ipayable.js) using SystemJS, you'll get an error because you can't import an empty file. You'll need to let SystemJS know that it has to treat `IPayable` as a module and register it in the global System registry. This can be done while configuring SystemJS by using the `meta` annotation, as shown next:

```
System.config({
  transpiler: 'typescript',
  typescriptOptions: {emitDecoratorMetadata: true},
  packages: {app: {defaultExtension: 'ts'}},
  meta: {
    'app/ipayable.ts': {
      format: 'es6'
    }
  }
```

Besides providing a way to create custom types and minimize the number of type-related errors, the mechanism of interfaces greatly simplifies the implementation of the Dependency Injection design pattern explained in chapter 4.

This concludes our brief introduction to interfaces. You can find more details in the "Interfaces" section of the TypeScript Handbook (http://mng.bz/spm7).

NOTE **A tool for documenting TypeScript code**

The TypeDoc utility is a convenient tool for generating program documentation based on the comments in your TypeScript code. You can get it at www.npmjs.com/package/typedoc.

We're almost done with this TypeScript syntax overview and it's time to bring TypeScript and Angular together.

B.9 Adding class metadata with annotations

There are different definitions of the term *metadata*. The popular definition is that metadata is data about data. We'll think of metadata as data that describes some code. TypeScript decorators provide a way to add metadata to the code. In particular, to turn a TypeScript class into an Angular component, you can *annotate* it with metadata. Annotations start with an `@` sign.

To turn a TypeScript class into an Angular UI component, you need to decorate it with the `@Component` annotation. Angular will internally parse your annotations and will generate code that adds the requested behavior to the TypeScript class.

```
@Component({
  // Include here the selector (the name) to identify
  // the component in the HTML document.

  // Provide the template property with the
  // HTML fragment to render the component.
  // Component styling also goes here.
})
class HelloWorldComponent {
  // The code implementing the component's
  // application logic goes here.
}
```

When you use annotations, there should be an annotation processor that can parse the annotation content and turn it into code that the runtime (the browser's JavaScript engine) understands. In the context of this book, Angular's compiler ngc performs the duties of the annotation processor.

To use the annotations supported by Angular, you need to import their implementation in your application code. For example, you need to import the `@Component` annotation from the Angular module:

```
import { Component } from 'angular2/core';
```

Although the implementation of these annotations is done inside Angular, you may want a standardized mechanism for creating your own annotations. This is what TypeScript *decorators* are for. Think of it this way: Angular offers you its annotations that allow you to decorate your code, but TypeScript allows you to create your own annotations with the support of decorators.

B.10 Type definition files

For several years, a large repository of TypeScript definition files called *DefinitelyTyped* was the only source of TypeScript type definitions for the new ECMAScript API and for hundreds of popular frameworks and libraries written in JavaScript. The purpose of these files is to let the TypeScript compiler know the types expected by the APIs of these libraries. Although the http://definitelytyped.org repository still exists, npmjs.org became a new repository for type definition files, and we use it in all the code samples in this book.

The suffix of any definition filename is *d.ts*, and you can find the definition files in Angular modules in the subfolders of the node_modules/@angular folder after running `npm install` as explained in chapter 2. All required *.d.ts files are bundled with Angular npm packages, and there's no need to install them separately. The presence of the definition files in your project will allow the TypeScript compiler to ensure that your code uses the correct types while invoking the Angular API.

For example, Angular applications are launched by invoking the `bootstrapModule()` method, giving it the root module for your application as an argument. The application_ref.d.ts file includes the following definition for this function:

```
bootstrapModule<M>(moduleType: ConcreteType<M>, compilerOptions?: CompilerOptions | CompilerOptions[]):
```

By reading the above definition, we (and the tsc compiler) know that this function can be invoked with one mandatory parameter of type `ConcreteType` and an optional array of compiler options. If the application_ref.d.ts file wasn't a part of your project, TypeScript's compiler would allow you to invoke the `bootstrapModule` function with a wrong parameter type, or without any parameters at all, which would result in a runtime error. But the application_ref.d.ts file is present, so TypeScript would generate a compile-time error that reads "Supplied parameters do not match any signature of call target."

Type definition files also allow IDEs to show context-sensitive help as you're writing code that invokes Angular functions or assigns values to objects' properties.

B.10.1 Installing type definition files

To install TypesScript type definition files for a library or framework written in JavaScript, developers have used type definition managers: tsd and Typings. The former was deprecated, as it only allowed you to get *.d.ts files from definitelytyped.org. Prior to the release of TypeScript 2.0, we used Typings (https://github.com/typings/typings), which allowed us to bring in type definitions from an arbitrary repository.

With the release of TypeScript 2.0, there's no need to use type definition managers for npm-based projects. Now the npmjs.org npm repository includes a @types organization that stores type definitions for the popular JavaScript libraries. All libraries from definitelytyped.org are published there.

Let’s say you need to install a type definitions file for jQuery. Running the following command will install the type definitions in the node_modules/@types directory and will save this dependency in the package.json file of your project:

```
npm install @types/jquery --save-dev
```

In this book we’ll install type definitions using similar commands in many sample projects. For example, ES6 has introduced the `find()` method for arrays, but if your TypeScript project is configured to use ES5 as a target for compilation, your IDE will highlight the `find()` method in red because ES5 didn’t support it. Installing the type definition files for es6-shim will get rid of the redness in your IDE:

```
npm i @types/es6-shim --save-dev
```

SIDEBAR **What if tsc can’t find the type definition file**

At the time of writing (TypeScript 2.0) there’s a chance that tsc won’t find type definition files located in the node_modules/@types directory. If you run into this issue, add the required files to the `types` section of your tsconfig.json. Here’s an example:

```
"compilerOptions": {
    ...
  "types":["es6-shim", "jasmine"],
}
```

SIDEBAR **Module resolution and the reference tag**

Unless you use CommonJS modules, you’ll need to explicitly add a reference to your TypeScript code pointing at the required type definitions, like this:

```
/// <reference types="typings/jquery.d.ts" />
```

We use CommonJS modules as a tsc option, and each project includes the following option in the tsconfig.json file:

```
"module": "commonjs"
```

When tsc sees an import statement referring to some module, it automatically tries to find the <module-name>d.ts file in the node_modules directory. If that’s not found, it goes one level up and repeats the process. You can read more about this in the "Typings for npm modules" section in the TypeScript Handbook (http://mng.bz/ih4z). In upcoming releases of tsc, the same strategy will be implemented for AMD module resolution.

Angular includes all required definition files, and you don't need to use any type definition manager unless your application uses other third-party JavaScript libraries. In this case, you need to install their definition files manually to get context-sensitive help in your IDE.

Angular uses the ES6 syntax in its d.ts files, and for most modules you can simply use the following import syntax: `import {Component} from 'angular2/core';`. The definition of the `Component` class will be found. You'll be importing all other Angular modules and components.

CONTROLLING CODE STYLE WITH TSLINT

TSLint is a tool that allows you to ensure that your programs are written according to specified rules and coding styles. You can configure TSLint to check that the TypeScript code in your project is properly aligned and indented, that the names of all interfaces start with a capital *I*, that class names use CamelCase notation, and so on.

You can install TSLint globally using the following command:

```
npm install tslint -g
```

To install the TSLint node module in your project directory, run the following command:

```
npm install tslint
```

The rules that you want to apply to your code are specified in a tslint.json configuration file. A sample rules file comes with TSLint. The file's name is sample.tslint.json, and it's located in the docs directory. You can turn specific rules on or off as needed.

For details on using TSLint, visit www.npmjs.com/package/tslint. Your IDE may support linting with TSLint out of the box.

SIDEBAR **IDEs**

We want to make the content of this book IDE-agnostic, and we won't include instructions specific to any IDE. But several IDEs support TypeScript. The most popular are WebStorm, Visual Studio Code, Sublime Text, and Atom. All these IDEs and editors work under Windows, Mac OS, and Linux. If you develop your TypeScript/Angular applications on a Windows computer, you can use Visual Studio 2015.

B.11 An overview of the TypeScript/Angular development process

The process of developing and deploying TypeScript/Angular applications consists of multiple steps, which should be automated as much as possible, and there are multiple ways to do that. The following is a sample list of steps that could be performed to create an Angular application:

1. Create a directory for your project.
2. Create a package.json file that lists all your application dependencies, such as Angular packages, Jasmine testing frameworks, and so on.
3. Install all the packages and libraries listed in package.json using the command `npm install`.
4. Write the application code.
5. Load your application into the browser with the help of the SystemJS loader, which not only loads, but also transpiles TypeScript into JavaScript in the browser.
6. Minimize and bundle your code and resources with the help of Webpack and its plugins.
7. Copy all the files into the distribution directory using the npm scripts.

Chapter 2 explains how to start a new Angular project and work with the npm package manager and the SystemJS module loader.

NOTE **Angular-CLI**
Angular-CLI is a command-line utility that can scaffold your project, generate components and services, and prepare builds. At the time of this writing, Angular-CLI is still a work in progress, so we don't use it in this book.

NOTE **Error handling**
We haven't mentioned the subject of error handling in this chapter, but because TypeScript is a superset of JavaScript, the error handling is done the same way as in JavaScript. You can read about different types of errors in the JavaScript Reference article on the `Error` constructor, on the Mozilla Developer Network (http://mng.bz/FwfO).

B.12 Summary

In this appendix we've shown you how to use the TypeScript compiler and type definition files. We've introduced the main elements of the TypeScript language as well as the process of writing and transpiling TypeScript code into JavaScript. We've also provided a brief overview of the tooling required for developing Angular applications in TypeScript. These are the main takeaways from this appendix:

- Developing in TypeScript increases productivity.
- TypeScript is more declarative than JavaScript and is easier to read and write.

- Using transpilers eliminates the dependency on the browsers' support for the latest JavaScript specifications.
- TypeScript is a preferred language for writing Angular applications.