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OpenLayers 3

Get started with OpenLayers 3 and enhance your web pages by creating and displaying dynamic maps

Beginner's Guide

Thomas Gratier
Erik Hazzard

Paul Spencer

[PACKT] open source*
PUBLISHING community experience distilled

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BIRMINGHAM - MUMBAI

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I'd like to thank the OpenLayers developers and contributors for developing this powerful web-mapping framework that works well for both simple and complex use cases. My thanks go to Packt Publishing's editing team for their knowledge and input to write this book. Without their invaluable help to keep me on track, this book could not have been completed. I would also like to thank Erik Hazzard, the author of the initial book, *OpenLayers 2.10 Beginner's Guide*, Packt Publishing. His version has been useful as a starting base. I'd like to thank Paul Spencer, my co-author for his fruitful collaboration despite time-zone constraints. It has been a real pleasure to share ideas on similar interests. His experience and insights have been invaluable to complete the task of writing my first book. My thanks go to my family and friends for their constant support, time, and kind understanding through the years.

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I would like to thank my wife and son, without whose support and encouragement, I would not have been able to write this book.

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I would like to thank my girlfriend, Elena Cedillo, for her continuous support and love.

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Arnaud Vandecasteele is a map lover and an open source / open data evangelist. After his PhD in computer science and GIS, he decided to move to Canada to conduct research on OpenStreetMap and to promote the use of Open Source GIS software. His experience with OpenLayers started from the very beginning of the library in 2006. From his website (<http://geotribu.net>), he wrote several tutorials to help beginners to use OpenLayers. Currently, Arnaud runs a GIS consultancy firm called Mapali (<http://mapali.re/>) that creates online mapping applications and provides consultancy services in the fields of web cartography and online GIS using open source software to a wide range of clients in the Indian Ocean (Réunion island, Mauritius).

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Preface

Web mapping is the process of designing, implementing, generating, and delivering maps on the Web and its products. OpenLayers is a powerful, community-driven, open source, pure JavaScript web mapping library. With this, you can easily create your own web map mashup using a myriad of map backends. Interested in knowing more about OpenLayers?

This book is going to help you learn OpenLayers from scratch. *OpenLayers 3 Beginner's Guide* will walk you through the OpenLayers library in the easiest and most efficient way possible. The core components of OpenLayers are covered in detail, with examples, structured so that you can easily refer back to them later.

The book starts off by showing you how to create a simple map and introduces you to some basic JavaScript programming concepts and tools. You will also find useful resources to learn more about HTML and CSS. Through the course of this book, we will review each component needed to make a map in OpenLayers 3, and you will end with a full-fledged web map application.

You will learn some context to help you understand the key role of each OpenLayers 3 component in making a map. You will also learn important mapping principles such as projections and layers. Maps require sources of data as well; so, you will see how to create your own data files and connect to backend servers for mapping. A key part of this book will also be dedicated to building a mapping application for mobile devices and its specific components.

With *OpenLayers 3 Beginner's Guide*, you will learn how to create your own map applications independently, without being stuck at the first stage of learning. You will acquire the information you need to develop your skills and knowledge of the OpenLayers 3 library.

What this book covers

Chapter 1, Getting Started with OpenLayers will introduce you to OpenLayers 3 and will help you to learn some basic mapping principles. You will see how to get ready for development in OpenLayers and create your first map.

Chapter 2, Key Concepts in OpenLayers will introduce the main components of the OpenLayers library and illustrate how they are related. We will introduce some key concepts, including events and observable properties, and learn some basic debugging techniques.

Chapter 3, Charting the Map Class will describe two of the core components, the Map and View classes, in detail. We will learn about the properties, methods, and events of both classes and apply them in practical examples.

Chapter 4, Interacting with Raster Data Source will introduce the concept of layers and focus on raster layers. We will explain the difference between tiled and untiled layers and learn how to use OpenLayers to visualize any type of image, even non-geospatial ones.

Chapter 5, Using Vector Layers will introduce vector layers and the related source, format, feature, and geometry classes. We will learn the properties, methods, and events associated with each, and how to use them to load a variety of vector data into an OpenLayers map.

Chapter 6, Styling Vector Layers will expand on our knowledge of vector layers by learning how to apply both static and dynamic styles to them. Through hands-on examples, we'll learn how to modify styles interactively in response to user interaction.

Chapter 7, Wrapping Our Heads Around Projections will cover the basic concepts behind map projections and their characteristics. We will cover projection support within OpenLayers by introducing the Proj4js library and applying it to map, vector, and raster layers.

Chapter 8, Interacting with Your Map will dive into the concept of interactions and introduce the default interactions. After covering the available interactions in detail, we will finish with an example showing how to use interactions to draw a rectangle.

Chapter 9, Taking Control of Controls will demonstrate the use of controls and introduce the default controls provided by OpenLayers. We will also review each of the controls in more detail and learn how to make a custom control.

Chapter 10, OpenLayers Goes Mobile will teach us to take advantage of mobile-specific features such as Geolocation and Device Orientation. We will also learn how to debug mobile web applications and look at some mobile-specific browser features that can be useful for geospatial applications.

Chapter 11, Creating Web Map Apps will build a complete application from scratch and learn how to use the OpenLayers build system to create a production-ready application from our code.

Appendix A, Object-oriented Programming – Introduction and Concepts covers the main concepts of **Object-oriented Programming (OOP)**. After, we will discover how to reuse them exploring the OpenLayers API documentation with OOP in mind.

Appendix B, More details on Closure Tools and Code Optimization Techniques will cover more details on Closure Tools and code optimization techniques. This appendix introduces Closure Tools, a set of tools that OpenLayers 3 library relies on. It provides an understanding on how to use the Closure Library and Closure Compiler with a focus on compressing OpenLayers code files. We will finish with a review of styles and syntax for good coding practices.

Appendix C, Squashing Bugs with Web Debuggers provides JavaScript beginners with an in-depth review of browser developer tools. We will review Chrome Developer Tools, additional extensions and finish with debugging tools in other browsers such as IE and Firefox.

What you need for this book

The main thing you'll need for this book is a computer and text editor. Your operating system will come with a text editor, any will do, but you will likely find that a text editor focused on developer needs will be most useful. There are many excellent developer-oriented text editors available for various operating systems, see <https://github.com/showcases/text-editors> and https://en.wikipedia.org/wiki/List_of_text_editors for some options. An Internet connection will be required to view the maps, and you'll also need a recent version of a modern web browser, such as Firefox, Google Chrome, Safari, Opera, or Internet Explorer (version 9 or higher).

For some advanced uses cases, you will also need Python, NodeJS, Java, and Git (a source code control management software). Installation instructions are provided for these additional tools.

No knowledge of Geographic Information Systems (GIS) is required, nor is extensive JavaScript experience. A basic understanding of JavaScript syntax and HTML/CSS will greatly aid in understanding the material, but is not required.

Who this book is for

This book is for anyone who has an interest in using maps on their website, from hobbyists to professional web developers. OpenLayers provides a powerful, but easy-to-use, pure JavaScript and HTML (no third-party plug-ins involved) toolkit to quickly make cross-browser web maps. A basic understanding of JavaScript will be helpful, but there is no prior knowledge required to use this book. If you've never worked with maps before, this book will introduce you to some common mapping topics and gently guide you through the OpenLayers 3 library. If you're an experienced application developer, this book will also serve as a reference to the core components of OpenLayers 3.

Sections

In this book, you will find several headings that appear frequently (Time for action, What just happened?, Pop quiz, and Have a go hero).

To give clear instructions on how to complete a procedure or task, we use these sections as follows:

Time for action – heading

1. Action 1
2. Action 2
3. Action 3

Instructions often need some extra explanation to ensure they make sense, so they are followed with these sections:

What just happened?

This section explains the working of the tasks or instructions that you have just completed.

You will also find some other learning aids in the book, for example:

Pop quiz – heading

These are short multiple-choice questions intended to help you test your own understanding.

Have a go hero – heading

These are practical challenges that give you ideas to experiment with what you have learned.

Conventions

In this book, you will find a number of styles of text that distinguish between different kinds of information. Here are some examples of these styles, and an explanation of their meaning.

Code words in text, folder names, filenames, file extensions, pathnames, URLs, and user input are shown as follows: "You can name the folder whatever you like, but we'll refer to it as the `sandbox` folder."

A block of code is set as follows:

```
var map = new ol.Map({
  target: 'map',
  layers: [layer],
  view: view
});
```

When we wish to draw your attention to a particular part of a code block, the relevant lines or items are set in bold:

```
var map = new ol.Map({
  target: 'map',
  view: view,
  layers: [layer],
  renderer: 'dom'
});
```

Any command-line input or output is written as follows:

```
weinre -boundHost <your ip address>
```

New terms and **important words** are shown in bold. Words that you see on the screen, in menus or dialog boxes for example, appear in the text like this: "You can do this in several ways but the easiest is to load your page into a web browser and look at the **Network** tab".

 Warnings or important notes appear in a box like this.

 Tips and tricks appear like this.

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1

Getting Started with OpenLayers

Within the past few years, the popularity of interactive web maps has exploded. In the past, creating interactive maps was reserved for large companies or experts with lots of money. But now, with the advent of free services such as Google and Bing Maps, online mapping is easily accessible to everyone. Today, with the right tools, anyone can easily create a web map with little or even no knowledge of geography, cartography, or programming.

Web maps are expected to be fast, accurate, and easy to use. Since they are online, they are expected to be accessible from anywhere on nearly any platform. There are only a few tools that fulfill all these expectations. OpenLayers is one such tool. It's free, open source, and very powerful. Providing both novice developers and seasoned GIS professionals with a robust library, OpenLayers makes it easy to create modern, fast, and interactive web-mapping applications for desktop and mobile.

In this chapter, we will:

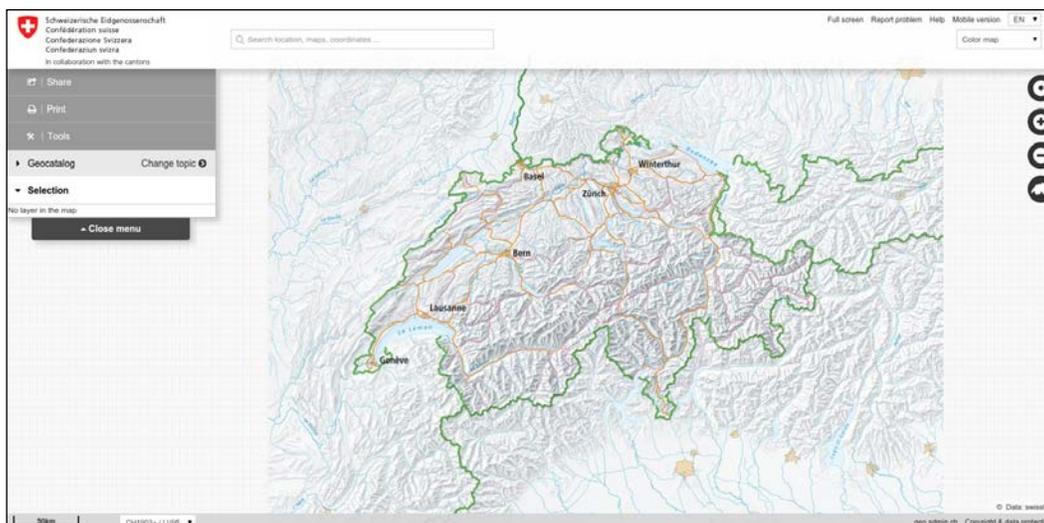
- ◆ Learn in detail about OpenLayers
- ◆ Discuss some web mapping application concepts
- ◆ Make our first map
- ◆ Provide information on resources

Introducing OpenLayers

OpenLayers is an open source, client-side JavaScript library for making interactive web maps, viewable in nearly any web browser. Since it is a client-side library, it requires no special server-side software or settings—you can use it without even downloading anything! Originally developed by MetaCarta as a response, in part, to Google Maps, the 2.x series of the library has grown into a mature, popular framework with many passionate developers and a very helpful community. At the time of writing, this version is still actively used and maintained, but this book will focus on the latest version, which is 3.0. For people wishing to switch to OpenLayers 3, particularly people already using the OpenLayers 2 series, the main reasons to change are:

- ◆ OpenLayers 2 was released eight years back, and it has its design flaws. As the first main open source mapping library, its conception has been done along the way with web evolution, particularly with JavaScript. Due to these facts, code modularity suffered and it was becoming impossible to make new evolutions.
- ◆ OpenLayers 3 provides out-of-the-box mobile support.
- ◆ The library ability to easily incorporate animation.
- ◆ The Canvas renderer by default, which is more efficient than the DOM renderer bundled in OpenLayers 2.x, and the WebGL support in the roadmap, enabling a more powerful map display than Canvas.
- ◆ Increased performance and build size using Closure Compiler.
- ◆ The maintenance mode on OpenLayers 2 series that will limit your application for future usages.

You can also add the fact that the library is already used in production, that demonstrates good performance at the Swiss federal geoportal, <http://map.geo.admin.ch> (see screenshot for reference) and the OpenGeo Suite, a commercial open source based solution which already bundles the library:



Advantages of using OpenLayers

OpenLayers makes creating powerful web mapping applications easy and fun. It is very simple to use—you don't even need to be a programmer to make a great map with it. It's open source, free, and has a strong community behind it. A big advantage of OpenLayers is that you can integrate it into any closed or open source application because it is released under the BSD 2-Clause license. So, if you want to dig into the internal code, or even improve it, you're encouraged to do so. Cross browser compatibility is handled for you by the Google Closure Library— but you need to have IE9+ because VML rendering (specific to IE8 and older versions) is no longer supported. Furthermore, OpenLayers 3.0 supports modern mobile, touch devices making it easy to develop for mobile technology.

OpenLayers is not tied to any proprietary technology or company, so you don't have to worry much about your application breaking with third party code (unless you break it). Although it's open source, you will get good support from the community and there are commercial support options as well. The library is recognized as well —established by the **OSGeo (Open Source Geospatial Foundation)**, having passed through the OSGeo Incubation process, a kind of open source quality mark for geospatial projects.


 You can read further about OSGeo Incubation at http://wiki.osgeo.org/wiki/Incubation_Committee

OpenLayers allows you to build entire mapping applications from the ground up, with the ability to customize every aspect of your map—layers, controls, events, and so on. You can use a multitude of different map server backends together, including a powerful vector layer. It makes creating map mashups extremely easy.

What, technically, is OpenLayers?

We said OpenLayers is a client-side JavaScript library, but what does this mean? The following context answers this question.

Client side

When we say client-side, we are referring to the user's computer, specifically their web browser. The only thing you need to make OpenLayers work is the OpenLayers code itself and a web browser. You can either download it and use it on your computer locally, or download nothing and simply link to the JavaScript file served on the site that hosts the OpenLayers project (<http://openlayers.org>). OpenLayers works on nearly all modern web browsers and can be served by any web server or your own computer. Using a modern, standard based browser such as Firefox, Google Chrome, Safari, or Opera is recommended.

Library

When we say library, we mean that OpenLayers is a map engine that provides an **API (Application Program Interface)** that can be used to develop your own web maps. Instead of building a mapping application from scratch, you can use OpenLayers for the mapping part, which is maintained and developed by a bunch of brilliant people.

For example, if you'd want to write a blog, you could either write your own blog engine, or use an existing one such as WordPress or Drupal and build on top of it. Similarly, if you'd want to create a web map, you could either write your own from scratch, or use software that has been developed and tested by a group of developers with a strong community behind it.

By choosing to use OpenLayers, you do have to learn how to use the library (or else you wouldn't be reading this book), but the benefits greatly outweigh the costs. You get to use a rich, highly tested, and maintained code base, and all you have to do is learn how to use it. Hopefully, this book will help you with it.

OpenLayers is written in JavaScript, but don't fret if you don't know it very well. All you really need is some knowledge of the basic syntax, and we'll try to keep things as clear as possible in the code examples.

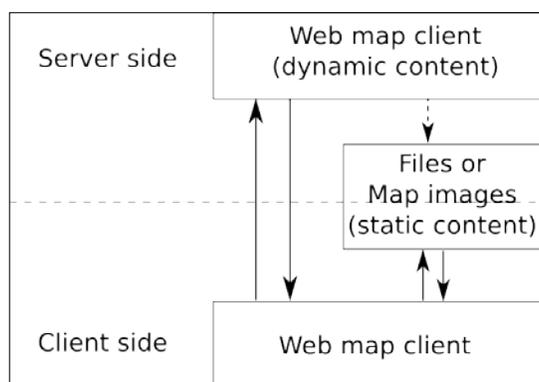


If you are unfamiliar with JavaScript, Mozilla provides phenomenal JavaScript documentation at <https://developer.mozilla.org/en/javascript>. We should also visit Eloquent JavaScript at <http://eloquentjavascript.net>, an online book to get started with the JavaScript language. We recommend you also do some interactive exercises at Codecademy, <http://codecademy.com>, a website dedicated to learn JavaScript programming basics and much more.

Anatomy of a web mapping application

First off, what is a web-mapping application? To put it bluntly, it's some type of Internet application that makes use of a map. This could be a site that displays the latest geo-tagged images from Flickr (we'll do this in *Chapter 11, Creating Web Map Apps*), a map that shows markers of locations you've traveled to, or an application that tracks invasive plant species and displays them. If it contains a map and it does something, you could argue that it is a web map application. The term can be used in a pretty broad sense.

So, where exactly does OpenLayers fit in? We know OpenLayers is a client-side mapping library, but what does that mean? Let's take a look at the following figure:



This is called the client/server model and it is, essentially, the core of how all web applications operate. In the case of a web map application, some sort of map client (for example: OpenLayers) communicates with some sort of web map server (for example: a map server using the **WMS (Web Map Service)** standard, an OpenStreetMap backend, or some satellite images). We've added a bit of complexity in it because the truth is that you can also rely only on client-side for web mapping applications using static content that you have pre-generated. To illustrate, you can use GeoJSON files, a JSON based format to display pins. For example, it is very useful for mobile content.

Web map client

OpenLayers lives on the client-side. One of the primary tasks the client performs is to get map images from a map server. Essentially, the client asks a map server for what you want to look at. Every time you navigate or zoom around on the map, the client has to make new requests to the server—because you're asking to look at something different.

OpenLayers handles this all for you, and it is happening via **AJAX (asynchronous JavaScript + XML)** calls to a map server. Refer to [http://en.wikipedia.org/wiki/Ajax_\(programming\)](http://en.wikipedia.org/wiki/Ajax_(programming)) for further information on AJAX. To reiterate—the basic concept is that OpenLayers sends requests to a map server for map data every time you interact with the map, then OpenLayers pieces together all the returned map data (which might be images or vector data) so it looks like one big, seamless map. In *Chapter 2, Key Concepts in OpenLayers*, we'll cover this concept in more depth.

Web map server

A map server (or map service) provides the map itself. There are a myriad of different map server backends. The examples include:

- ◆ The map servers using WMS and WFS standards (such as the GeoServer, Mapserver, and so on)
- ◆ Proprietary backends provided such as Bing Maps or Esri's ArcGIS Online, mainly based on proprietary data
- ◆ Backends based on OpenStreetMap data such as the official OpenStreetMap, Stamen maps, or MapQuest maps

If you are unfamiliar with these terms, don't sweat it. The basic principle behind all these services is that they allow you to specify the area of the map you want to look at (by sending a request), and then the map servers send back a response containing the map image. With OpenLayers, you can choose to use as many different backends in any sort of combination as you'd like.



OpenLayers is not a web map server; it only consumes data from them. So, you will need access to some type of WMS. Don't worry about it though. Fortunately, there are a myriad of free and/or open source web map servers available that are remotely hosted or easy to set up yourself, such as MapServer. We speak a lot about web map servers but you must be aware that depending on your web-mapping application, you can use geographic data files to provide the needed data consumed by OpenLayers.

Throughout this book, we'll often use a freely available web-mapping service from <http://www.openstreetmap.org/>, so don't worry now about having to provide your own.

With many web map servers, you do not have to do anything to use them—just supplying a URL to them in OpenLayers is enough. OSGeo, OpenStreetMap, Google, Here Maps, and Bing Maps, for instance, provide access to their map servers (although some commercial restrictions may apply with various services in some situations).

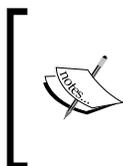
Connecting to Google, Bing Maps, and other mapping APIs

The Google, Yahoo!, Bing, and ESRI's Mapping APIs allow you to connect with their map server backend. Their APIs also usually provide a client-side interface.

The Google Maps API, for instance, is fairly powerful. You have the ability to add markers, plot routes, and use KML data (things you can also do in OpenLayers)—but the main drawback is that your mapping application relies totally on Google. The map client and map server are provided by a third party. This is not inherently a bad thing, and for many projects, Google Maps and the others like it, are a good fit.

However, there are quite a few drawbacks such as:

- ◆ You're not in control of the backend
- ◆ You can't really customize the map server backend, and it can change any time
- ◆ There may be commercial restrictions, or some costs involved for consuming maps images or other services such as geocoding or routing for car traffic
- ◆ These other APIs also cannot provide you with anything near the amount of flexibility and customization that an open source mapping application framework (that is, OpenLayers) offers



Although we mentioned Google Maps API as one of the main maps, its support in OpenLayers is limited. As there are more tiles providers nowadays, it's not worth it to have code maintenance to support Google Maps API, a third party code that can break the main library, as sometimes happened earlier with the OpenLayers 2 API.

Layers in OpenLayers

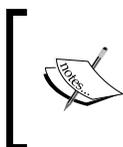
So, what's with the layers in OpenLayers? Well, OpenLayers allows you to have multiple different backend servers that your map can use. To access a web map server, you declare a layer and add it to your map with OpenLayers.

For instance, if you wanted to have a Bing Maps and an OpenStreetMap service displayed on your map, you would use OpenLayers to create a layer referencing Bing Maps and another one for OpenStreetMap, and then add them to your OpenLayers map. We'll soon see an example with an OpenStreetMap layer, so don't worry if you're a little confused.

Understanding a layer

Like layers of an onion, each layer is above and will cover up the previous one; the order that you add in the layers is important. With OpenLayers, you can arbitrarily set the overall transparency of any layer, so you are easily able to control how many layers cover each other up, and dynamically change the layer order at any time.

Most of the time, you make a distinction between base layers and non-base layers. Base layers are layers below the others and are used as a background on your maps to give general context. When you choose one base layer, the others will not be shown. On the top of base layers, you have non-base layers used to emphasize particular topics. You can also choose to use only overlay layers if you're considering that they are enough to understand the map. As a classical example, you could have a Bing map as your base layer, a layer with satellite imagery that is semi-transparent, and a vector layer, all active on your map at once. A vector layer is a powerful layer that allows for the addition of markers and various geometric objects to our maps—we'll cover it in *Chapter 5, Using Vector Layers*. Thus, in this example, your map would have three separate layers. We'll study in detail about layers and how to use and combine them in *Chapter 4, Interacting with Raster Data Source*.



At the code level, the distinction between base and non-base layers can be misleading. It does not exist in OpenLayers 3, whereas it was in OpenLayers 2 series. However, the concept remains interesting to conceive your maps.

The OpenLayers website

The website for OpenLayers 3 is located at <http://openlayers.org>. Have a look at the following screenshot:

 **OpenLayers 3**

[Learn](#)
[Examples](#)
[API](#)
[Code](#)

A high-performance, feature-packed library for all your mapping needs.

LATEST
OpenLayers v3.0.0 is here! Check out the [docs](#) and the [examples](#) to get started. The full distribution can be downloaded from the [v3.0.0 release page](#).
 If you've come here looking for OpenLayers 2.x information, you'll find everything you need on the [2.x page](#).

FEATURES

Tiled Layers

Pull tiles from OSM, Bing, MapBox, Stamen, MapQuest, and any other XYZ source you can find. OGC mapping services and untiled layers also supported.



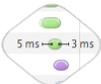
Vector Layers

Render vector data from GeoJSON, TopoJSON, KML, GML, and a growing number of other formats.



Fast & Mobile Ready

Mobile support out of the box. Build lightweight custom profiles with just the components you need.



Cutting Edge & Easy to Customize

Map rendering leverages WebGL, Canvas 2D, and all the latest greatness from HTML5. Style your map controls with straight-forward CSS.



LEARN MORE

 **Quick Start**

Seen enough already? Go here to get started.

 **Download**

Get the latest release or dig through the archives.

 **Tutorials**

Spend time learning the basics and graduate up to advanced mapping techniques.

 **API Docs**

Browse through the API docs for details on code usage.

GET INVOLVED

 **Fork the repo**

 **Open a ticket**

 **Join the discussion**

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To begin, you need to download a copy of OpenLayers (or we can directly link to the library—but we'll download a local copy). You can download the compressed library as a `.zip` by clicking on the green button at the bottom of the release page at <https://github.com/openlayers/ol3/releases/tag/v3.0.0>.

We will cover the website links by following the different areas of the main web page. Let's start with the navigation bar located at the top right area:

- ◆ First link, **Learn** refers to the documentation for the OpenLayers library.
- ◆ **Examples** points to the list of the latest examples available for the current development library. At the time of writing, you can see 95 of them. You can filter the list of examples with keywords to find your way.
- ◆ **API** redirects to the API documentation. It documents the API where you can find the syntax, methods, and properties for all the core library components. Without it, it would be impossible to find your way within the library.
- ◆ Last link, **Code** is simply the link to the Github library account located at <http://github.com/openlayers/ol3>, for people who want to contribute or learn more about the core library code.
- ◆ In the central area, the main content is divided from top to bottom in four parts:
- ◆ The first block **LATEST** speaks for itself. It's the latest news about the project.
- ◆ The **FEATURES** part is a good reminder and teaser about what you can do with the OpenLayers library.
- ◆ The **LEARN MORE** part is one of the most important parts of the web page:
 - With **Quick Start**, you can learn a simple way to make your first map.
 - The **Download** section is the place to find all release codes hosted at GitHub. You can also find the releases notes — the list of evolution and fixes to the library core code.
 - The **Tutorials** section is the entry to learn more after the **Quick Start**. At the time of writing, it's nearly empty. It should grow following the library adoption curve.
 - The **API Docs** section is one of the keys of OpenLayers. It documents the API where you can find the syntax, methods, and properties for all the core library components. Without it, it would be impossible to find your way within the library.
- ◆ **GET INVOLVED**, the last block, is also important when you want to find help or make a contribution:
 - **Fork the repo** sends you to the URL of the official development repository on Github.
 - **Open a ticket** is the place where you can create a ticket. You can do it to describe an unexpected behavior when using the library, or if you want to ask for a new feature in the library, or if you are an advanced user or a developer and wish to submit code or give your opinion on an existing ticket.
 - The last topic **Join the discussion** links to the official OpenLayers 3 mailing list.



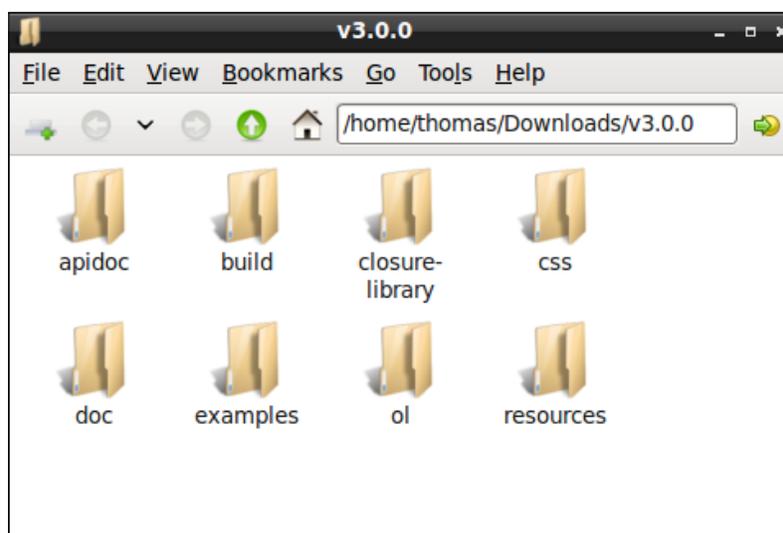
Be aware that currently both versions of OpenLayers exist

- ◆ The version 2.13, the latest version of the 2.x series of the library and all related content, hosted at: <http://openlayers.org/two>
- ◆ The latest version, the 3.0.0 version, hosted at: <http://openlayers.org>

Time for action – downloading OpenLayers

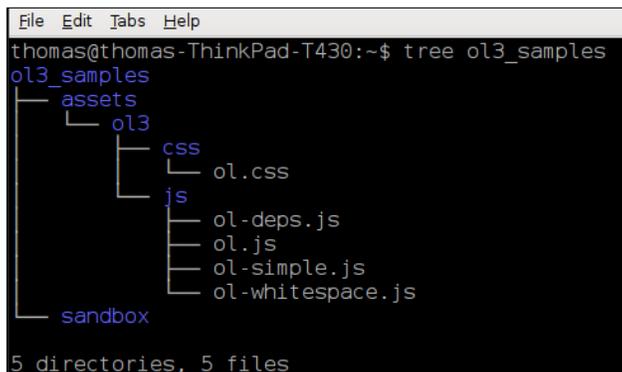
Let's download the OpenLayers library. After you're done, you should have the OpenLayers library files set up on your computer. Perform the following steps:

1. Go to the OpenLayers website (<http://openlayers.org>), go to the **Download** part to follow the link and download the `v3.0.0.zip` version of the OpenLayers `v3.0.0`. It's the green button on the bottom left of the Github release page for `v3.0.0`.
2. Extract the file you just downloaded. When you extract it, you'll end up with a folder called `v3.0.0` (or whatever your version is).
3. Open the `v3.0.0` folder. Once inside, you'll see a lot of folders, but the ones we are concerned with right now are the folders named `build` and `css`, as seen in the following screenshot:



4. Create an `ol3` folder within an `assets` folder contained within a new folder `ol3_samples` in your home directory (or `C:\` on Windows). Copy the previous `build` folder from `v3.0.0` and rename it as `js` into the new `ol3` directory and also copy the `css` folder into the same `ol3` folder.

5. Create a new folder called `sandbox` into the `ol3_samples` directory. You can name the folder whatever you like, but we'll refer to it as the `sandbox` folder. Your new folder structure should look similar to the following screenshot:



```
File Edit Tabs Help
thomas@thomas-ThinkPad-T430:~$ tree ol3_samples
ol3_samples
├── assets
│   └── ol3
│       ├── css
│       │   └── ol.css
│       └── js
│           ├── ol-deps.js
│           ├── ol.js
│           ├── ol-simple.js
│           └── ol-whitespace.js
└── sandbox
5 directories, 5 files
```

What just happened?

We just installed OpenLayers 3 by copying over different pre-built, compressed JavaScript files containing the entire OpenLayers 3 library code (from the build directory) and the associated assets (style sheets). To use OpenLayers, you'll need at a minimum, the `ol.js` file (the other `.js` files will be needed during the book but are not always required) and the `ol.css` file. For best practice, we already gave you some tips to structure the code like separate assets, such as `css` and `js`, or separate library code from your own code.

If you open the `ol.js` file, you'll notice it is nearly unreadable. This is because this is a minified and obfuscated version, which basically means extra white space and unnecessary characters have been stripped out to cut down on the file size and some variables have been shortened whenever possible. While it is no longer readable, it is a bit smaller and thus requires less time to download. If you want to look at the uncompressed source code, you can view it by looking in the `ol-debug.js` file within the `js` folder of the `ol3` directory.

You can, as we'll see in the last chapter of this book, build your own custom configurations of the library, including only the things you need. But for now, we'll just use the entire library. Now that we have our OpenLayers library files ready to use, let's make use of them!

Making our first map

The process for creating a map with OpenLayers requires, at a minimum, the following things:

- ◆ Include the OpenLayers library files
- ◆ Creating an HTML element that the map will appear in
- ◆ Creating a layer object from a `ol.layer.*` class

- ◆ Creating a map object from the `ol.Map` class by adding a layer
- ◆ Creating a view from the `ol.View` class to set for the `Map` class (defining the area where the map will initially be displayed)

Now, we're finally ready to create our first map!

Time for action – creating your first map

Let's dive into OpenLayers and make a map! After you finish this section, you should have a working map, which uses a publicly available OSM server backend from the `OpenStreetMap.org` project. Execute the following steps:

1. Navigate to the `assets` directory, create a folder `css`, and create a new file called `samples.css`. Add the following code:

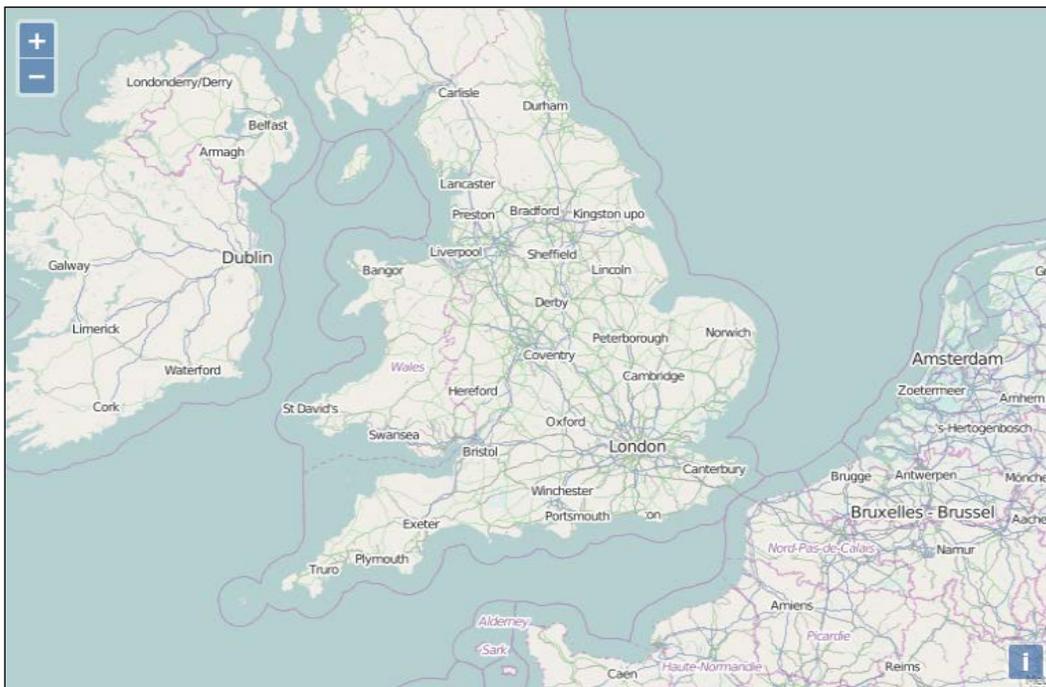
```
map {
  height: 500px;
  width: 100%;
  background-color: #b5d0d0;
}
```

2. Add the following code to a new file called `hello_openstreetmap.html` and save the file in the `sandbox` directory. If you are using Windows, we suggest using Notepad++ in particular because you need to be sure you're editing UTF-8 encoded files. On Linux, you can use Gedit or Geany and for Mac OSX, you can use Text Wrangler (free but not open source). Do not try to edit the file in a program such as Microsoft Word, as it will not save properly. The following code will also be used as the base template code for many future examples in this book, so we'll be using it often and coming back to it a lot:

```
<!doctype html>
<head>
  <title> Hello OpenStreetMap </title>
  <link rel="stylesheet" href="../assets/ol3/css/ol.css"
type="text/css" />
  <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
</head>
<body>
  <div id="map" class="map"></div>
<script src="../assets/ol3/js/ol.js">
</script>
<script>
  var osmLayer = new ol.layer.Tile({
    source: new ol.source.OSM()
```

```
});  
var birmingham = ol.proj.transform([-1.81185, 52.44314],  
'EPSG:4326', 'EPSG:3857');  
var view = new ol.View({  
  center: birmingham,  
  zoom: 6  
});  
var map = new ol.Map({  
  target: 'map'  
});  
map.addLayer(osmLayer);  
map.setView(view);  
</script>  
</body>  
</html>
```

3. Open `hello_openstreetmap.html` in your web browser. It can be hosted on a server or opened as a file. You should see something similar to the screenshot that follows:



What just happened?

We just created our first map using OpenLayers! If it did not work for you for some reason, try double-checking the code and making sure all the commas and parentheses are in place. You can also open the browser debugger and look for JavaScript errors within the console. If you don't know what a console is, don't worry, we will see it soon. You can also refer to the *Preface* where a link to code samples used in the book is given. By default, we're given a few controls if we don't specify any. We will use the file we created as a template for many examples throughout the book, so save a copy of it so you can easily refer to it later.

The control on the left side (the navigation buttons) is called the Zoom control, which is a `ol.control.Zoom` object. You can click the buttons to navigate around the map, drag the map with your mouse, use the scroll wheel to zoom in, or use your keyboard's arrow keys. `ol.control.Attribution` is added by default. It will be populated if a layer (such as OSM) has attribution info available. This control is on the bottom right corner and gives the credits for the data you're using such as license and data producer.

We'll cover controls in greater detail in *Chapter 9, Taking Control of Controls*.

Now, let's take a look at the code, line by line.

- ◆ **Lines 1 to 7:** It sets up the HTML page. Every HTML page needs an `<html>` and `<head>` tag, and the extraneous code you see specifies various settings that inform your browser that this is an HTML5 compliant page. For example, we include the `DOCTYPE` declaration in line 1 to specify that the page conforms to standards set by the WC3. We also specify a `<title>` tag, which contains the title that will be displayed on the page. We also add a `css stylesheet` content to display correctly the zoom and attribution controls, and set the future map size to a height of `500px` and a width of `100%` (the width will always be at the max width depending on the browser window).

This is the structure that all our code examples will follow, so this basic code template will be implicitly assumed in all examples that follow throughout the book.

- ◆ **Lines 8 and 9:**

```
<body>
<div id="map" class="map"></div>
```

To make an OpenLayers map, we need an HTML element where the map will be displayed in. Almost always, this element will be a `div`. You can give it whatever ID you would like, and the ID of this HTML element is passed into the call to create the map object. You can style the `<div>` tag however you would like—setting the width and height to be 100 percent, for instance, if you want a full page map. We choose a class for this, also called `map`.

◆ **Line 10:**

```
<script src="../../assets/ol3/js/ol.js" type="text/javascript"></script>
```

This includes the OpenLayers library. The location of the file is specified by the `src='../../assets/ol3/js/ol.js'` attribute. Here, we're using a relative path. As the `hello_openstreetmap.html` page is within the `sandbox` at the same level as the `assets`, we need to go outside the `sandbox` directory and then set the path to `ol.js` file. The file could either be on your computer, or another computer. Browsers can load it on any computer thanks to the relative path.

We can also use an absolute path, which means we pass in a URL where the script is located at. `openlayers.org` hosts the script file as well; we could use the following line of code to link to the library file directly:

```
<script src='http://openlayers.org/en/v3.0.0/build/ol.js'></script>
```

Notice how the `src` specifies an actual URL which is an absolute path `http://openlayers.org/en/v3.0.0/css/ol.css` at line 5. Either way works, however, throughout the book we'll assume that you are using a relative path and have the OpenLayers library on your own computer/server. If you use the hosted OpenLayers library, you cannot be sure that it will always be available, so using a local copy is recommended.

Be aware that when browsers load a page, they load it from top to bottom. To use any DOM (Document Object Model) elements (any HTML element on your page) in JavaScript, they first have to be loaded by the browser. So, you cannot reference HTML with JavaScript before the browser sees the element. It'd be similar to trying to access a variable that hasn't yet been created. Because of this behavior, don't forget to call your JavaScript content after the `<div id="map" class="map"></div>`.

- ◆ **Line 11:** This starts a `<script>` block. We'll set up all our code inside it to create our map. Since the OpenLayers library has been included in line 13, we are able to use all the classes and functions the library contains.

◆ **Lines 12 to 14:**

```
var osmLayer = new ol.layer.Tile({
  source: new ol.source.OSM()
});
```

In the previous three lines of code, we created a global variable called `osmLayer`. In JavaScript, any time we create a variable we need to place `var` in front of it to ensure that we don't run into scope issues (what functions can access which variables). When accessing a variable, you do not need to put `var` in front of it.

Since we are defining `osmLayer` as a variable at the global level (outside of any functions), we can access it anywhere in our code. We declare the `osmLayer` as an `ol.layer.Tile` object. It means we use an `ol.layer.Tile` class for creating the variable `layerOsm`.

The object created is also referred to as an instance of the `ol.layer.Tile` class. We'll talk about what this means later in the *Appendix A, Object-oriented Programming – Introduction and Concepts*.

Now, let's look at the right hand side of the equal sign (=): `new` keyword means that we are creating a new object from the class that follows it. `ol.layer.Tile` is the class name which we are creating an object from. Notice that something is inside the parenthesis: `{source: new ol.source.OSM() }`. This means we are passing one thing into the class (called an argument). Every class in OpenLayers expects different arguments to be passed into it, and some classes don't expect anything.

The `ol.layer.Tile` class expects one parameter following the API doc reference. Take a look at: <http://openlayers.org/en/v3.0.0/apidoc/ol.layer.Tile.html>. The `{source: new ol.source.OSM() }` is the layer options, consisting of `key:value` pairs (for example, `{key:value}`). This is also called JavaScript Object Literal Notation, a way to create objects on the fly.

JavaScript object literal notation

In OpenLayers, we often pass in anonymous objects to classes. In JavaScript, anonymous objects are comma separated `key:value` pairs, and are set up in the format of `{key1:value1, key2:value2}`. They are, basically, objects that are created without deriving from a class. This format is also referred to as object literal notation.



When we say `key1:value1`, it's similar to saying `key1 = value1`, but we use a colon instead of an equals sign. We can also affect to a variable an object and reuse this variable instead of creating it on the line, for example:

```
var layer_parameters = {source: new ol.source.OSM()};
var osmLayer = new ol.layer.Tile(layer_parameters);
```

So, the option `source new ol.source.OSM()` is the way to tell the characteristic of the tiles we want to retrieve such as the URL or the default attribution text, whereas `ol.layer.Tile` is the way to say how you ask the map image, not where it comes from.

The type of `ol.source` can be any from a multitude of different services, but we are using OSM here as a source. **OSM (OpenStreetMap)**, is a crowdsourcing project focusing on creating open source map data. The main visible part of the project is the OSM world map we are using.

The arguments, like the source we can pass in for layers, are dependent on the layer class—we cover layers in detail in *Chapter 3, Charting the Map Class*. If you don't want to wait, you can also check out the documentation at <http://openlayers.org/en/v3.0.0/apidoc/> to see what arguments different layers of classes expect.

◆ **Line 15:**

```
var birmingham = ol.proj.transform([-1.81185 52.44314],  
  'EPSG:4326', 'EPSG:3857');
```

In this line of code, we take coordinates from a place, Birmingham in the UK, and we use a custom function that transforms [longitude, latitude] to the projected coordinate the map will expect in the view.

◆ **Lines 16 to 19:**

```
var view = new ol.View({  
  center: birmingham  
  zoom: 6  
});
```

In the preceding four lines of code, we are defining a view from class `ol.View`. It's to use a view. Until now, we have defined what we will see, but with the view, we will define from where we are seeing it. Think of view as equivalent to a shot you might see in a cinema and where the cameraman chooses to see actors with more or less light, from far away or near, from below or above. Maps are usually 2D objects but because of new capabilities in the library, you can also have a tilted 2D view. We will not cover it because it requires advanced knowledge.

We have two options here in the JavaScript object: `center` and `zoom`.

The first one sets the center of the map with coordinates. These are not using latitude and longitude coordinates but Spherical Mercator coordinates, a common web mapping standard projection. We will explain this topic in *Chapter 7, Wrapping Our Heads Around Projections*.

The zoom is a way to set the level of details you get on the map when you open the web page. Change this value to understand better. The value for using the OSM layer can be between 0 and 18. The more you increase the value, the more you zoom in. If you set the value to 20, you will see that the image is always of the level 18 but the library resizes the image itself and the image quality will be reduced.



Since this is the last thing passed into the `ol.View` object creation call, make sure there is not a trailing comma. Trailing commas are a common error and are often tedious to debug.

◆ **Lines 20 to 22:**

```
var map = new ol.Map({
  target: 'map'
});
```

We previously created a layer in order to add it to a map but this map was not already created. We have done it using the `ol.Map` class. The map object is the crux of our OpenLayers application— we call its functions to tell the view bound to the map to zoom to areas, fire off events, keep track of layers, and so on.

The `ol.Map` class expects a JavaScript object parameter. Within this object, we use one object parameter: `target`. You can provide another parameter `renderer` to choose the way the image will be displayed in the browser. It can be, DOM, Canvas, or WebGL. Don't worry about these terms, we will explain what they cover. This is not a mandatory option but we'd prefer to tell you already to be aware of this. You will learn more about this in *Chapter 2, Key Concepts in OpenLayers*.

The other object parameter is `target`. Its purpose is to set where you will attach your map in the HTML. It refers to the `id` of an HTML element available in your web page.

Notice, we don't include everything on one line when creating our map object—this improves readability, making it easier to see what we pass in. The only difference is that we are also adding a new line after the comma separating arguments, which doesn't affect the code (but does make it easier to read).

◆ **Line 23:**

```
map.addLayer(osmLayer);
```

Now that we have created both the map and layer, we can add the layer to the map. In OpenLayers, every map needs to have at least one layer. The layer points to the backend, or the server side map server, as we discussed earlier.

Notice, we are calling a function of the map object. There are actually a few ways to go about adding a layer to a map object. We can use the previous code (by calling `map.addLayer`), where we pass in an individual layer but we can also add the layers when instantiating the `ol.Map` with something such as the following:

```
var map = new ol.Map({ target: 'map',
  layers: [osmLayer]
});
```

In this second case, you have to create your layer before the map. Most official examples use the second syntax but for learning purposes, we thought it would be better to separate map instantiation from layers addition.

◆ **Line 24:**

```
map.setView(view);
```

This line enables you to set the view to render the image and display it at the right place you defined previously in the `ol.View` instance, the `view` variable.

◆ **Lines 25 to 27:**

```
    </script>  
  </body>  
</html>
```

These lines close the JavaScript block and the remaining HTML blocks.

After reviewing this first example, if the concept of object-oriented programming is unfamiliar to you, we recommend that you take some time to explore this topic. While you don't necessarily need to know OOP concepts thoroughly to use this book, understanding keywords such as class, properties, abstract class, methods, instance, constructor, or inheritance should ring a bell in your mind. If not, we advise you to visit the *Appendix A, Object-oriented Programming – Introduction and Concepts*.

Now, let's introduce you to the main resources for getting the most important information about OpenLayers and its ecosystem.

Where to go for help

Our coverage of the sample code was not meant to be extremely thorough; just enough to give you an idea of how it works. We'll be covering OOP concepts in more detail throughout the remaining chapters, so if anything is a bit unclear, don't worry too much.

As OpenLayers is a library and provides functions for you, it is important to know what these functions are and what they do. There are many places to do this, but the best source is the API docs.

API docs

The API documentation is always up-to-date and contains an exhaustive description of all the classes in OpenLayers. It is usually the best and first place to go when you have a question. You can access the documentation at: <http://openlayers.org/en/v3.0.0/apidoc/> for the 3.0.0 release. It contains a wealth of information. We will constantly refer to it throughout the book, so keep the link handy! Sometimes, however, the API docs may not seem clear enough, but there are plenty of other resources out there to help you. We'll cover a bit about how to find your way in API documentation in *Chapter 2, Key Concepts in OpenLayers* and in *Appendix A, Object-oriented Programming – Introduction and Concepts*.

This book's website

The extension website for this book can be found at: <http://openlayersbook.github.io/openlayersbook/>. Current, up-to-date corrections and code fixes, along with more advanced tutorials and explanations, can be found there. You can also grab the code and more information about this book at Packt Publishing's website, located at <https://www.packtpub.com/web-development/openlayers-3-beginner%E2%80%99s-guide>.

Mailing lists

The OpenLayers mailing list is an invaluable resource that lets you not only post questions, but also browse questions others have asked (and answered). There were two main OpenLayers news groups—Users and Dev for the OpenLayers 2 Version. There is a list only for OpenLayers 3 development discussions located at <https://groups.google.com/forum/#!forum/ol3-dev>. You may find some users' questions in the archives as it was before for both development and users questions.

Now, user questions should be only posted on <http://stackoverflow.com> and tagged with *openlayers*. OpenLayers 3 library developers will answer directly here.

When posting a question, please be as thorough as possible, stating your problem, what you have done, and the relevant source code (for example, "I have a problem with using a WMS layer. I have tried this and that, and here is what my source code looks like..."). A good guideline for asking questions in a way that will best elicit a response can be found at <http://www.catb.org/~esr/faqs/smart-questions.html>.

Other online resources

Books are great, but they're basically just a one way form of communication. If you have any questions that the book does not answer, your favorite search engine is the best place to go to. The Questions and Answers website <http://gis.stackexchange.com>, the *young brother* of StackOverflow, dedicated to **GIS (Geographical Information System)** can also be quite useful. But, at the end, don't forget that mailing lists and IRC are other great resources.

OpenLayers issues

Sometimes, you will hit an error without understanding why you encounter it, for example related to a mobile browser's unexpected behavior. Before asking to check mailing lists or IRC, we encourage you to make a small search in the list of issues located at Github <https://github.com/openlayers/ol3/issues>. You can search issues by milestone, status (opened, closed, etc), or keywords.

IRC

IRC (Internet Relay Chat) is another great place to go to if you have questions about OpenLayers. IRC is used for group communication; a big chat room, essentially. If you have exhausted Google, issues' trackers, and the mailing list, IRC provides you in real time with other people interested in OpenLayers.

Generally, the people who hang out in the OpenLayers chat room are very friendly, but please try to find an answer before asking in IRC. The server is `irc.freenode.net` and the chat room is `#openlayers`. You can download an IRC client online; a good Windows one is mIRC (<http://mirc.com>). More information about how to use IRC can be found at <http://www.mirc.com/install.html>. For beginners, we recommend using Chatzilla, a Firefox Mozilla add—on <http://chatzilla.hacksrus.com> or CIRC, a Google Chrome add—on <http://flackr.github.io/circ/>.

When you've installed it, just type `irc://irc.freenode.net/openlayers` (for Chatzilla only) in your browser address bar, press enter, wait and you're ready to speak on OpenLayers IRC channel.

OpenLayers source code repository

The source code repository location is hosted at GitHub. You can access the entire code repository at <http://github.com/openlayers/ol3>.

Feel free to download a copy and play around with it yourself. When you become an advanced user, you can submit evolutions to the official source code base and become a contributor to the library. Without going so far, it cannot hurt to download a copy of the code base and look around it yourself to figure out how it's really working!

Getting live news from RSS and social networks

Nowadays, some people prefer to aggregate content using RSS feeds or social networks.

Let's review how you can access alternatively to all the previous resources and more.

For the OpenLayers 3 Developers mailing list, you can use atom or RSS feed, available at <https://groups.google.com/forum/#!aboutgroup/ol3-dev>

When you want to get news about OpenLayers 3 development, you have to rely on Github website capabilities.

You can see:

- ◆ The releases <https://github.com/openlayers/ol3/releases.atom>
- ◆ The commits <https://github.com/openlayers/ol3/commits/master.atom>
- ◆ The Wiki edits <https://github.com/openlayers/ol3/wiki.atom>
- ◆ If you are interested in knowing more about the people behind the library, find the list of its developers at https://api.github.com/orgs/openlayers/public_members and follow them on Twitter.
- ◆ To really get the main news, the official OpenLayers Twitter account is also useful <https://twitter.com/openlayers>

Summary

In this chapter, we were introduced to OpenLayers and learnt a bit about it.

We saw what web map applications are and how they work. After that, we created our first map with OpenLayers, then analyzed how the code works. Then, we covered a fundamental concept, object-oriented programming, which we'll need to know about while really working with OpenLayers. Lastly, resources for help and information outside this book were provided.

Now that we have a basic handle on OpenLayers, we'll jump straight into *Chapter 2, Key Concepts in OpenLayers*. We will discover relationships between library core parts. Using examples, we will also review Events and Observe behaviors. It would be impossible to get an interactive map without them. Then, to finish, we will focus on basic debugging techniques. To learn more about JavaScript debugging, you can also refer to *Appendix C, Squashing Bugs with Web Debuggers*.

2

Key Concepts in OpenLayers

Now that we've seen the basics and made our first map with OpenLayers, let's take a step back and look at the big picture. OpenLayers is a software library based on an Object-oriented design principles, which means that it contains classes to encapsulate behavior, formal relationships between those classes, and standardized mechanisms for communication between objects. While OpenLayers contains many classes, there are just a few that form the foundation of the OpenLayers architecture. In this chapter, we will introduce these core components of the library and also two key concepts— events and observable properties—that are the basis for standardized communication between objects. Along the way, we'll use concrete examples and introduce some basic debugging techniques you can use to solve problems and explore the relationships between objects in a running application.

In this chapter, we will:

- ◆ Illustrate the key classes that form the basis of the OpenLayers architecture
- ◆ Discover the relationship between these classes
- ◆ Understand the roles of the key classes
- ◆ Introduce basic debugging techniques that will allow you to solve problems with your application and to explore the relationship between instances of the key classes in a running application
- ◆ Understand what events and observable properties are, and how to use them
- ◆ Understand collections

OpenLayers' key components

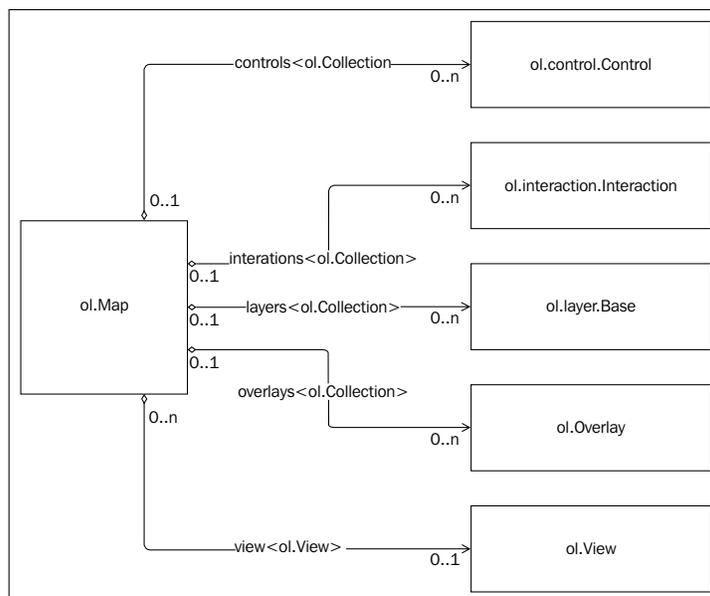
The OpenLayers library provides web developers with components useful to build web mapping applications. Following the principles of an Object-oriented design, these components are called classes. The relationship between all the classes in the OpenLayers library is part of the deliberate design, or architecture, of the library. There are two types of relationships that we, as developers using the library, need to know about: relationships between classes and inheritance between classes. We briefly talked about object-oriented programming in *Chapter 1, Getting Started with OpenLayers* and a more detailed discussion is included in *Appendix A, Object-oriented Programming – Introduction and Concepts* but for the purpose of this chapter, let's summarize the two types of relationships we are interested in:

- ◆ Relationships between classes describe how classes, or more specifically, instances of classes, are related to each other. There are several different conceptual ways that classes can be related, but basically a relationship between two classes implies that one of the class uses the other in some way, and often vice versa.
- ◆ Inheritance between classes shows how behavior of classes, and their relationships are shared with other classes. Inheritance is really just a way of sharing common behavior between several different classes.

We'll start our discussion of the key components of OpenLayers by focusing on the first of these—the relationship between classes. OpenLayers includes a lot of classes for our use, and we'll cover a lot of these in later chapters, but for now, we'll start by looking at the Map class—`ol.Map`.

It's all about the map

Instances of the map class are at the center of every OpenLayers application. These objects are instances of the `ol.Map` class and they use instances of other classes to do their job, which is to put an interactive map onto a web page. Almost every other class in the OpenLayers is related to the `Map` class in some direct or indirect relationship. The following diagram illustrates the direct relationships that we are most interested in:



The preceding diagram shows the most important relationships between the `Map` class and other classes it uses to do its job. It tells us several important things:

- ◆ A map has 0 or 1 **view** instances and it uses the name `view` to refer to it. A view may be associated with multiple maps, however.
- ◆ A map may have 0 or more instances of **layers** managed by a `Collection` class and a layer may be associated with 0 or one `Map` class. The `Map` class has a member variable named `layers` that it uses to refer to this collection.
- ◆ A map may have 0 or more instances of **overlays** managed by a `Collection` class and an overlay may be associated with 0 or one `Map` class. The `Map` class has a member variable named `overlays` that it uses to refer to this collection.
- ◆ A map may have 0 or more instances of **controls** managed by a class called `ol.Collection` (more on collections at the end of this chapter) and controls may be associated with 0 or one `Map` class. The `Map` class has a member variable named `controls` that it uses to refer to this collection.
- ◆ A map may have 0 or more instances of **interactions** managed by a `Collection` class and an interaction may be associated with 0 or one `Map` class. The `Map` class has a member variable named `interactions` that it uses to refer to this collection.

Although these are not the only relationships between the `Map` class and other classes, these are the ones we'll be working with the most. We've already seen some of these classes in action in the examples from the previous chapter. We'll do another example in a moment, but first let's introduce each of these new classes.

- ◆ The `View` class (`ol.View`) manages information about the current position of the `Map` class.

 If you are familiar with the programming concept of **MVC (Model-View-Controller)**, be aware that the view class is not a View in the MVC sense. It does not provide the presentation layer for the map, rather it acts more like a controller (although there is not an exact parallel because OpenLayers was not designed with MVC in mind.)

- ◆ The `Layer` class (`ol.layer.Base`) is the base class for classes that provide data to the map to be rendered.
- ◆ The `Overlay` class (`ol.Overlay`) is an interactive visual element like a control, but it is tied to a specific geographic position.
- ◆ The `Control` class (`ol.control.Control`) is the base class for a group of classes that collectively provide the ability to a user to interact with the map. Controls have a visible user interface element (such as a button or a form input element) with which the user interacts.
- ◆ The `Interaction` class (`ol.interaction.Interaction`) is the base class for a group of classes that also allow the user to interact with the map, but differ from controls in which they have no visible user interface element. For example, the `DragPan` interaction allows the user to click on and drag the map to pan around.

Time for action – creating a map

Let's create a new OpenLayers application and identify the components as we go:

1. First, create a new file called `components.html` in the sandbox directory and put in the standard HTML structure for our applications as follows:

```
<!doctype html>
<html>
  <head>
    <title>OpenLayers Components</title>
    <link rel="stylesheet" href="../assets/ol3/css/ol.css"
type="text/css" />
    <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
  </head>
  <body>
    <div id="map" class="map"></div>
    <script src="../assets/ol3/js/ol.js"></script>
    <script>
```

```
    </script>
  </body>
</html>
```

2. Now, we can add our code inside the second, empty script tag. First, we'll create a layer to display our map. The layer will be added to the map's `layers` collection:

```
var layer = new ol.layer.Tile({
  source: new ol.source.OSM()
});
```

3. Next, we'll create an interaction called `DragRotateAndZoom`:

```
var interaction = new ol.interaction.DragRotateAndZoom();
```

4. Now, we'll create a control called `FullScreen`:

```
var control = new ol.control.FullScreen();
```

5. Let's create an overlay as well. For this, we'll need to add an HTML element as well as some code. First, add the following after the `<div>` tag containing our map:

```
<div id="overlay" style="background-color: yellow; width: 20px;
height: 20px; border-radius: 10px;">
```

6. Now, add the code for the overlay:

```
var center = ol.proj.transform([-1.812, 52.443], 'EPSG:4326',
'EPSG:3857');
var overlay = new ol.Overlay({
  position: center,
  element: document.getElementById('overlay')
});
```

7. The last step is to create a view. We'll use the same center as the overlay's position:

```
var view = new ol.View({
  center: center,
  zoom: 6
});
```

8. Now, we can create the map and give it references to all our components:

```
var map = new ol.Map({
  target: 'map',
  layers: [layer],
  interactions: [interaction],
  controls: [control],
  overlays: [overlay],
  view: view
});
```

9. Open the HTML file in your web browser, you should see something like the following screenshot:



If you try to interact with the map, you'll notice something immediately—you can't click and drag to pan. Instead, if you hold down the *Shift* key while clicking and dragging, you'll get a whole new behavior. We've also lost the zoom in and out buttons at the top left corner, and the attribution icon in the bottom right corner, but there is a new button in the top-right corner. What does it do?

What just happened?

In the first step, we added our boilerplate HTML code for a simple OpenLayers application. This includes standard HTML tags suitable for any web page, and also includes the OpenLayers CSS and JavaScript files.

Next, we started creating instances of various OpenLayers components to use with our map. The first one was a layer that renders tiles from the **OpenStreetMap** tile servers. Next, we created an interaction called `DragRotateAndZoom`. This interaction has no visible element, but rather is triggered by holding down the *Shift* key while dragging the map. As the name suggests, this interaction will rotate and zoom the map in response to dragging the mouse cursor. Then we created a control called `FullScreen`. Again, the name gives away what it does—launches the web page into fullscreen mode. Because it is a control, it has a button that is clicked to activate its behavior. Next, we created an overlay, which displays an HTML element at a specific geographic location. Finally, we created the view, giving it the same center as the position we provided to the overlay.

The last step is to tie it all together with the `Map` class object by passing all our components as part of the constructor. We'll look at the `Map` class's constructor in more detail in *Chapter 3, Charting the Map Class* but for now, it's enough to know that we can provide arrays of layers, interactions, controls, and overlays as options, and the `Map` class will know what to do with them.

We saw that by providing our own set of interactions and controls; we changed the default behavior of an OpenLayers application. This is because the `Map` class has a default set of interactions and controls that it creates when they are not explicitly provided as options to the constructor. There are two ways we can restore the default behavior and add our new components as well.

The first way is to use helper functions provided by OpenLayers to obtain the collection of default interactions and default controls and extend those with our new components. We will do something like this (this example is not complete as the `Map` class is missing a view):

```
// create our interaction
var interaction = new ol.interaction.DragRotateAndZoom();
// get the default interactions and add our new one
var interactions = ol.interaction.defaults().extend([interaction]);

// create our control
var control = new ol.control.FullScreen();
// get the default controls and add our new one
var controls = ol.control.defaults().extend([control]);

// create the map and pass in the extended set of interactions and
controls
var map = new ol.Map({
  interactions: interactions,
  controls: controls
});
```

The second method is to add them to the map after calling the constructor, for instance, (again, this example is not complete):

```
var interaction = new ol.interaction.DragRotateAndZoom();
var control = new ol.control.FullScreen();
var map = new ol.Map();
map.addInteraction(interaction);
map.addControl(control);
```

The advantage of the first method (passing constructor options) is that it gives you complete control over which interactions and controls are in use, while the second method (adding them after creating the map) has the advantage of being simpler if you want to add to the existing set of interactions and controls.

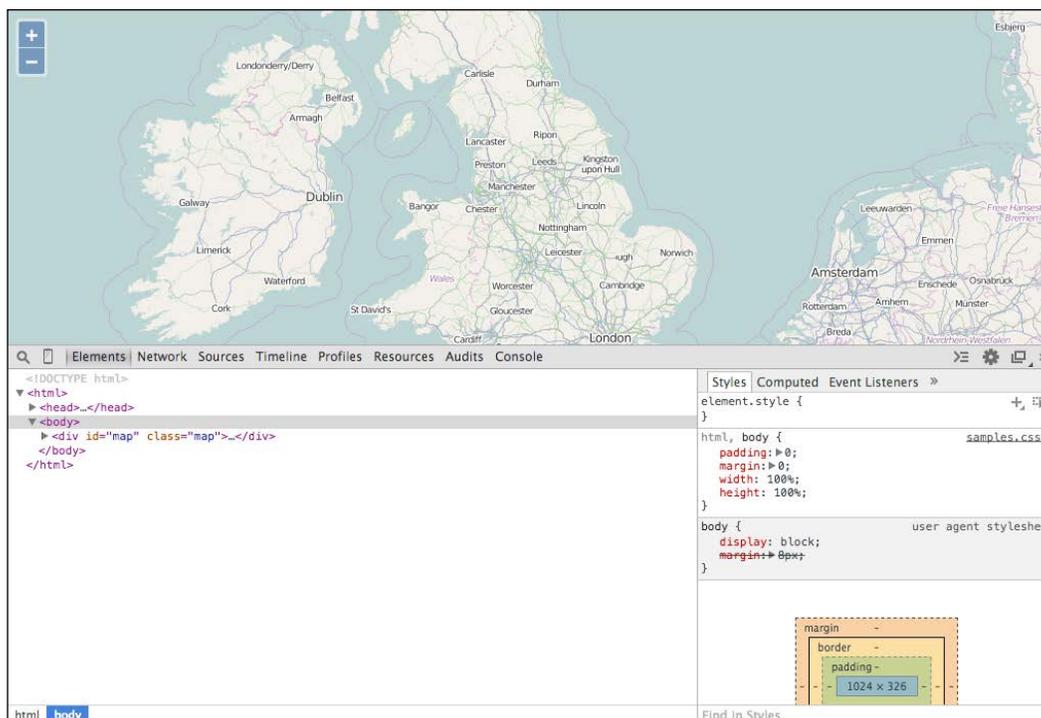
In many parts of OpenLayers, you will discover that there are multiple ways of accomplishing a given task. This is part of the design of the OpenLayers library and provides developers with the option to write code in a way that makes most sense for them.

Time for action – using the JavaScript console

We noted at the end of the previous example that the map wasn't working normally. We replaced the default controls and interactions and so the default behavior wasn't present any more. Let's take a moment to try to fix this. In many cases, mistakes or oversights in our code will produce unexpected results. Web developers have a number of tools available to help them diagnose and fix these problems. In this example, we'll work with the Developer Tools available in the Chrome browser. Similar tools exist for all major browsers; if you are not using Chrome, you should still be able to follow along using your browser's Developer Tools. With the previous example open in your browser, let's get started:

- 1.** The first step is to open the Developer Tools. In Chrome, this is done by using one of the following methods:
 - Select the Chrome menu at the top-right corner of your browser window, then select **Tools | Developer Tools**.
 - Right-click on any element on the web page and select **Inspect Element**.
 - Use a keyboard shortcut. On Windows or Linux, you can use *Ctrl-Shift-I*. On a Mac, you can use *Cmd-Shift-I*.

Using any of these methods, a new Developer Tools window will open. By default, the Developer Tools window will be docked to the current tab at the bottom. You can change this by detaching it to a separate window or moving it to one side, but for now, let's keep it at the bottom. It should look something like the following screenshot:



2. Look at the bar between the map and the Developer Tools console. From left to right, the components are:
 - **A magnifying glass:** If you click this, you can then hover over elements in the web page to select them and reveal them in the **Elements** panel.
 - **A vertical rectangle that looks a bit like a phone:** If you click this, it enables device mode that allows you to emulate the size and features of most popular mobile devices.
 - **Elements:** This panel shows the HTML elements that make up the current state of the **Document Object Model (DOM)**. It's displayed as a tree structure. You can expand parts of the tree to investigate the structure of the web page. When you click an element, the panel on the right is updated to show the CSS styling information for the selected elements. You can edit both the element itself (in the tree view) and most of its CSS properties on the right. This is a great tool for testing quick CSS changes.

- ❑ **Network:** This panel displays the network requests made by the web page to load remote assets. You can see what is requested, the size, and response time to load assets, and if you click one you can see details about the request and response.
- ❑ **Sources:** This panel allows you to interact with your JavaScript code. You can set break points in different files, and when the execution of your code is stopped in the debugger, you can investigate the state of any variables and even modify their values.
- ❑ **Timeline:** This panel shows performance details about loading and executing your web page and can be very useful for identifying bottlenecks in your code.
- ❑ **Profiles:** This panel allows you to capture a snapshot of running code over a period of time and see which functions were called, how many times, and how much time was spent executing each function. This is another useful tool to use in improving performance of a slow web application.
- ❑ **Resources:** This panel shows you resources used by the current web page, including cookies and local storage.
- ❑ **Audits:** This panel can analyze your web page as it loads and provides suggestions for decreasing load time and improving real or perceived responsiveness.
- ❑ **Console:** This panel allows you to type in arbitrary JavaScript and run it within the context of the web page. If the debugger is currently paused on a line of code, then that will be the current context for the console.
- ❑ The next group of buttons, aligned to the right edge, shows (respectively) any errors or warnings for the current page (this will be missing if there are no errors or warnings), toggles an inline console that appears at the bottom of the current panel, a gear icon to access settings for the Developer Tools, a button to detach the Developer Tools into a separate window, and a button to close the Developer Tools on the far right.

3. Open the console by clicking the **Console** tab. We will run some interactive JavaScript commands to add back some missing behavior. Specifically, we'll get the default OpenLayers interactions and add them to the map. Type the following code into the **Console** and hit *Enter* key to execute it. This should return the default set of controls for us:

```
controls = ol.control.defaults();
```

This should output the value that was assigned to the variable `controls`, something like the following screenshot:

```

> controls = ol.control.defaults();
< ▶ A {0: Ic, Se: A, pd: null, c: 0, closure_uid_103498290: 12-}
> |

```

You can click the small triangle next to the line of output to expose properties of the object, like the following screenshot:

```

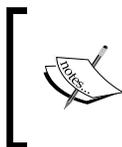
> controls = ol.control.defaults();
< ▼ A {0: Ic, Se: A, pd: null, c: 0, closure_uid_103498290: 12-}
  ▶ 0: Ic
  ▶ Se: A
  ▶ pd: null
  ▶ c: 0
  ▶ closure_uid_103498290: 12
  ▶ ga: Object
  ▶ p: Object
  ▶ __proto__: c
> |

```

We can't even tell what kind of object this is! Let's fix that first.

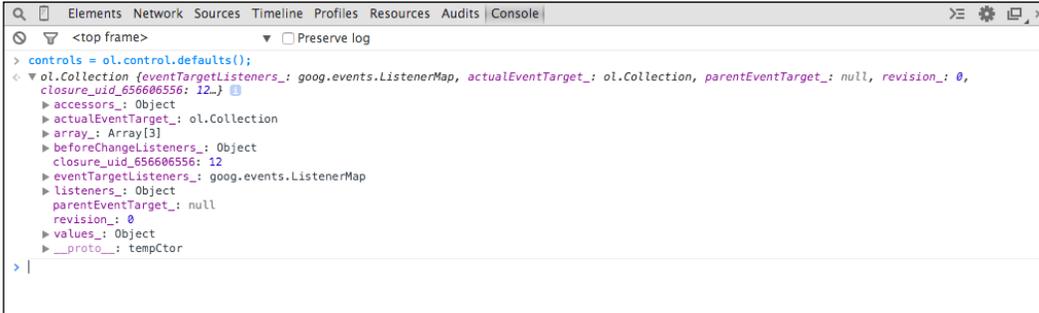
4. The version of OpenLayers we are using is compressed to minimize its size. While this is good for production use, it's not helping us because much of the useful information is obfuscated by the compression process. We'll need to use the debug version to get any further. Open the page in your text editor and change the script tag that adds `ol.js` to load the debug version `ol-debug.js`:

```
<script src="../assets/ol3/js/ol-debug.js"></script>
```



The build process used to create production and debug versions of OpenLayers is covered in detail in *Chapter 11, Creating Web Map Apps* and *Appendix B, More details on Closure Tools and Code Optimization Techniques*.

- Now, reload the page in your browser and type the JavaScript from step 4 into the **Console** tab again. You should be able to hit the up arrow to recall it easily and just hit **Enter** again. Now, we will get more useful information:

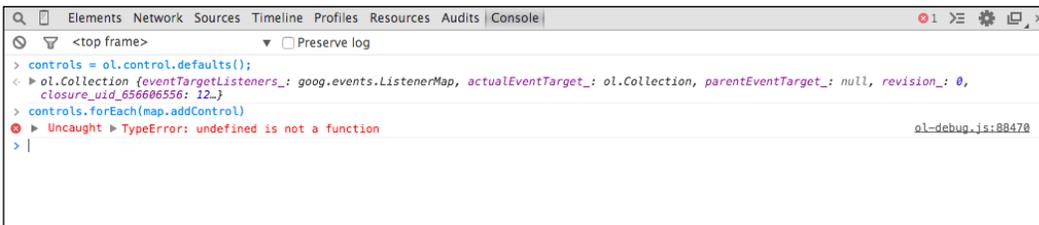


```
> controls = ol.control.defaults();
< ol.Collection {eventTargetListeners_: goog.events.ListenerMap, actualEventTarget_: ol.Collection, parentEventTarget_: null, revision_: 0, closure_uid_656606556: 12}
  ► accessors_: Object
  ► actualEventTarget_: ol.Collection
  ► array_: Array[3]
  ► beforeChangeListeners_: Object
  ► closure_uid_656606556: 12
  ► eventTargetListeners_: goog.events.ListenerMap
  ► listeners_: Object
  ► parentEventTarget_: null
  ► revision_: 0
  ► values_: Object
  ► __proto__: tempCtor
```

Now, we can see that the `controls` variable is an instance of `ol.Collection` and we should be able to add each of the elements of the collection to the map. The line of output expanded, you can see the properties of the collection object.

The last entry is labeled `__proto__` and has a triangle next to it. The `__proto__` property is a special property that shows us an object's prototype, essentially the methods it gains from the class the object was created from. We can explore this property for methods available to be called on the object. Note that the `__proto__` property may also have a `__proto__` property revealing further methods inherited from other classes in the inheritance hierarchy.

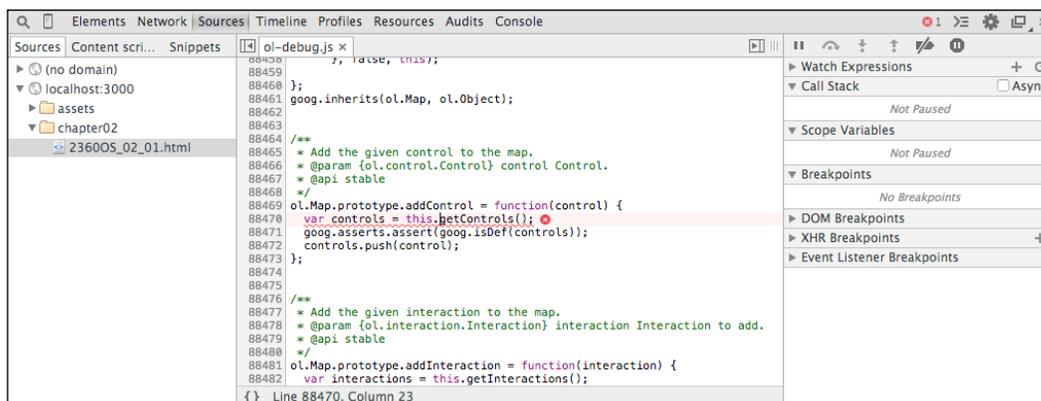
- We can use the map's `addControl` method to add one control at a time, so we need a way of doing this for each individual controls in the collection. Collections have a `forEach` method that invokes a function for each item in the collection, which sounds ideal! Let's give it a try by running the following code in the **Console** tab:
`controls.forEach(map.addControl) ;`



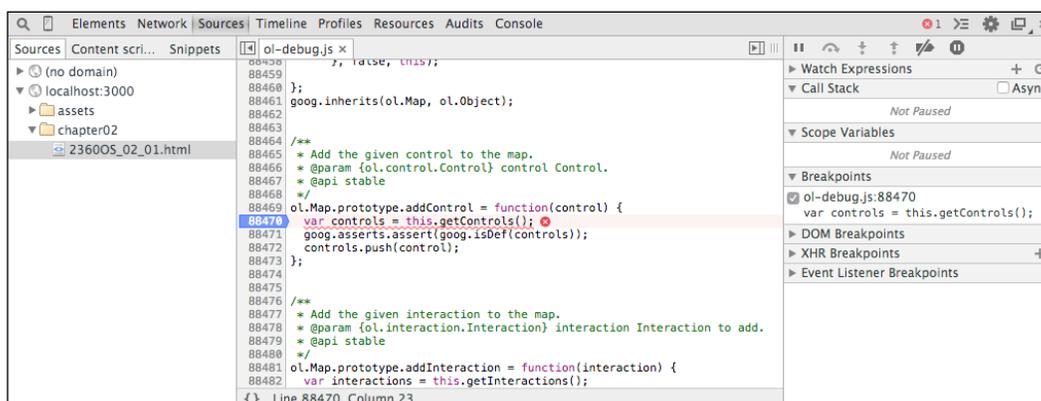
```
> ol.control.defaults();
< ol.Collection {eventTargetListeners_: goog.events.ListenerMap, actualEventTarget_: ol.Collection, parentEventTarget_: null, revision_: 0, closure_uid_656606556: 12}
> controls.forEach(map.addControl)
Uncaught TypeError: undefined is not a function
ol-debug.js:88470
```

Something is not right, we are getting an error. Let's investigate.

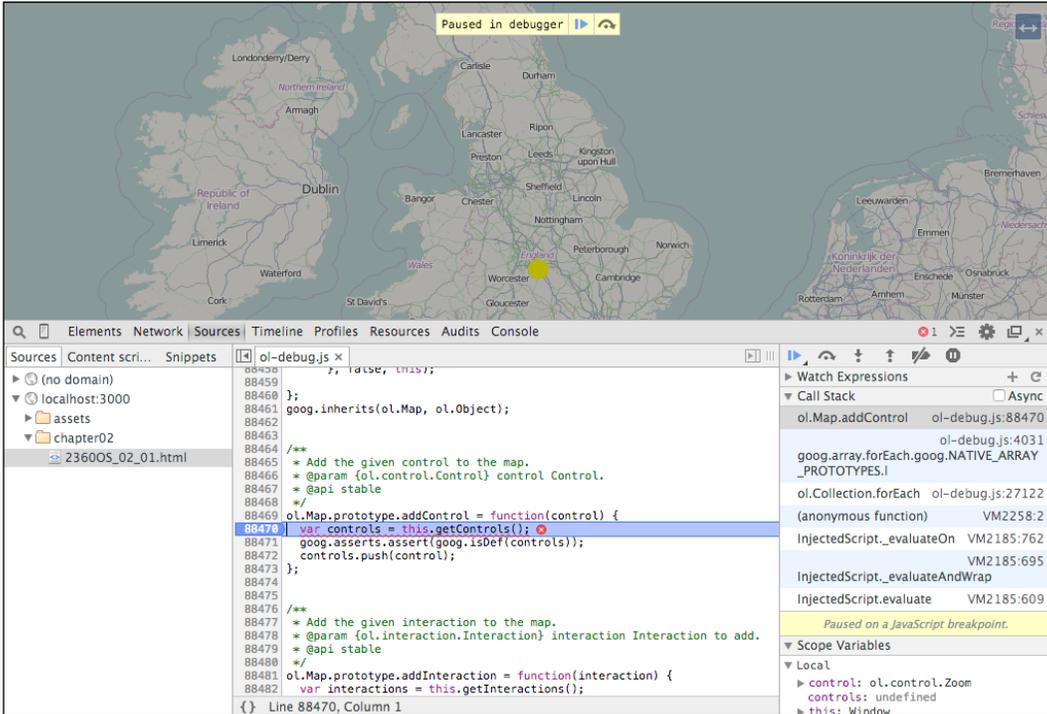
7. To the right of the line showing the error is the file in which it occurred and line number on which it occurred. Click on the filename to open the **Sources** panel at the line of code that is producing the error.



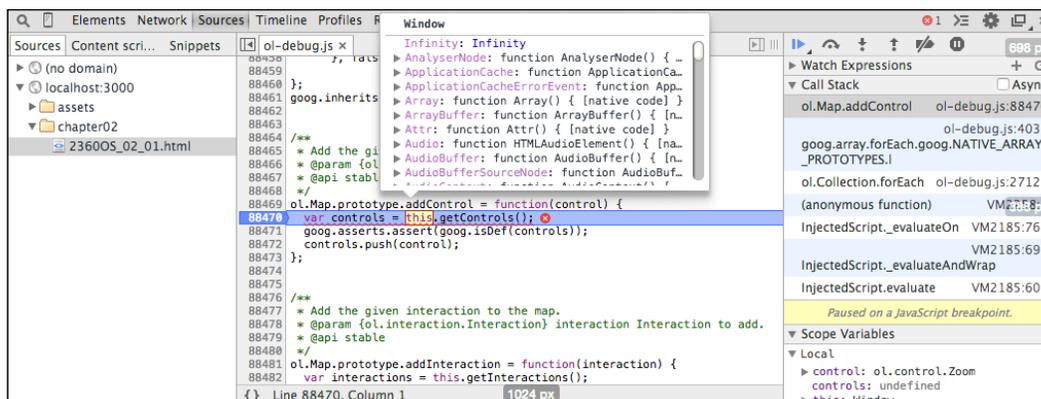
8. We want to stop here and see what is going on. There are two ways we can do this. We can set a break point on this line of code, or we can ask the debugger to stop automatically when an error is detected. Let's take the first route and add a break point. To add a break point, simply click on the line number to the left of the line of code you want to stop on in the **Sources** panel and the line number is highlighted in blue. To remove a break point, just click it again.



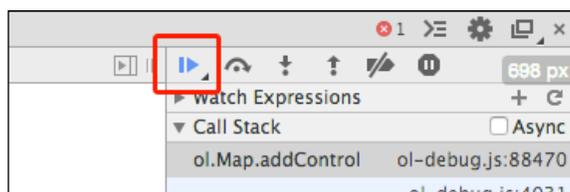
- With the break point set, click on **Console** again and rerun that last line of code. The debugger will automatically pause execution of the code when it gets to our break point and switch to the **Sources** panel for us.



- The line of code we've stopped at assigns a variable, `controls`, with the result of calling `this.getControls()`. Move the mouse over the `this` keyword and the debugger will show us what its value is. Now, we can see that `this` is the `Window` object and not a `Map` class object, which is why the `getInteractions` method is undefined! We need to provide the correct object, `map`, as the scope of the `forEach` function call by passing it as the second argument.



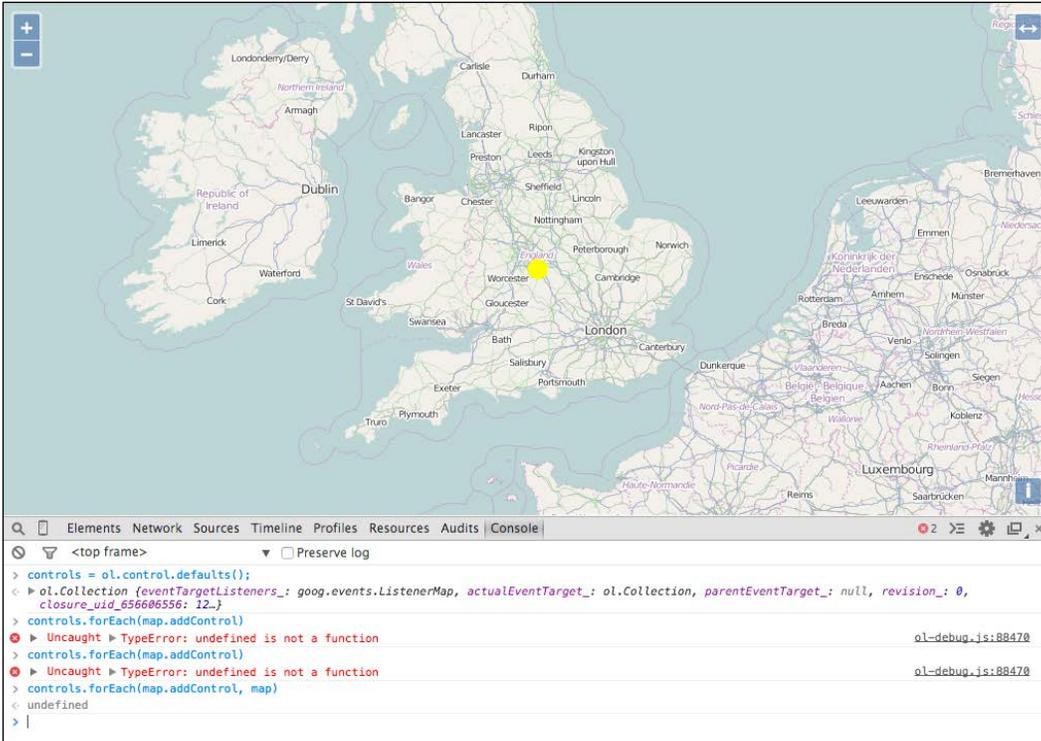
- 11.** Before we can try this, we need to let the execution of JavaScript code continue. Click the highlighted line number to remove the breakpoint. To the right of the code, where the debugger has paused, is another panel that shows various information about the current state of the code. At the top of this panel is a row of buttons that control the debugger. The left-most button, a sideways triangle, will resume execution when the code is paused. Go ahead and click it now. A mini console will open at the bottom of the debugger and show us the error again.



- 12.** In the console, retype the last command, this time passing a second argument to specify the correct scope object for the callback function:

```
controls.forEach(map.addControl, map);
```

Much better! Now, we have all our controls back.



What just happened?

We used the Developer tools console to execute some JavaScript and modify our running application to add the default zoom controls that were missing. Along the way, we ran into a problem and switched to the debug build of the OpenLayers library so that we could get more useful information about problems we ran into. We touched briefly on using the powerful Developer tools, including the **Console** and **Sources** panels.

There are a great many things we can do with the Developer tools, and this just touches briefly on one aspect of them. Please read *Appendix C, Squashing Bugs with Web Debuggers* to learn more about using the Developer tools in application development.

In the following sections, we'll look a little more closely at each of the components we've introduced so far, starting with the view class.

Have a go hero

Based on the previous example, use the **Console** to add the default interactions to the running application. You can get the default interactions by calling the `ol.interaction.defaults()` method.

Controlling the map's view

The OpenLayers view class, `ol.View`, represents a simple two-dimensional view of the world. It is responsible for determining where, and to some degree how, the user is looking at the world. We'll cover views in more detail at the end of *Chapter 3, Charting the Map Class*, but briefly, it is responsible for managing the following information:

- ◆ The geographic center of the map
- ◆ The resolution of the map, which is to say how much of the map we can see around the center
- ◆ The rotation of the map

Although you can create a map without a view, it won't display anything until a view is assigned to it. Every map must have a view in order to display any map data at all. However, a view may be shared between multiple instances of the `Map` class. This effectively synchronizes the center, resolution, and rotation of each of the maps. In this way, you can create two or more maps in different HTML containers on a web page, even showing different information, and have them look at the same world position. Changing the position of any of the maps (for instance, by dragging one) automatically updates the other maps at the same time! We'll see an example of this in the next chapter.

Displaying map content

So, if the view is responsible for managing where the user is looking in the world, which component is responsible for determining what the user sees there? That's the job of layers and overlays.

A layer provides access to a source of geospatial data. There are two basic kinds of layers, that is, raster and vector layers:

- ◆ In computer graphics, the term **raster** (*raster graphics*) refers to a digital image. In OpenLayers, a raster layer is one that displays images in your map at specific geographic locations. So far, all of our examples have used raster layers. We'll cover raster layers in *Chapter 4, Interacting with Raster Data Source*.

- ◆ In computer graphics, the term **vector** (*vector graphics*) refers to images that are defined in terms of geometric shapes, such as points, lines, and polygons—or mathematic formulae such as Bézier curves. In OpenLayers, a vector layer reads geospatial data from vector data (such as a KML file) and the data can then be drawn onto the map. We'll cover vector layers in *Chapter 5, Using Vector Layers*.

Layers are not the only way to display spatial information on the map. The other way is to use an overlay. As we saw in the example earlier in this chapter, we can create instances of `ol.Overlay` and add them to the map at specific locations. The overlay then positions its content (an HTML element) on the map at the specified location. The HTML element can then be used like any other HTML element.

The most common use of overlays is to display spatially relevant information in a pop-up dialog in response to the mouse moving over, or clicking on a geographic feature.

Time for action – overlaying information

In the previous example, we added an overlay but we didn't really investigate how it behaves. Let's do something a bit more interesting with overlays to illustrate what they do. In this example, we'll build an OpenLayers application that displays the latitude and longitude of the mouse position in an overlay when you click on the map:

1. Create a new file called `overlay.html` in the `sandbox` directory. Add the standard boilerplate content to get started:

```
<!doctype html>
<html>
  <head>
    <title>OpenLayers Overlays</title>
    <link rel="stylesheet" href="../assets/ol3/css/ol.css"
type="text/css" />
    <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
  </head>
  <body>
    <div id="map" class="map"></div>
    <script src="../assets/ol3/js/ol.js"></script>
  </script>
  </body>
</html>
```

2. Now, add the following code to set up a simple map with the OpenStreetMap data.

```
var layer = new ol.layer.Tile({
  source: new ol.source.OSM()
});

var center = ol.proj.transform([-1.812, 52.443], 'EPSG:4326',
  'EPSG:3857');
var view = new ol.View({
  center: center,
  zoom: 6
});

var map = new ol.Map({
  target: 'map',
  layers: [layer],
  view: view
});
```

3. We'll create an overlay object to display when the user clicks on the map. We will need an HTML element; so, add the following line of code right after Map's `<div>` element. You can change the style of the element if you wish:

```
<div id="overlay" style="background-color: white; border-radius:
10px; border: 1px solid black; padding: 5px 10px;">
```

4. The overlay object itself is pretty simple. Add this at the end, after creating the Map class:

```
var overlay = new ol.Overlay({
  element: document.getElementById('overlay'),
  positioning: 'bottom-center'
});
```

5. Now, we need to respond to the user clicking on the map by updating the content of our overlay and adding it to the map at the correct position. Put the following code snippet in the overlay:

```
map.on('click', function(event) {
  var coord = event.coordinate;
  var degrees = ol.proj.transform(coord, 'EPSG:3857', 'EPSG:4326');
  var hdms = ol.coordinate.toStringHDMS(degrees);
  var element = overlay.getElement();
  element.innerHTML = hdms;
  overlay.setPosition(coord);
  map.addOverlay(overlay);
});
```

- The result should look something like this, depending on where you click! After clicking on the map, try panning or zooming the map and notice how the overlay stays in the same geographic location (it moves with the map).



What just happened?

In this example, we illustrated how an overlay is positioned at a geographic location on the map, how it moves with the map to stay at that same location, and how it can be used to display information about some location.

After setting up the boilerplate HTML structure for the page, we added a raster layer with the OpenStreetMap data, a view, and a map to the application. We then created an overlay object pointing at an HTML element for content and with the positioning set to 'bottom-center', which tells OpenLayers to align the bottom, center of the HTML element with the geographic position of the overlay. This means that the overlay will appear above the location, centered on it.

The last step was to register an event handler (more on events later in this chapter) for the map's `click` event. When the user clicks on the map, the event handler function is called with an event object that contains `coordinate` (the geographic position) of the click on the map. We transform the coordinate from the map's projection into decimal degrees (longitude and latitude values) and use a helper function in the OpenLayers library to format this into degrees minutes and seconds (a standard way of representing geographic location in human readable form). We then update the content of our overlay's HTML element with this information, set the position of the overlay to the coordinate provided with the event, and add it to the map using the `addOverlay` method.

If some of this seems overwhelming, don't worry, we'll be covering all of this in later chapters.

Interacting with the map

As mentioned earlier, the two components that allow users to interact with the map are interactions and controls. Let's look at them in a bit more detail.

Using interactions

Interactions are components that allow the user to interact with the map via some direct input, usually by using the mouse (or a finger with a touch screen). Interactions have no visible user interface. The default set of interactions are:

- ◆ `ol.interaction.DoubleClickZoom`: If you double-click the left mouse button, the map will zoom in by a factor of 2
- ◆ `ol.interaction.DragPan`: If you drag the map, it will pan as you move the mouse
- ◆ `ol.interaction.PinchRotate`: On touch-enabled devices, placing two fingers on the device and rotating them in a circular motion will rotate the map
- ◆ `ol.interaction.PinchZoom`: On touch-enabled devices, placing two fingers on the device and pinching them together or spreading them apart will zoom the map out and in respectively
- ◆ `ol.interaction.KeyboardPan`: You can use the arrow keys to pan the map in the direction of the arrows
- ◆ `ol.interaction.KeyboardZoom`: You can use the + and – keys to zoom in and out
- ◆ `ol.interaction.MouseWheelZoom`: You can use the scroll wheel on a mouse to zoom the map in and out
- ◆ `ol.interaction.DragZoom`: If you hold the *Shift* key while dragging on map, a rectangular region will be drawn and when you release the mouse button, you will zoom into that area.

We will discuss interactions in detail in *Chapter 8, Interacting with Your Map*.

Controls

Controls are components that allow the user to modify the map state via some visible user interface element, such as a button. In the examples we've seen so far, we've seen zoom buttons in the top-left corner of the map and an attribution control in the bottom-right corner of the map. In fact, the default controls are:

- ◆ `ol.control.Zoom`: This displays the zoom buttons in the top-left corner.
- ◆ `ol.control.Rotate`: This is a button to reset rotation to 0; by default, this is only displayed when the map's rotation is not 0.

- ◆ The `ol.control.Attribution`: This displays attribution text for the layers currently visible in the map. By default, the attributions are collapsed to a single icon in the bottom-right corner and clicking the icon will show the attributions.

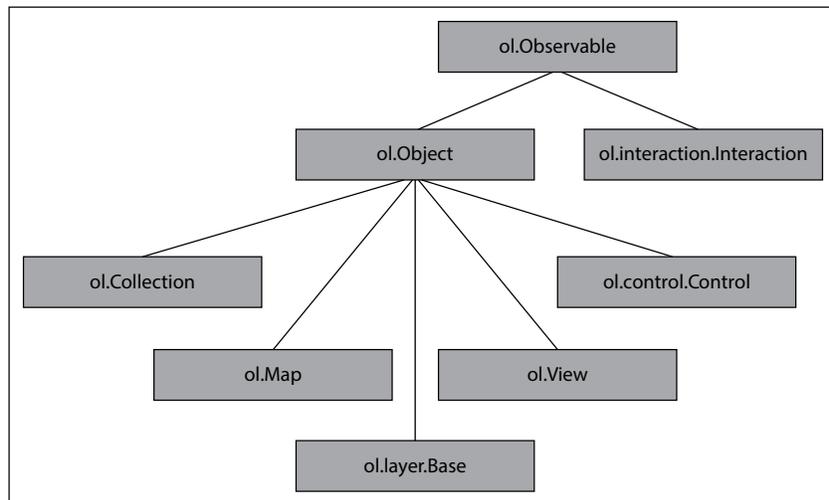
We will discuss these controls and more in detail in *Chapter 9, Taking Control of Controls*.

This concludes our brief overview of the central components of an OpenLayers application. We saw that the `Map` class is at the center of everything and there are some key components—the view, layers, overlays, interactions, and controls—that it uses to accomplish its job of putting an interactive map onto a web page. At the beginning of this chapter, we talked about both relationships and inheritance. So far, we've only covered the relationships. In the next section, we'll show the inheritance architecture of the key components and introduce three classes that have been working behind the scenes to make everything work.

OpenLayers' super classes

In this section, we will look at three classes in the OpenLayers library that we won't often work directly with, but which provide an enormous amount of functionality to most of the other classes in the library. The first two classes, `Observable` and `Object`, are at the base of the inheritance tree for OpenLayers—the so-called super classes that most classes inherit from. The third class, `Collection`, isn't actually a super class but is used as the basis for many relationships between classes in OpenLayers—we've already seen that the `Map` class relationships with layers, overlays, interactions, and controls are managed by instances of the `Collection` class.

Before we jump into the details, take a look at the inheritance diagram for the components we've already discussed:



As you can see, the `Observable` class, `ol.Observable`, is the base class for every component of OpenLayers that we've seen so far. In fact, there are very few classes in the OpenLayers library that do not inherit from the `Observable` class or one of its subclasses. Similarly, the `Object` class, `ol.Object`, is the base class for many classes in the library and itself is a subclass of `Observable`. Because the functionality contained in these two classes is so fundamental to the understanding of how OpenLayers works, we'll be relying on them for the rest of the book.

The `Observable` and `Object` classes aren't very glamorous. You can't see them in action and they don't do anything very exciting from a user's perspective. What they do though is provide two common sets of behaviour that you can expect to be able to use on almost every object you create or access through the OpenLayers library—**Event management** and **Key-Value Observing (KVO)**.

Event management with the Observable class

An event is basically what it sounds like—something happening. Events are a fundamental part of how various components of OpenLayers—the map, layers, controls, and pretty much everything else—communicate with each other. It is often important to know when something has happened and to react to it. One type of event that is very useful is a user-generated event, such as a mouse click or touches on a mobile device's screen. We used this earlier in the chapter to display an overlay at the location of a mouse click. Knowing when the user has clicked and dragged on the `Map` class allows some code to react to this and move the map to simulate panning it. Other types of events are internal, such as the map being moved or data finishing loading. To continue the previous example, once the map has moved to simulate panning, another event is issued by OpenLayers to say that the map has finished moving so that other parts of OpenLayers can react by updating the user interface with the center coordinates or by loading more data.

Classes inheriting from `ol.Observable` (including `ol.Object`) get the following event related methods:

Method	Parameters	Description
<code>getRevision()</code>	◆ none	This method returns a number representing the current revision of the object. Internal methods can change the revision number and this gives developers the ability to detect whether an object has changed.

Method	Parameters	Description
<code>on(type, listener, scope)</code>	<ul style="list-style-type: none"> ◆ <code>type</code> - string Array.<string> ◆ <code>listener</code> - function ◆ <code>scope</code> - Object undefined 	<p>This method registers a listener function to be called when a certain type of event or events happen. The <code>scope</code> argument is optional. If specified, then it will be the value of <code>this</code> in the <code>listener</code> function.</p> <p>The returned value is a key that uniquely identifies this listener and can be used with <code>unByKey()</code> to remove the listener.</p> <p>The <code>listener</code> function will be called with a single parameter, an event object, the contents of which depend on the event being fired. In general, it will contain both <code>type</code> and <code>target</code> properties.</p>
<code>once(type, listener, scope)</code>	<ul style="list-style-type: none"> ◆ <code>type</code> - string Array.<string> ◆ <code>listener</code> - function ◆ <code>scope</code> - Object undefined 	<p>This method works exactly the same way as <code>on()</code> but the listener is only called once, the first time the event happens after being registered. The listener is automatically removed after it is called. This method also returns a key.</p>
<code>un(type, listener, scope)</code>	<ul style="list-style-type: none"> ◆ <code>type</code> - string Array.<string> ◆ <code>listener</code> - function ◆ <code>scope</code> - Object undefined 	<p>This method removes a previously registered listener using <code>on()</code>.</p>
<code>unByKey(key)</code>	<ul style="list-style-type: none"> ◆ <code>key</code> - Object 	<p>This method removes an event listener by the key returned by <code>on()</code> or <code>once()</code> without having to know the listener and <code>scope</code> values originally used.</p>

Working with events

It is very important to pass the exact same `listener` and `scope` values to `un()` as were passed to `on()`. A common practice is to pass anonymous functions as arguments to functions such as `on()`, which takes function arguments. Because `un()` needs the exact same listener argument to work correctly, we can't use anonymous functions if we want to call `un()` later. However, we can store the key returned by `on()` and use it with `unByKey()`. Let's look at some code examples:

```
var map = new ol.Map({
  target: 'map',
```

```
    view: view
  });
```

This creates a `Map` class object, nothing new here.

```
map.on( 'moveend', function() {
  console.log('move end event!');
});
```

Next, we will register for the `moveend` event. The `moveend` event is triggered by the map after it has been panned or zoomed. The function we provide will be called every time the map moves. Our code will output some text to the debug console. Because we used an inline or anonymous function, we have no way to remove our function if we no longer want to receive events. Or do we?

```
var key = map.on('moveend', function() {
  console.log('move end event!');
});
map.unByKey(key);
```

This code registers for the same `moveend` event using an anonymous function but this time we will assign the return value to `key`. We can then use the value assigned to `key` to unregister our handler.

Let's look at another way:

```
function onMoveEnd(event) {
  console.log('moveend event 2');
}
map.on('moveend', onMoveEnd);
map.un('moveend', onMoveEnd);
```

This block declares a function called `onMoveEnd()` and registers it for the `moveend` event. The last line unregisters it. This achieves exactly the same result as the previous code; so, what's the difference? It is mostly to accommodate different coding styles and patterns. Some people prefer to write their code a certain way, or perhaps they have to follow a particular coding style guide (see *Appendix B, More details on Closure Tools and Code Optimization Techniques* for more information on this), and `OpenLayers` provides various ways to make it easier.

What about the scope parameter? This is useful for code that is written in an Object oriented style. Here is a contrived example that illustrates how it will be used:

```
var MyClass = function(label) {
  this.label = label;
  this.onMoveEnd = function() {
    console.log( this.label + ': moveend event');
  }
}
```

```
}  
var obj1 = new MyClass('Object 1');  
var obj2 = new MyClass('Object 2');
```

A simple class called `MyClass` is defined, which contains a single attribute, `label`, and a single method, `onMoveEnd()`. Next, two instances of this class are created with different label values. We can use the `onMoveEnd()` method of our instances as a function in the second parameter of the `on()` method. When the `onMoveEnd()` method is called, it will log a message to the debug console containing the value of the `label` attribute. Here are some examples of how this can be used:

```
map.on('moveend', obj1.onMoveEnd);
```

Registering the `onMoveEnd()` method for the `moveend` event will work, but the output will be as follows:

```
Undefined: zoomend event
```

What's wrong? It turns out that `this.label` is not defined because the value of `this` is the global **window** object. We can correct this by passing a `scope` object as the third parameter to the `on()` function:

```
map.on('moveend', obj1.onMoveEnd, obj1);  
map.on('moveend', obj2.onMoveEnd, obj2);
```

Now, the output will be what we expected:

```
Object 1: moveend event  
Object 2: moveend event
```

We then need to use the `scope` to unregister for the events as follows:

```
map.un('moveend', obj1.onMoveEnd, obj1);  
map.un('moveend', obj2.onMoveEnd, obj2);
```

Key-Value Observing with the Object class

OpenLayers' `Object` class inherits from `Observable` and implements a software pattern called **Key-Value Observing (KVO)**. With KVO, an object representing some data maintains a list of other objects that wish to observe it. When the data value changes, the observers are notified automatically.

The following methods are available in all OpenLayers classes, which inherit from `ol.Object`. Note that the `Object` class also contains all the methods provided by the `Observable` class even though they are not listed here:

Method	Parameters	Description
<code>bindTo(key, target, targetKey)</code>	<ul style="list-style-type: none"> ◆ <code>key</code> - string ◆ <code>target</code> - <code>ol.Object</code> ◆ <code>targetKey</code> - string 	<p>This method is used to add an observer to a property on the object. The <code>key</code> parameter specifies which property of the object is being bound. The <code>target</code> parameter specifies the object to which the property is bound. The <code>targetKey</code> parameter specifies the property of the <code>target</code> object to which the property of this object is being bound to. If <code>targetKey</code> is not provided, then it is assumed that the <code>target</code> object has a property identified by the <code>key</code> parameter.</p> <p>A change in the <code>target</code> property automatically updates the bound property, and vice versa.</p> <p>This is a powerful concept and we'll explore it with an example afterwards.</p> <p>The <code>bindTo</code> method returns an object with a <code>transform</code> method that can be used to modify the property value being shared between the objects. We'll provide an example of this further in this chapter.</p>
<code>get(key)</code>	<code>key</code> - string	This gets the value of a property of an object. The type of the value returned is specific to the property being retrieved.
<code>getKeys()</code>	None	This method returns an array of all the keys that are observable for this object.
<code>getProperties()</code>	None	This method returns an object literal with all the keys as attributes and their current values as properties.
<code>set(key, value)</code>	<ul style="list-style-type: none"> ◆ <code>key</code> - string ◆ <code>value</code> - mixed 	This method sets the property identified by <code>key</code> to the provided <code>value</code> . All observers of the property will be notified, for example, <code>anObject.setValue('key1', 'value 1');</code>

Method	Parameters	Description
setValues (values)	values - Object	This method sets several properties at once. The values parameter is an object literal. All properties that are updated will trigger notifications to observers, for example, <code>anObject.setValues({ key1: 'value 1', key2: 'another value' });</code> .
unbind(key)	key - string	This method removes the observer of a property identified by key. Unbinding will set the unbound property to the current value. The object will not be notified as the value has not changed.
unbindAll()		This method removes all observers from all properties.



Remember that the `Object` class itself inherits from the `Observable` class and has all the event methods as well.

Time for action – using bindTo

The `bindTo` method is extremely powerful and makes many seemingly advanced tasks quite easy to accomplish. Let's set up an HTML checkbox element that we can use to control the visibility of a map layer.

- Using the same sample file we started earlier in the chapter, add the following on a new line between `<div id="map">` and the `<script>` tag:

```
<input type="checkbox" id="visible" checked> Toggle Layer  
Visibility
```

This will add a new HTML element, a checkbox, to our web page and we will use this to turn our layer on and off.

- Next, add the following two lines of code at the end of the script tag:

```
var visible = new ol.dom.Input(document.  
getElementById('visible'));  
visible.bindTo('checked', layer, 'visible');
```

This code creates a new instance of `ol.dom.Input`, an OpenLayers helper class that connects to our checkbox element. It then uses the `bindTo()` method to observe changes in the checked attribute and send them to the layer, specifically to the visible property.

3. Reload the example in your web browser.



4. Toggle the checkbox below the map to turn the layer on and off.

What just happened?

You successfully used the `bindTo()` method to establish the `layer` as an observer of the checkbox using the `ol.dom.Input` helper class. We bound the `visible` property of our layer to the `checked` property of the `ol.dom.Input`. When the checkbox is clicked, `ol.dom.Input` updates the `checked` property and notifies observers of the `checked` property that it has changed. Because we bound the `visible` property of the layer to the `checked` property of the input, the layer is notified of the change and updates the `visible` property, which causes the layer to turn on and off.

Property binding works both ways. You can manually change the visibility of the layer using the **Console** in Web Inspector. Try the following and observe what happens to the checkbox:

```
layer.setVisible(false);
layer.setVisible(true);
```

You should see the checkbox change state as if you had clicked it.

Transforming values with bindTo

Sometimes, the property value that you are sharing between two objects is not exactly what you need. For instance, you might want to synchronize two maps so that they are looking at the same center point, but at different resolutions. If we share a view between the maps, we can't have one of them at a different resolution. We could use two views and use events to manually synchronize them—and this is a perfectly valid approach—but wouldn't it be nice if we could use `bindTo` and just modify the resolution value a little bit? This is exactly what the object returned from `bindTo` allows us to do. The return value from `bindTo` is an object with a single function, `transform`, that you can invoke with two functions as arguments. The first function is used to transform the value going `from` the source to the target and the second is used to transform the value going `to` the source from the target. For instance:

```
var transformer = view1.bindTo('resolution', view2);
var from = function(value) {
  return value * 2;
};
var to = function(value) {
  return value / 2;
};
transformer.transform(from, to);
```

This example binds the `resolution` property of `view2` (the target) to the `resolution` property of `view1` (the source). We can capture the return value in the variable `transformer`, create two functions that will transform the `resolution` value, and call the `transformer` variable's `transform` function with our two functions. The result is that `view2` parameter's `resolution` property will be bound to `view1` parameter's property but will always have a value twice that of `view1`.

More about KVO properties

Most classes in the OpenLayers library have one or more KVO properties (these are specified in the library documentation) and have some special features. As we saw, the name of the property can be used as the `key` parameter in any of the KVO methods described earlier. Additionally, three events are triggered when the value of a property changes.

The first event is `beforepropertychange` and is triggered before a property will change. It provides the name of the property that will change to the listener:

```
layer.on('beforepropertychange', function(event) {
  console.log('layer changed in some way');
  // event.type == 'beforepropertychange'
  // event.key == '<the key that is changing>'
});
```

The second event is `propertychange` is triggered as (effectively after) the property is changed:

```
layer.on('propertychange', function(event) {
  console.log('layer changed in some way');
  // event.type == 'propertychange'
  // event.key == '<the key that has changed>'
});
```

A third event is a `change` event specific to the property that changed. The name of the event is derived from the property name with the prefix `change:`. This means that we can be notified of changes to individual properties. In our previous example of binding a layer's visibility to a checkbox, we can register to be notified of the change like this:

```
layer.on('change:visible', function(event) {
  console.log('layer visibility changed');
  // event.type == 'change:visible'
  // event.target == layer
});
```

It may seem like there are a lot of events that happen in response to a KVO property changing and you are right, there are! Each event, though, is slightly different and provides both convenient and optimal ways of responding to changes that happen to objects in OpenLayers.

In addition to events, KVO properties also have special accessor functions called **setters** and **getters** defined for them. This means that instead of using the KVO methods `get(key)` and `set(key, value)`, you can use `get<Property>()` and `set<Property>(value)`, where `<Property>` is the capitalized property name. For instance:

```
layer.get('visible');
layer.getVisible();
layer.set('visible', true);
layer.setVisible(true);
```

These methods are primarily for convenience and you can use either depending on your own preferences.

Working with collections

The last section for this chapter is about the OpenLayers' `Collection` class, `ol.Collection`. As mentioned, the `Collection` class is not a super class like `Observable` and `Object`, but it is an integral part of the relationship model. Many classes in OpenLayers make use of the `Collection` class to manage one-to-many relationships.

At its core, the `Collection` class is a JavaScript array with additional convenience methods. It also inherits directly from the `Object` class and inherits the functionality of both `Observable` and `Object`. This makes the `Collection` class extremely powerful and we will use it many times in the rest of this book.

Creating a collection

A collection is created just like any other class, just use the new operator:

```
var collection = new ol.Collection();
```

The `Collection` constructor takes one optional argument, an array that is used to initially populate the collection with elements. The elements in the array can be of any type, but if you are using the collection with one of the OpenLayers API methods, the type of the values will typically be specified in the API documentation. For instance, the `Map` class constructor allows passing a collection of layers, interactions, controls, and overlays. In these cases, the contents of the collection must be instances of the correct type of an object. For instance, check the following code snippet:

```
var layer1 = new ol.layer.Tile({/*options */});
var layer2 = new ol.layer.Vector({/* options */});
var layerCollection = new ol.Collection([layer1, layer2]);
var map = new ol.Map({
  layers: layerCollection
});
```

Collection properties

A `Collection` class, inherited from the `Object` class, has one observable property, `length`. When a collection changes (elements are added or removed), its `length` property is updated. This means it also emits an event, `change:length`, when the `length` property is changed.

Collection events

A `Collection` class also inherits the functionality of the `Observable` class (via `Object` class) and emits two other events—`add` and `remove`. Registered event handler functions of both events will receive a single argument, a `CollectionEvent`, that has an `element` property with the element that was added or removed.

Collection methods

The `Collection` class has the following methods (the ones from `Object` and `Observable` classes are not included in this list, but those methods are also available):

Method	Parameters	Description
<code>clear()</code>	none	This removes all elements from the collection.
<code>extend(arr)</code>	<code>arr</code> - array	This adds the elements from the <code>arr</code> parameter to the collection.
<code>forEach(iterator, opt_this)</code>	<ul style="list-style-type: none"> ◆ <code>iterator</code> - function ◆ <code>opt_this</code> - optional, object 	This method invokes the <code>iterator</code> function for each element in the collection, passing the element, index and a reference to the collection itself as arguments. If the <code>opt_this</code> parameter is provided, it will be the value of <code>this</code> inside the iterator function.
<code>getArray()</code>	none	This returns a reference to the internal array managed by the collection, which is useful if you need a real JavaScript array for something. You should not modify the array returned by this value as no events will be triggered and the <code>length</code> property will go out of sync.
<code>insertAt(index, element)</code>	<ul style="list-style-type: none"> ◆ <code>index</code> - number ◆ <code>element</code> - mixed 	This inserts an element into the collection at the given index. This will change the length of the array.
<code>item(index)</code>	<code>index</code> - number	This returns the element at the given index.
<code>pop()</code>	none	This removes the last element from the collection and returns it.
<code>push(element)</code>	<code>element</code> - mixed	This adds an element to the end of the collection and returns the new length.
<code>remove(element)</code>	<code>element</code> - mixed	This removes the first occurrence of the element from the collection.
<code>removeAt(index)</code>	<code>index</code> - number	This removes the element at the given index and returns it.
<code>setAt(index, element)</code>	<ul style="list-style-type: none"> ◆ <code>index</code> - number ◆ <code>element</code> - mixed 	This replaces an element at a given index with a new element.

Summary

This wraps up our overview of the key concepts in the OpenLayers library. We took a quick look at the key components of the library from two different aspects—relationships and inheritance. With the `Map` class as the central object of any OpenLayers application, we looked at its main relationships to other classes including views, layers, overlays, interactions, and controls. We briefly introduced each of these classes to give an overview of primary purpose. We then investigated inheritance related to these objects and reviewed the super classes that provide functionality to most classes in the OpenLayers library—the `Observable` and `Object` classes. The `Observable` class provides a basic event mechanism and the `Object` class adds observable properties with a powerful binding feature. Lastly, we looked at the `Collection` class. Although this isn't part of the inheritance structure, it is crucial to know how one-to-many relationships work throughout the library (including the `Map` class relationships with layers, overlays, interactions, and controls).

In the next chapter, we'll dig into the `Map` and `View` class in much more detail.

3

Charting the Map Class

The Map class is, as you have probably realized by now, the core piece behind your map. The map object(s) you create is the most important thing behind your map, as without a map object you can't do anything with layers or controls. In this chapter, we'll talk about the `Map` class, which we've been taking for granted so far.

We will also introduce the concept of a view, which is used to change what we see in a map, and several core concepts you'll need to understand the rest of this book.

We used the `Map` and `View` classes so far in this book, without really understanding what's going on. This chapter aims to not only explain how and why we've been doing things, but will also provide thorough coverage of two core classes—the `Map` and `View` classes. Specifically, we'll look at:

- ◆ What the `Map` class is
- ◆ How the `Map` class relates to the other classes we've discussed
- ◆ Options that can be used when creating a map
- ◆ Using functions of the `Map` class
- ◆ Using the `View` class to change the location displayed by the map
- ◆ Working with events to define and extend map behaviors
- ◆ Creating a simple application that contains multiple maps

Understanding the Map class

The OpenLayers' `Map` class is the core component of OpenLayers. We use it to manage the layers, controls, interactions, and overlays. We've worked with it already by creating a map object, adding layers to it, then using its view to modify its extent. We are yet to discuss the functionality behind the `Map` class, the core component of our applications.

In OpenLayers, everything belongs to the `Map` class. The `Layer`, `Control`, and `Interaction` classes must be hooked up to a map if we want them to do anything. So, we need a map object to actually create a useful map—and as you might imagine, we'll see later in this chapter that it is possible to make an application that uses multiple map objects.

Time for action – creating a map

Let's walk through creating a simple map from the beginning. Create a new file in your text editor to get started. To make it easy, save this file in the `sandbox` folder. Remember that all the samples are set up to use the version of OpenLayers we've provided in the `assets` folder:

1. Start with the HTML code needed to set up the page:

```
<!doctype html>
<html>
  <head>
    <title> Map Examples </title>
    <link rel="stylesheet" href="../assets/ol3/ol.css" type="text/
css" />
    <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
  </head>
  <body>
    <div id="map" class="map"></div>
  <script src="../assets/ol3/ol.js">
  </script>
```

We are just setting up a standard HTML 5 web page and including our stylesheets and the OpenLayers library.

2. Add a `<script>` block with the following code:

```
<script>
  var layer = new ol.layer.Tile({
    source: new ol.source.OSM()
  });
  var london = ol.proj.transform([-0.12755, 51.507222],
'EPSG:4326', 'EPSG:3857');
```

```

var view = new ol.View({
  center: london,
  zoom: 6,
});
var map = new ol.Map({
  target: 'map',
  layers: [layer],
  view: view
});
</script>

```

This code should look familiar to the ones used in the previous chapters, and you'll be seeing it (with minor variations) quite a bit through the rest of this book. We create a layer that will show OSM tiles, use `london` as our starting point for the view and create an instance of `ol.Map` in our `map` div.

3. Finish off by closing the body and HTML tags:

```

</body>
</html>

```

4. Save this file as `map.html` and open it in your web browser, you should see a familiar sight, as shown here:



What just happened?

Let's look a little closer at how we create our map object in this block of code:

```
var map = new ol.Map({
  target: 'map',
  layers: [layer],
  view: view
});
```

We use the `new` operator to create an instance of the `ol.Map` class and pass it an object literal containing several options, namely, `target`, `view`, and `layers`. We've used these before in the previous examples without really explaining them or any of the other options we might want to use. Here's the full list of available options and what they do:

Name	Type	Description
<code>controls</code>	<code>ol.Collection</code> <code>Array.<ol.Control></code>	Controls are covered in detail in <i>Chapter 7, Wrapping Our Heads Around Projections</i> ; so, we don't need to go in-depth here. We can define our map's controls when we create the map object by specifying them with this option, or we can add them via the <code>addControl()</code> method later. If you don't specify this option, then OpenLayers will add an attribution control, a logo control, and a zoom control to your map by default.
<code>deviceOptions</code>	<code>olx.DeviceOptions</code> <code>undefined</code>	The <code>deviceOptions</code> allows you to fine-tune performance options, particularly on devices with slow memory (such as mobile phones). This is passed as an object literal and can have two attributes: <code>loadTilesWhileAnimating</code> : This, when set to <code>false</code> , will prevent tiles from loading during animation such as zooming and panning <code>loadTilesWhileInteracting</code> : This, when set to <code>false</code> , will prevent tiles from loading while the user is interacting with the map Both are <code>true</code> by default.

Name	Type	Description
interactions	ol.Collection	Interactions are used by the map to handle browser events, such as the user clicking or dragging on the map. The map passes browser events to each of its interactions in sequence, allowing each to determine whether it should take action and whether it should consume (stop further processing of) the event. The order of interactions is important—if an interaction consumes a browser event, subsequent interactions will not see the event. Interactions are closely related to controls and are discussed in more detail in <i>Chapter 8, Interacting with Your Map</i> with controls. The default interactions, if this option is not provided, are <code>DragRotate</code> , <code>DoubleClickZoom</code> , <code>TouchPan</code> , <code>TouchRotate</code> , <code>TouchZoom</code> , <code>DragPan</code> , <code>KeyboardPan</code> , <code>KeyboardZoom</code> , <code>MouseWheelZoom</code> , and <code>DragZoom</code> if they are available.
keyboardEventTarget	Element Document string undefined	This option indicates which HTML element will be used to receive keyboard events for interactions that use them (such as <code>KeyboardPan</code> and <code>KeyboardZoom</code>). By default, the map's <code>target</code> is used.
layers	ol.Collection Array.<ol.layer.Layer>	The <code>layers</code> option defines which layers are to be added to the map initially. Layers can be added and removed later using the <code>addLayer()</code> and <code>removeLayer()</code> methods.
logo	Boolean String olx.LogoOptions	This controls the display of the ol3 logo in the map, <code>true</code> by default. Set to <code>false</code> to hide the logo. Alternately, you can use your own logo by providing a URL or a logo options object.
overlays	ol.Collection Array.<ol.Overlay>	The <code>overlays</code> option defines which overlays will be added to the map initially. We will review them thoroughly in <i>Chapter 8, Interacting with Your Map</i> .
pixelRatio	Number	The number of physical pixels per screen pixel, normally computed automatically.
renderer	String	The <code>renderer</code> option determines which rendering technology is to be used for drawing the map. The allowed values are: <ul style="list-style-type: none"> ◆ <code>webgl</code> ◆ <code>canvas</code> ◆ <code>dom</code> We'll discuss what these actually mean a little further on in this chapter.

Name	Type	Description
target	Element String	The target identifies the HTML element in which the map will be drawn on the web page. In all our examples, we pass a string value that matches the <code>id</code> attribute of the HTML element we want the map displayed in, and for the most part, this is what you will want to do. You can also pass the actual DOM element object instead of a string, but this is beyond the scope of this book.
view	<code>ol.View</code>	The <code>view</code> controls the location and orientation of the map. The <code>View</code> class has options that define its initial state and methods that enable manipulation of the view and these are discussed in more detail later in this chapter.

Map renderers

By default, OpenLayers draws, or renders, the map in the browser using an HTML 5 canvas element and its associated 2D drawing context. This is known as the **Canvas renderer**. However, OpenLayers actually comes with three renderers. The ability to choose a different renderer for the map can be very powerful but it should also be used with care. Each renderer has some specific capabilities and limitations. In particular, only the Canvas renderer is considered stable at the time of writing this book.

The Canvas renderer

The Canvas renderer draws the map's contents onto an HTML 5 canvas element (http://en.wikipedia.org/wiki/Canvas_element). The canvas element is a high-performance 2D drawing surface supported by all modern web browsers (on Internet Explorer, Canvas support starts with version 9). The canvas renderer is the most fully supported renderer in OpenLayers. It does not support some of the advanced features of the WebGL renderer, including 3D, controlling the contrast, brightness, hue and saturation of a layer, and other advanced capabilities requiring the power of WebGL.

You will most likely want to use this renderer until WebGL is more broadly supported, unless you are building an application that can target browsers that specifically support WebGL.

The WebGL renderer



WebGL (<http://en.wikipedia.org/wiki/WebGL>) is a powerful technology that gives the web browser access to hardware-accelerated 2D and 3D graphics rendering, normally available only to desktop software, typically games. With this renderer, OpenLayers will be able to efficiently render a lot of vector and raster data simultaneously. At the time of this writing, rendering of vector data with WebGL was still in development and not yet available.

It even provides the ability to render data in 3D and give full 3D navigation. Given how fantastic all this sounds, why wouldn't you use it all the time? Unfortunately, WebGL support in a browser is dependent on two things. First, the user's computer must have a graphics card and software drivers that are capable of supporting it. Second, the web browser itself must support it. Since WebGL is a relatively new specification, only the newest versions of Google Chrome, Safari, and Firefox will enable WebGL on systems with capable hardware. Internet Explorer up to version 10 does not provide WebGL support at all, although there are third-party plugins that can be added by users to provide it. Finally, mobile browser support is very limited and varies widely at this time.

In summary, the WebGL renderer can give your application amazing performance and some cutting edge capabilities if your intended users can be relied on to have the latest web browser versions and capable hardware. It isn't suitable if you need to support older web browsers, Internet Explorer, or mobile users.

The DOM renderer

The DOM renderer draws the map's contents using HTML elements (`` and `<div>` tags) and uses CSS to position them. This renderer is supported by older versions of most browsers, including Internet Explorer 8. However, it does not provide many of the capabilities enjoyed by the Canvas renderer. Of the features that it does not support, the most important is vector support covered in *Chapter 6, Styling Vector Layers*. The DOM renderer will also generally exhibit poorer performance.

There is some effort being undertaken by community members to provide some vector capabilities for the DOM renderer, including support for Internet Explorer 8, but in general, you will probably not want to use the DOM renderer unless you need to support older browsers that do not provide Canvas support.

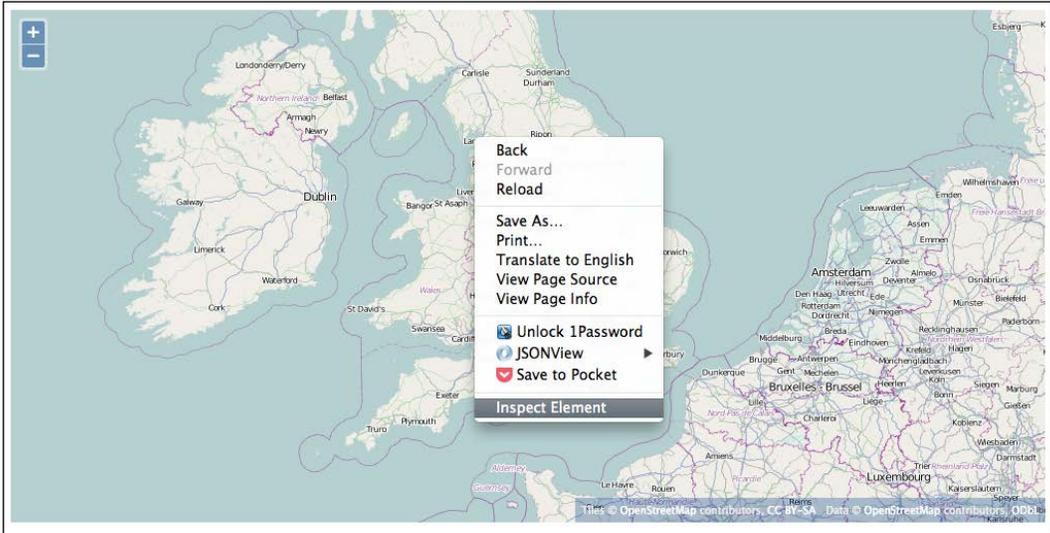


Vector support for the DOM renderer has been added to OpenLayers since the 3.0 release covered in this book and should be available for general use in the next release.

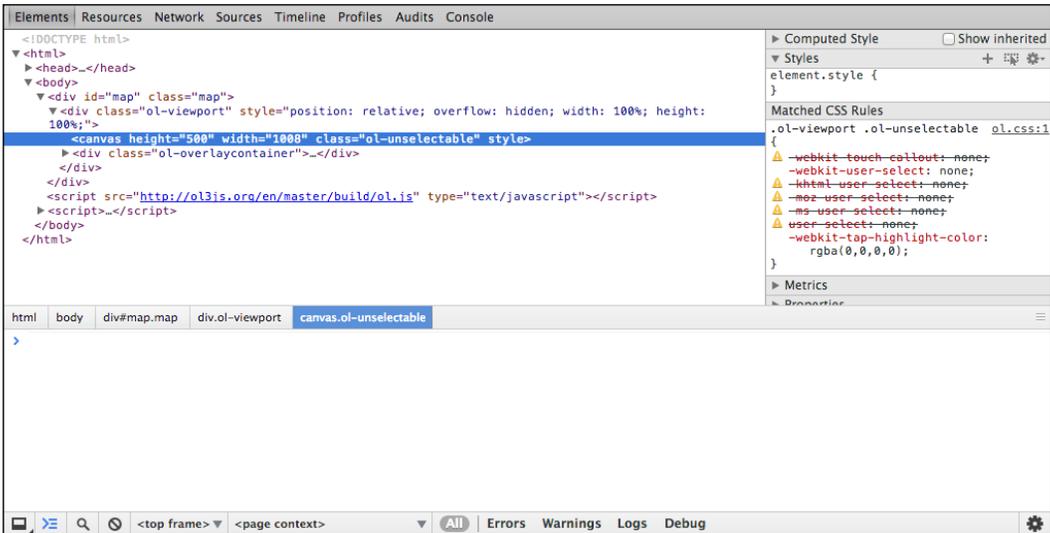
Time for action – rendering a masterpiece

Let's modify our example and add a renderer option to see what happens:

1. Open the example in your web browser. Right-click on the map and select **Inspect Element** to open the Web Inspector and see what OpenLayers creates in the web page to display the map.



2. You should see something like the following screenshot:

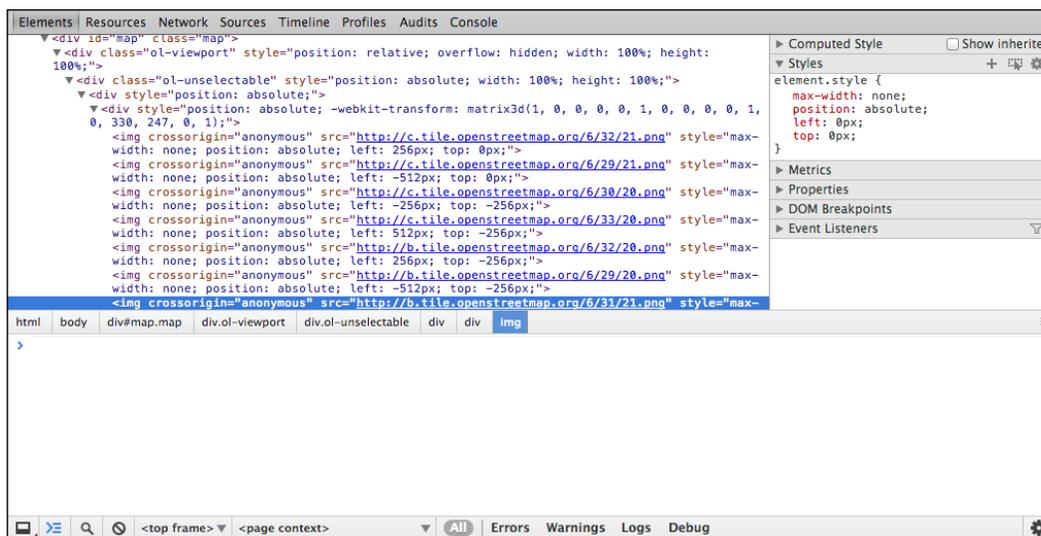


The inspector is highlighting the HTML element used to render the map. In this case, that element is the `<canvas>` element. This element is used for both the WebGL and Canvas renderers. Let's see what happens when we change the renderer.

3. Edit the example and change the map object constructor to use the DOM renderer, like this:

```
var map = new ol.Map({
  target: 'map',
  view: view,
  layers: [layer],
  renderer: 'dom'
});
```

4. Save this and load it in your web browser. Right-click on the map and select **Inspect Element** to open the Web Inspector and see what has changed:



What just happened?

Now, we see a lot of `` elements. By choosing the DOM renderer, we have asked OpenLayers to use a different way of presenting the map in the browser. OpenLayers now creates a new `` element for each map tile coming from the remote server and positions it next to the others to create the complete map.

Map properties

In *Chapter 2, Key Concepts in OpenLayers*, we introduced the concept of observable, or KVO, properties and how they can be used. Here are the KVO properties of the `Map` class:

Name	Type	Description
<code>layergroup</code>	<code>ol.LayerGroup</code>	The <code>layergroup</code> property is an instance of <code>ol.LayerGroup</code> and is used to manage the layers in the map. Although you can use this property to add and remove layers, there are convenience methods in the <code>Map</code> class to make it easier (see <code>layer</code> methods a little later in this chapter).
<code>size</code>	<code>ol.Size</code> undefined	The <code>size</code> property represents the size of the map in pixels.
<code>view</code>	<code>ol.IView</code>	The <code>view</code> property is an instance of a <code>View</code> class that provides the spatial context for the map. We will discuss views at the end of this chapter.
<code>target</code>	<code>Element</code> <code>string</code> undefined	The <code>target</code> property is the HTML element that the map is placed into. The value of this property will be the value that you supplied, either an HTML element or a string that is the ID of an HTML element.

All properties on the `Map` class, and all other classes in `OpenLayers` that inherit from `ol.Object`, can be used with the KVO methods described previously.

Time for action – target practice

In this example, we'll use the `target` property to move the map around in our web page:

- Working from the previous example, add a second `<div>` tag for the map and a `<button>` tag after the `<input>` element we added for the `bindTo()` example. Change the class of both `<div>` tags to `half-map`—this class tells the `<div>` tag to only take up to 50 percent of the width of the page. When the user clicks the button, we'll move the map between the two `<div>` tags:

```
<div id="map" class="half-map"></div>
<div id="map2" class="half-map"></div>
<input type="checkbox" id="visible" checked> Toggle Layer
Visibility
<button onclick="changeTarget();">Change Target</button>
```

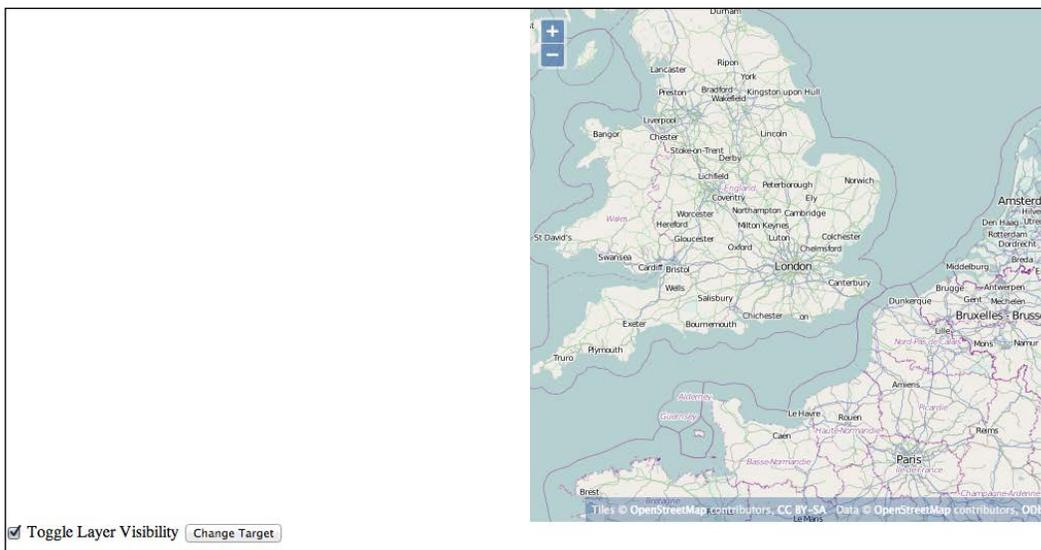
- Now, we can add a function to the end of the `<script>` element that contains our new code, right after the code we added in the `bindTo()` example. The function will first call `map.getTarget()` to get the ID of the element that the map is currently in. If the ID is `map`, then we set the target to `map2`; otherwise, we set it to `map`:

```
function changeTarget() {  
  var target = map.getTarget();  
  if (target == 'map') {  
    map.setTarget('map2');  
  } else {  
    map.setTarget('map');  
  }  
}
```

- Reload the example in your browser, you should see something like this:



4. Click the **Change Target** button, and you should see something like this:



What just happened?

When you click the button, the `changeTarget ()` function is called. This function uses `getTarget ()` to find out which element the map is rendered in and `setTarget ()` to move it to the other map element.

Have a go hero – hiding the map

Moving the map between two HTML elements is really a contrived example to illustrate how the methods work. A more likely use of these methods might be to show and hide the map entirely. Try changing the above example to show and hide the map, rather than moving it. Also, try using `get ()` and `set ()` instead of `getTarget ()` and `setTarget ()` methods.

[ Calling `setTarget ()` with no parameters will set the map target to nothing, effectively removing it from the page.]

Map methods

The `Map` class, being the central organizing point for `OpenLayers`, provides methods for managing many aspects of the map. As there are quite a few methods, we've grouped them into some logical groups—Control methods, Interaction methods, Layer methods, Overlay methods, Rendering methods, Conversion methods, and other methods.

Control methods

These methods are used to manage Controls associated with a map. Controls are covered in more detail in *Chapter 9, Taking Control of Controls*; so, we won't go into any detail here:

Method	Parameters	Description
<code>addControl(control)</code>	<code>control-ol.Control</code>	This method adds a control to the map.
<code>removeControl(control)</code>	<code>control-ol.Control</code>	This method removes a control from the map.
<code>getControls()</code>		This method returns an <code>ol.Collection</code> of controls associated with the map.

Interaction methods

These methods are used to manage interactions associated with a map. Interactions are covered in more detail in *Chapter 8, Interacting with Your Map*; so, we won't go into any detail here:

Method	Parameters	Description
<code>addInteraction(interaction)</code>	<code>interaction-ol.Control</code>	This method adds an interaction to the map.
<code>removeInteraction(interaction)</code>	<code>interaction-ol.Control</code>	This method removes an interaction from the map.
<code>getInteractions()</code>		This method returns an <code>ol.Collection</code> of interactions associated with the map.

Layer methods

The methods are used to manage layers in the map. Layers can also be managed through the `layergroup` property but these methods are a bit easier to use:

Method	Parameters	Description
<code>addLayer(layer)</code>	<code>layer-ol.Layer</code>	This method adds a layer to the map.
<code>removeLayer(layer)</code>	<code>layer-ol.Layer</code>	This method removes a layer from the map.
<code>getLayers()</code>		This method returns all the layers that have been added to the map as an <code>ol.Collection</code> .

Overlay methods

These methods are used to manage overlays associated with a map. Overlays are covered in more detail in *Chapter 8, Interacting with Your Map*; so, we won't go into any detail here:

Method	Parameters	Description
<code>addOverlay(overlay)</code>	<code>overlay - ol.Overlay</code>	This method adds an overlay to the map.
<code>removeOverlay(overlay)</code>	<code>overlay - ol.Overlay</code>	This method removes an overlay from the map.
<code>getOverlays()</code>		This method returns an <code>ol.Collection</code> of overlays associated with the map.

Map rendering methods

When we programmatically change the map's view (which we'll discuss at the end of this chapter), the state of the map changes and a redraw of the map is scheduled. This means that if we change the center of the view from London to New York, the map will re-center on New York and fetch tiles for that area and the screen will be updated almost instantly. This behavior can produce a jarring effect for the user. Fortunately, the `Map` class provides some ways to modify how the map will change state by using the `beforeRender()` method and how the map will appear using the `render()` and `renderSync()` methods.

Method	Parameters	Description
<code>beforeRender(fn)</code>	<code>fn - function</code>	This adds a render function and initiates frame rendering.
<code>render</code>	None	This programmatically triggers a redraw of the map. This will happen asynchronously, which means that it will not happen before this method returns but rather will be scheduled to occur at some later time.
<code>renderSync</code>	None	This causes the map to be redrawn synchronously, which means that by the time this method returns, the map will have been redrawn.

Animation functions

The primary use of the `beforeRender()` method is to add animation effects to our map's navigation. After we add a function using `beforeRender()`, the map will call the function and allow it to update the state of the map. This function can be used to smoothly animate any of the view's state including location, level of detail, and rotation.

While the creation of animation functions is beyond the scope of this book, their use is straightforward, and OpenLayers provides some useful ways for creating animation functions for most common scenarios. Let's indulge ourselves in a bit of fun by exploring how to create and use them.

All the following methods take a single options argument with three common parameters: `start`, `duration`, and `easing`.

- ◆ `start`: This is a number, the time in milliseconds to start the animation at. If not provided, the default is to start immediately. You can use the JavaScript `Date` object to get the current time in milliseconds, such as `var start = (new Date()).getTime();`. To specify a start time in the future, just add a number of milliseconds to this number; for instance, to start an effect one second from now, use `var start = (new Date()).getTime() + 1000;`
- ◆ `duration`: This is a number, the duration of the animation in milliseconds, the default is 1000 (1 second).
- ◆ `easing`: This function is an easing function. An easing function is a function that computes a smooth transition for an animation. The default is `ol.easing.inAndOut`, which provides a smooth acceleration into and out of an animated transition. These are the built-in easing functions:
 - `ol.easing.bounce`: This adds a bounce effect to the end of a transition
 - `ol.easing.easeIn`: This smoothly accelerates the start of the transition
 - `ol.easing.easeOut`: This smoothly decelerates the end of the transition
 - `ol.easing.inAndOut`: This smoothly accelerates the start and decelerates the end of the transition
 - `ol.easing.elastic`: This is similar to the bounce effect
 - `ol.easing.upAndDown`: This applies the transition, and then, reverses it

In addition to the three common options, each animation function has at least one additional property you can provide. Here are the functions with a note on the additional properties that can be passed. We'll try out these functions afterwards:

Function	Options	Description
<code>ol.animation.bounce(options)</code>	<code>resolution - number</code>	The <code>resolution</code> parameter is the resolution to bounce to. This function returns an animation function that provides a bounce effect when animating a transition. It is usually combined with other functions such as <code>pan</code> .

Function	Options	Description
<code>ol.animation.pan(options)</code>	<code>source - ol.Coordinate</code>	The <code>source</code> parameter is the location to start panning from. This function returns an animation function that smoothly transitions from one location to another. It is usually used immediately before updating the view's location to animate the transition from the current location to a new location
<code>ol.animation.rotate(options)</code>	<code>rotation - number</code>	The <code>rotation</code> parameter is the rotation to apply in radians. This function returns an animation function that rotates the map by the rotation indicated.
<code>ol.animation.zoom(options)</code>	<code>resolution - number</code>	The <code>resolution</code> parameter is the resolution to zoom to. This function returns an animation function that smoothly zooms the map from one resolution to another. It is usually used immediately before changing the view's resolution.

As you might guess, some of the built-in controls such as the zoom controls use these animation functions to create nice effects.

Time for action – creating animated maps

The best way to understand these animation functions is to try them out. Start from the previous example:

1. First, add some buttons to trigger the animation effects:

```
<button onclick="doBounce(london);">Bounce To London</button>
<button onclick="doBounce(rome);">Bounce To Rome</button>
<button onclick="doPan(london);">Pan To London</button>
<button onclick="doPan(rome);">Pan To Rome</button>
<button onclick="doRotate();">Rotate</button>
<button onclick="doZoom(2);">Zoom Out</button>
<button onclick="doZoom(0.5);">Zoom In</button>
```

These are regular HTML buttons that call a function when clicked. We'll add the functions in a moment.

2. Next, add a new location for Rome, next to the line where we defined the location of London:

```
var rome = ol.proj.transform([12.5, 41.9], 'EPSG:4326', 'EPSG:3857');
```

3. Now, we'll add functions at the end of our `<script>` tag to handle the button clicks. Start with the `doBounce()` function:

```
function doBounce(location) {
  var bounce = ol.animation.bounce({
    resolution: map.getView().getResolution() * 2
  });
  var pan = ol.animation.pan({
    source: map.getView().getCenter()
  });
  map.beforeRender(bounce);
  map.beforeRender(pan);
  map.getView().setCenter(location);
}
```

4. Next, add the `doPan()` function:

```
function doPan(location) {
  var pan = ol.animation.pan({
    source: map.getView().getCenter()
  });
  map.beforeRender(pan);
  map.getView().setCenter(location);
}
```

5. Next, add the `doRotate()` function:

```
function doRotate() {
  var rotate = ol.animation.rotate({
    rotation : Math.PI * 2
  });
  map.beforeRender(rotate);
}
```

6. Finally, add the `doZoom()` function:

```
function doZoom(factor) {
  var resolution = map.getView().getResolution();
  var zoom = ol.animation.zoom({
    resolution: resolution
  });
  map.beforeRender(zoom);
  map.getView().setResolution(resolution * factor);
}
```

7. Now, reload the example in your web browser and try clicking on the buttons. You should see the map zoom, pan, and bounce between London and Rome.

What just happened?

Not too bad! In a few lines of code, we managed to create some pretty impressive animation effects using `ol.animation` functions and the Map's `beforeRender()` method.

In step 3, we created the `doBounce()` function. This function takes a single parameter, `location`, which is the location that we want to bounce to. The effect we want to achieve is to smoothly zoom out from our current location and then into the new location. We called `ol.animation.bounce()` to create a function that implements the bounce animation effect. For this example, we provided only the `resolution` property and let the other properties (`start`, `duration`, and `easing`) take their default values. We set the `resolution` property to two times the current resolution of the map's view. This is equivalent to clicking the ZoomOut control (the button in the top-left corner of the map with the minus sign) once. What this does is smoothly zoom out from the current resolution to the next zoom level, and then back into the current resolution.

Next, we created a function that implements the pan animation effect. Again, we used the defaults for `start`, `duration`, and `easing` by not specifying them and set the `source` property to the current center of the map's view. We added both `bounce` and `pan` functions to the map by calling `beforeRender()`; then, we changed the map's view to go to the location we passed into this function.

In step 4, the `doPan()` function takes a single parameter, `location`, and smoothly pans the map to it. To do this, we called `ol.animation.pan()` with the map's current center for the source as we did in the `doBounce()` function, then we told the map's view to go to the new location.

In step 5, the `doRotate()` function doesn't take any parameters; we just wanted to spin the map 360 degrees. We used the `ol.animation.rotate()` function for this and set the `rotation` option to specify how much to rotate. When we add this to the map using `beforeRender()`, the effect happens immediately.



In OpenLayers, rotation is always specified in radians. When we think about rotation, we normally think in degrees. To convert from degrees to radians, it is useful to remember that *180 degrees = π radians*. We don't need to know the value of π , JavaScript provides us with the useful constant, `Math.PI`. The formula to convert degrees to radians is `var radians = degrees * Math.PI / 180;`. The inverse is `var degrees = radians * 180 / Math.PI;`. In our example, we wanted to rotate the map 360 degrees. Using the formula above, this becomes `2 * Math.PI`, which is the value we used.

Step 6 adds the `doZoom()` function. It takes a single parameter, `factor`, which is the amount to zoom. We used `ol.animation.zoom()` to create our animation function using the view's current resolution as our starting point. Then, we added our animation function and told the map's view to zoom to a new resolution by multiplying the current resolution by the factor parameter. A factor of two will cause the map to zoom out to the next zoom level and a factor of 0.5 will cause the map to zoom in to the next zoom level.

Have a go hero – exploring animation properties

Now that we've seen how the basic animations work, try modifying the animation properties in each function to see how to change its parameters and overriding the default duration, start time and easing functions. You can also try combining the animations in different ways.

Conversion methods

When we click on a web page, the browser generates a `MouseEvent` that contains, among other things, the position that the click happened at. This position is in pixels and is relative to the browser window. In an OpenLayers application, we will often want to respond to the user interacting with the map and it is important to understand these events specify the position in pixels. It is common to need to determine the geographic coordinate that corresponds to this position. OpenLayers provides several methods that allow us to convert between the browser's pixel space and geographic coordinates:

Method	Parameters	Description
<code>getCoordinateFromPixel(pixel)</code>	<code>pixel</code> - <code>ol.Pixel</code>	This method converts a pixel position to a geographic coordinate and returns an <code>ol.Coordinate</code> . The pixel position is relative to the HTML element the map is contained in.
<code>getPixelFromCoordinate(coordinate)</code>	<code>coordinate</code> - <code>ol.Coordinate</code>	This method converts a geographic coordinate into a pixel position relative to the HTML element that the map is contained in and returns an <code>ol.Pixel</code> .
<code>getEventCoordinate(event)</code>	<code>event</code> - <code>BrowserEvent</code>	This method computes the geographic coordinate from a browser event (such as a click or mouse move) and returns an <code>ol.Coordinate</code> .
<code>getEventPixel(event)</code>	<code>event</code> - <code>BrowserEvent</code>	The method computes the pixel location of a browser event relative to the map's HTML element and returns an <code>ol.Pixel</code> .

Other methods

The map object contains a few other methods that don't neatly fit into the previous groups; so, we've included them here for completeness:

Method	Parameters	Description
<code>forEachFeatureAtPixel (pixel, callback, opt_ this, opt_layerFilter, opt_this2)</code>	<ul style="list-style-type: none"> ◆ pixel - ol.Pixel ◆ callback - function ◆ opt_this - object, or null ◆ opt_layerFilter - function or null ◆ opt_this2 - object or null 	<p>This method queries all layers contained in the map for any features that intersect the pixel location provided. The callback function will be called once for each feature found with the feature as the first argument and the layer it was found in as the second argument. If provided, <code>opt_this</code> will be used as the context for the callback function (the value of <code>this</code> inside the function). By default, all layers will be queried; however, you can choose which layers to query by providing a function for the <code>opt_layerFilter</code> argument. This function will be called once for each layer, passing the layer as the only argument, and is expected to return <code>true</code> if the layer is to be queried and <code>false</code> if the layer is not to be queried. The final <code>opt_this2</code> argument will be used as the context for the layer filter function if provided.</p>
<code>getViewport ()</code>	None	<p>This method returns the HTML element that the map is contained within. Unlike the map's <code>target</code> property, which may return either a string or an HTML element, this method will always return the HTML element.</p>
<code>updateSize ()</code>	None	<p>This method tells the map to recalculate its size based on its container. This is used when other code changes the size of the map's target element.</p>

Events

The standard KVO events `beforepropertychange` and `change` are available, as well as one event for each of the observable properties: `change:layergroup`, `change:size`, `change:target`, and `change:view`. Review the section on KVO in *Chapter 2, Key Concepts in OpenLayers* if you don't remember how these events work.

In addition to the KVO related events, however, there are quite a few new events that can be triggered from a map object. As with any other event, you can register for these events using the `on()` and `once()` methods discussed earlier. We'll group these events into browser events, map events, and render events.

Browser events

The Browser events are all events that are provided in response to the user interacting with the map's HTML element. The available events are:

- ◆ `click`: This event is fired once for every discrete click on the map. If the user double-clicks on the map, this event will be fired twice. If you want to distinguish between a click and a double-click, use the `singleclick` event instead.
- ◆ `dblclick`: This event is fired if the user double-clicks the map.
- ◆ `pointerdrag`: This event is fired when the user moves the mouse while holding down one of the mouse buttons.
- ◆ `pointermove`: This event is fired when the user moves the mouse.
- ◆ `singleclick`: This event is fired when the user single-clicks on the map. There is a short 250 ms delay after the click event before this event is triggered to ensure that the user is not double-clicking the map.

Listeners attached to the Browser events will receive an object of the `ol.MapBrowserEvent` type that contains the following properties:

- ◆ `type` – This is a string, `MapBrowserEvent`.
- ◆ `map`: The `ol.Map` is a reference to the map object on which the event happened.
- ◆ `browserEvent`: The `DOMEvent` is a standard browser event that was originally issued by the browser. This will contain information about the event (its position and what the user did—move, click, and so on) that you'd be usually looking for.
- ◆ `frameState`: This is an object representing the current frame state of the map.

Map events

There are two events that are triggered when the map state changes.

- ◆ `moveend`: This event is triggered when the map completes a transition from one position to another, typically after panning or zooming
- ◆ `postrender`: This event is triggered when the map has completed rendering the current state

Listeners attached to the map events will receive an object of the `ol.MapEvent` type, which contains the following properties:

- ◆ `type`: This is a `MapEvent` string
- ◆ `target`: The `ol.Map`, a reference to the map object on which the event happened
- ◆ `frameState`: This is an object representing the current frame state of the map

Render events

There are two events that are triggered when the map is being rendered. These can be used to programmatically alter the appearance of the rendered map image in interesting ways:

- ◆ `precompose`: This event is triggered when the map is rendered, just before all the layers will be drawn into the rendering context.
- ◆ `postrender`: This event is triggered when the map has completed rendering all the layers into the current rendering context. This is a very interesting event as it provides an opportunity to modify the canvas (for Canvas and WebGL renderers) after the map has been rendered. We'll explore this in *Chapter 6, Styling Vector Layers* when we discuss vector styling.

Listeners attached to the render events will receive an object of the `ol.render.Event` type that contains the following properties:

- ◆ `type`: This is a `MapEvent` string
- ◆ `target`: The `ol.Map` is a reference to the map object on which the event happened
- ◆ `vectorContext`: This is a rendering API capable of drawing to the context
- ◆ `frameState`: This is an object representing the current frame state of the map
- ◆ `context`: This is the 2D context associated with the canvas (if applicable)
- ◆ `glContext`: This is a WebGL rendering context (if applicable)

Views

The map object is the central component of an OpenLayers web application. It is a central place to add and remove things such as layers and controls, and bind them all together. The remaining chapters in the book will introduce you to these other things, but one of those bits is really very closely tied to the map object, and that is the view object. The view object provides the map with the information it needs to decide what location and level of detail—or zoom level—you are looking at. A view also has a projection (which we discussed in *Chapter 2, Key Concepts in OpenLayers*) that determines the geospatial reference system of the map.

The view Class

OpenLayers currently provides a single `View` class, `ol.View`. This class represents a simple 2D view, which can be manipulated through three key properties: `center`, `resolution`, and `rotation`. We will create a new instance of `ol.View` in the same way that we create a map object, like the following:

```
var view = new ol.View(ViewOptions);
```

We've used views in all our examples because a view is a mandatory parameter when creating a new map instance, but we haven't discussed it in detail yet. Let's dive in.

View options

The options you can use when creating a new `ol.View` instance are as follows:

Property	Type	Description
<code>center</code>	<code>ol.Coordinate</code> <code>undefined</code>	This is the initial center for the view. The coordinate system for the center is specified with the <code>projection</code> option. The default value is <code>undefined</code> , and if this property is not set, then layer sources will not fetch data (no map will render).
<code>constrainRotation</code>	<code>boolean</code> <code>number</code>	This option controls how the view will constrain rotation. <code>False</code> indicates no constraint. <code>True</code> indicates that the view should snap to 0 rotation when the rotation is close to zero, but otherwise, not constraint rotation. If this option is set to a number, then rotation is constrained to that many values. For instance, a value of 4 constrains to 0, 90, 180, and 270.
<code>enableRotation</code>	<code>boolean</code>	This controls whether the view can be rotated at all; the default is <code>true</code> .

Charting the Map Class

Property	Type	Description
extent	ol.Extent undefined	This establishes a constraint for the center of the view such that it always lies within this extent. If not provided (the default), the view's center is not constrained.
maxResolution	number undefined	This is the maximum resolution in projection units per pixel that the map supports. This property, combined with minResolution, maxZoom, minZoom, and zoomFactor, determines the zoom levels and resolutions that the map supports. See the section after this table for a complete description of how these properties work together.
minResolution	number undefined	This is the minimum resolution in projection units per pixel that the map supports.
maxZoom	number undefined	This is the maximum zoom level that the map supports.
minZoom	number undefined	This is the minimum zoom level that the map supports.
projection	ol.proj.ProjectionLike	This is the projection of the view; default is EPSG:3857 (Spherical Mercator).
resolution	number undefined	This is the initial resolution for the view. The units are projection units per pixel (for example, meters per pixel).
resolutions	Array.<number> undefined	These are resolutions to determine the resolution constraint. If set, the maxResolution, minResolution, maxZoom, minZoom and zoomFactor options are ignored.
rotation	number undefined	This is the initial rotation for the view in radians (positive rotation clockwise).
zoom	number undefined	This is the zoom level used to calculate the initial resolution for the view. The initial resolution is determined using the constrainResolution method.
zoomFactor	number undefined	This is the zoom factor used to determine the resolution constraint. It is used together with maxResolution, minResolution, maxZoom, and minZoom. The default value is 2.

Understanding resolution

It is important to understand what is meant by the term resolution and how the various view options related to resolution work together.

In the context of OpenLayers, the term resolution means the number of projection units per pixel. A projection determines how the real world, which is a sphere, is represented in 2D space. The definition of a projection includes a number of things, including a 2D coordinate system and an algorithm for converting real-world locations (latitude and longitude) to and from the projection's coordinate system. The projection's coordinate system is defined in a particular set of units, such as meters, feet, or even decimal degrees. The projection's coordinate system has a bounding box defined as values in the projection's unit system. When we say projection units per pixel, we mean a value expressed in the unit system of the projection.

The most zoomed out state of the map will render the bounds of the projection into a 256 x 256 pixel tile. This is considered the maximum resolution and can be calculated as the width of the projection's bounds divided by 256. When the map is at its most zoomed in, the minimum resolution can be calculated as the width of the projection's bounds divided by the number of tiles wide times 256. We yet don't know how many tiles are required to draw the map at the most zoomed in level; so, this has to be known or computed in some way.

The most zoomed out state of the map is, by convention, called **ZoomLevel 0**. When a user zooms in or out, they change to the next zoom level. Zooming effectively changes the number of tiles used to represent the projection's bounds. The default zoom factor is 2, which means that zooming in to the next zoom level doubles the number of tiles in the map (in each dimension) and halves the resolution. If ZoomLevel 0 is 1 tile (wide and high), then ZoomLevel 1 is 4 tiles (2 wide and 2 high). ZoomLevel 3 is 16 tiles (4 wide and 4 high). In fact, the number of tiles required for the width and height of any zoom level can be easily calculated as $numTiles = 2^z$. Each zoom level has a resolution defined by the projection's bounds divided by the zoom level's width in tiles. For any given zoom level z , the resolution can be computed as $resolution = projection\ width / (2^z)$. Likewise, the zoom level equivalent to any resolution can be computed by rearranging the algorithm to $z = \log_2(projection\ width / resolution)$.

When a view is configured, it needs to know a maximum and minimum resolution and a zoom factor for determining the resolutions between the maximum and minimum for zooming. The `View` class provides several options that are used together to determine the resolution constraints. Since zoom level and resolution can be computed from each other, the constraints can be determined in terms of resolution (`maxResolution` and `minResolution`), zoom levels (`minZoom` is equivalent to `maxResolution`, `maxZoom` is equivalent to `minResolution`), or some combination of these. OpenLayers uses the resolution options in preference to the zoom options if both are provided.

In practice, it is usually sufficient to define just the `maxZoom` or `minResolution` because `minZoom` defaults to 0 (the maximum resolution computed from the projection bounds).

View KVO properties

As with the `Map` class, the `View` class has a number of KVO properties that have `accessor` methods (`get` and `set`), property binding, and events as discussed earlier:

Name	Type	Description
<code>center</code>	<code>ol.Coordinate</code>	This is the center of the view, with units determined by the projection.
<code>resolution</code>	<code>number</code>	This is the resolution of the view. The units are projection units per pixel (for example, meters per pixel).
<code>rotation</code>	<code>number</code>	This is the rotation of the view in radians (positive rotation clockwise).

View methods

The `View` class has several methods in addition to its properties:

Method	Parameters	Description
<code>calculateExtent(size)</code>	<code>size - ol.Size</code>	This calculates the extent in projection units for the given size, based on the current resolution and center.
<code>centerOn(coordinate)</code>	<code>coordinate - ol.Coordinate</code>	This centers the view at the geographic coordinate provided.
<code>constrainCenter(center)</code>	<code>coordinate - ol.Coordinate</code>	Given a center coordinate, this applies any constraints and returns the resulting coordinate.
<code>constrainResolution(resolution, delta, direction)</code>	<code>resolution - number undefined</code> <code>delta - number</code> <code>direction - number</code>	Given a resolution, this applies any resolution constraints and returns the resulting resolution.
<code>constrainRotation(rotation, delta)</code>	<code>rotation - number</code> <code>delta - number</code>	Given a rotation value, this applies any rotation constraint and returns the resulting rotation.
<code>fitExtent(extent, size)</code>	<code>extent - ol.Extent</code> <code>size - ol.Size</code>	This fits the given extent based on the given map size.

Method	Parameters	Description
<code>fitGeometry(geometry, size, options)</code>	<p><code>geometry</code> - <code>ol.Geometry</code></p> <p><code>size</code> - <code>ol.Size</code></p> <p><code>options</code> - <code>Object</code></p>	<p>This zooms the map to show the extent of a geometry in a given box size. The options object may contain any of the following:</p> <ul style="list-style-type: none"> ◆ <code>padding</code>: This is an array of four numbers to use as extra padding around the geometry. The order to apply the padding values is top, right, bottom, then left. Default is all 0s (no padding). ◆ <code>constrainResolution</code>: This is a Boolean value indicating whether the resolution after zooming should be constrained to the nearest zoom level. The default value is <code>false</code>. ◆ <code>nearest</code>: This is a Boolean value used when <code>constrainResolution</code> is <code>true</code>, which indicates whether the nearest resolution should be chosen or not. If this is <code>false</code>, then the next most zoomed out resolution will be used (ensuring the geometry's extent will definitely be visible). If this is <code>true</code>, then the closest zoom level will be used, which might mean that the geometry's extent is not entirely contained after zooming. The default value is <code>false</code>. ◆ <code>minResolution</code>: This is the minimum resolution to zoom to when fitting a geometry, which can be used to prevent zooming in really far on small geometries. The default value is 0, which means zoom in as far as possible.
<code>getCenter()</code>		This returns the center of the view.

Method	Parameters	Description
<code>getProjection()</code>		This returns the projection of the view.
<code>getResolutionForExtent(extent, size)</code>	extent - <code>ol.Extent</code> size - <code>ol.Size</code>	This computes the resolution of a given extent and map size.
<code>getZoom()</code>		This returns the zoom level of the view.
<code>rotate(rotation, opt_anchor)</code>	rotation - number opt_anchor - <code>ol.Coordinate</code>	This rotates the view around the specified coordinate, or the center of the map if an anchor is not provided.
<code>setZoom(zoom)</code>	zoom - number	This sets the zoom level of the view.

Time for action – linking two views

We'll wrap up this chapter with a final update to our example by adding a second map and linking the two maps together.

- First, remove the button that we used to move the map between the two `<div>` tags; it's the HTML that looks like this:


```
<button onclick="changeTarget();">Change Target</button>
```
- Also, remove the associated function, `changeTarget()`, as we won't need it any more.
- Next, add some code to create a second instance of `ol.Map` and put it into the `map2 <div>` tag. Note that there is no `view` option!


```
var map2 = new ol.Map({
  target: 'map2',
  layers: [layer]
});
```
- Now, we'll bind the map's `view` property to the other map object:


```
map2.bindTo('view', map);
```
- Reload the example in your browser and try it out. Zooming and panning in the first map automatically updates the view of the second map. The animation buttons also work on the first map and the second map's view gets updated. Panning and zooming in the second map also works and updates the first map.

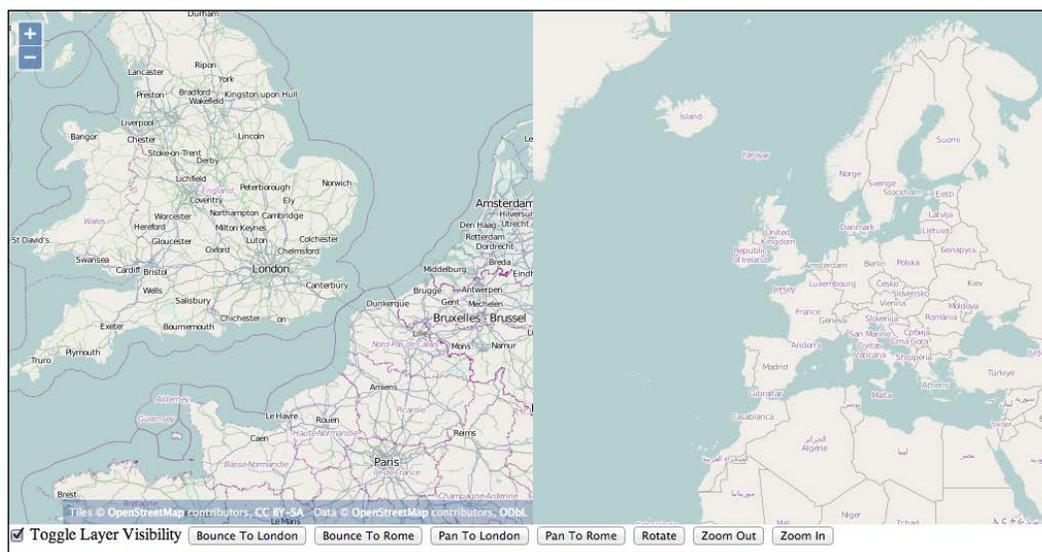
What just happened?

With a single line of code, we bound the view property of the two maps and were able to produce a pretty interesting effect. By itself, this doesn't do much that could be considered useful but it is the basis for building some interesting functionalities such as creating an overview map or a highlight map that shows the same area as a main map but at a different level of detail.

One thing you probably noticed with the previous example is that changes from one map aren't animated in the other one. This behavior is to be expected. If you recall, we mentioned in the animation section that programmatic changes are applied instantly. Since we aren't adding animation effects with `beforeRender()`, the changes applied from one view to the other happen instantly and the result is sometimes quite jarring.

Have a go hero – an overview map

Use the knowledge you've gained in this chapter to adapt the previous example into something more useful. Try to make the second map respond to changes in the first map, but zoomed out three times. Remember that zooming out once is equivalent to doubling the zoom level. When the page loads, it should look like this:



When the first map is panned or zoomed, the second map should center on the same location and stay zoomed out in three levels. The second map should not have any controls or interactions—set both the `controls` and `interactions` option to `new ol.Collection()` to achieve this.

[ You will need a separate view object for the second map.]

Pop quiz

Let's do a series of questions to see what you understood during the chapter:

Q1. I want to start my map looking at a specific location and level of detail. Which object is responsible for this?

1. the Map
2. the View

Q2. I want to take some action when the user pans the map. What event should I listen for?

1. `moveend`
2. `zoomend`

Q3. Which object fires this event?

1. the View
2. the Map

Q4. I want to update a property called `center` of the view object when the `center` property on another object `obj`, changes. Which class provides the `bindTo()` method that I'll use?

1. `ol.Map`
2. `ol.View`
3. `ol.Object`

Summary

This brings us to the end of the `Map` and `View` classes. We covered a lot of detail in these two classes and also uncovered some of the common methods used throughout the OpenLayers library that will help us work with events and key-value observing. We tried out many of the methods in various examples.

In the next chapter, we'll dive into raster layers and discover how to add various types of raster data sources to our OpenLayers applications.

4

Interacting with Raster Data Source

Web maps are very popular today, and are growing in popularity. After Google Maps was introduced, there was an explosion of interactive web maps. Google provides an API to interact with its mapping service, as others do now, and OpenLayers works well with most of them. Not only can we use these third-party APIs with OpenLayers, we can also mash up other layers on top of them. Those services are the most popular, but they suffer from bottleneck depending on your web mapping application. So, you need to know mainstream API and alternatives to display raster images.

In this chapter, we will learn the following:

- ◆ What are layers
- ◆ What types of layers exist, particularly for raster
- ◆ Why some raster data are tiled/untiled
- ◆ What are sources in OpenLayers
- ◆ What is the web mapping history related to layers
- ◆ How does the main sources class associated with a layer works
- ◆ Working with the **Spherical Mercator** and combining different layer classes
- ◆ How to manage nongeographic images using map interactions

Introducing layers

A layer is basically a way to show multiple levels of information independent of each other. Layers are not just a mapping or cartography concept; graphic designers and digital artists make heavy use of layers.

Imagine a printed map of a city. Let's say you also have two sheets of transparent paper. One sheet has blue lines that indicate bus routes, and the other sheet contains green lines that indicate bicycle routes. Now, if you placed the transparent sheet of paper with bicycle routes on top of the map, you will see a map of the city with the bicycle routes outlined.

Putting on or taking off these transparent pieces of paper will be equivalent to turning a layer on or off. The order you place the sheets on top of each other also affects what the map will look like—if two lines intersect, you will either see the green line or the blue line on top. This is the basic concept of a layer.

Layers in OpenLayers 3

OpenLayers is a JavaScript library, and as discussed earlier is built using **Object Oriented Programming (OOP)**. When we want to actually create a layer, we will create (or instantiate) an object from an `ol.layer.Layer` subclass.

OpenLayers has many different `ol.layer` classes. The layer types are only for different kinds of data (tiles, images, and vector). Using an attached `ol.source.*` will allow you to connect to a different type of map server 'back end.' Each layer object is independent of other layer objects; so, doing things to one layer won't necessarily affect the other.

How many layers can I have?

The safest maximum amount of layers you can have on a map at one time depends largely on the user's machine (that is, their processing power and memory). Too many layers can also overwhelm users; many popular web maps (for example, Google and Yahoo!) contain just a few layers. We recommend that you don't use a lot of layers or limit the number of layers that you can turn on at the same time. Adding layers is cheap but making composition of the map image is expensive, particularly with Canvas renderer. If you turn on many layers at the same time, you will end up with an unusable map, whereas if only some of them are turned on, you will have good performance. You also need to be aware that using vector layers instead of raster layers is better for composition performances.



Whatever the purpose of your web map application is, you will need at least one layer to have a usable map. An OpenLayers map without any layers would be like an atlas without any maps. You need at least one layer—at least one **base layer**. All other layers that *sit above* the base layer are called **overlay layers**. The concept inherits from the existing OpenLayers 2 series and was seen in *Chapter 1, Getting Started with OpenLayers*.

The base layer

A base layer is at the very bottom of the layer list, and all other layers are on top of it. This would be our printed map from the earlier example. The order of the other layers can change, but the base layer is always below the overlay layers. By default, the first layer that you add to your map acts as the base layer. You can, however, change the order of any layer on your map to act as the base layer.

You can also have multiple base layers. Although you can set more than one base layer active at a time, for visual readability, most of the time, you only use one.

Overlay layers

Any layer that is not a base layer is called an overlay layer. Like we talked about earlier, the order that you add layers to your map is important. Every time you add a layer to the map, it is placed above the previous one.

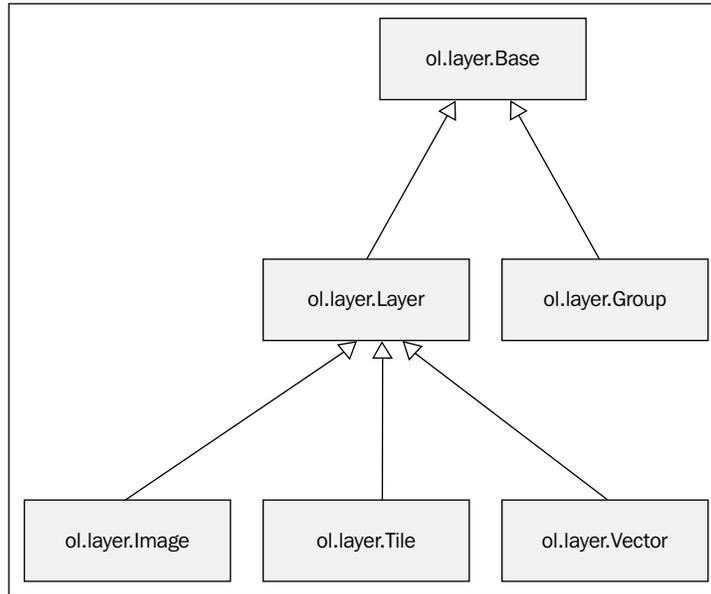
After this reminder about layers concepts, see what's happening at the OpenLayers 3 library level inheritance to discover the main layers type.

Types of layers

There are two types of layers: **raster** and **vector** layers. The main differences between both are:

- ◆ Raster layers are images like PNG or JPEG. They can be generated on server-side or are static. In most cases, your browser doesn't manipulate them but only consumes them.
- ◆ Vector layers are features, geographic objects that are described by their geographic coordinates. They scale up and down without losing visual quality and are easier to style because style can be done on client-side (your browser if you prefer).

To give you an overview of layers organization at the library level, let's look at the following diagram:



When you are creating a new web mapping application, you have to make a choice between benefits and drawbacks of those layers. For raster, it's mainly that images do not overload the browser as vector layers mostly can. As you can see in the diagram, raster layers such as vector layers are derived from a common `ol.layer.Layer` class. This `ol.layer.Layer` class inherits from an `ol.layer.Base` class, (base in this case means common behavior between layers). This class is also inherited by an `ol.layer.Group` class designed to group layers to treat them as a single layer. In our case, we will focus mainly on the two raster layer classes, `ol.layer.Image` and `ol.layer.Tile`. We will also do a review of the common `ol.layer.Layer` methods. Moreover, you can divide raster in two categories: **tiled** or **untiled**. We will cover both types in this chapter. The `ol.layer.Vector` class will be covered in *Chapter 5, Using Vector Layers*.

Common operations on layers

All raster layers inherit from `ol.layer.Layer`.

The following table is the list of available properties. You can also use them with vector although it's not required in this chapter:

Name	Type	Description
<code>brightness</code>	<code>number undefined</code>	This property sets the layer brightness. See Wikipedia webpage (https://en.wikipedia.org/wiki/Brightness) for more information.
<code>contrast</code>	<code>number undefined</code>	This property sets the layer contrast.
<code>hue</code>	<code>number undefined</code>	This property sets the layer hue. You can discover more about hue with the Wikipedia page, https://en.wikipedia.org/wiki/Hue .
<code>opacity</code>	<code>number undefined</code>	This property sets the layer opacity. Possible values are between 0 and 1. The default value is 1.
<code>saturation</code>	<code>number undefined</code>	This property sets the layer saturation. See the dedicated Wikipedia article (https://en.wikipedia.org/wiki/Colorfulness) for more.
<code>source</code>	<code>ol.source.Source</code>	This property defines the source for the layer. Sources are a way to access a resource such as single, tiled images or geographic features.
<code>visible</code>	<code>boolean undefined</code>	This property sets the visibility. The default value is <code>true</code> (visible).
<code>minResolution</code>	<code>number undefined</code>	This is the minimum resolution (inclusive) at which this layer will be visible.
<code>maxResolution</code>	<code>number undefined</code>	This is the maximum resolution (exclusive) below which this layer will be visible.

You can use those properties to set layer properties at startup. If you need to change one of those properties after layer creation, you always have setters and getters. Getters, if you don't remember the part about JavaScript initialization, are methods of objects you can use to get properties. Setters are also methods but to set properties. The setter and getter for a property are derived from the property name. It starts with a `get` or `set` keyword followed by the property with the first letter using uppercase. For example, for `opacity`, the getter name is `getOpacity` and the setter name is `setOpacity`.

You also have some methods that are specific to `ol.layer.Layer` and not related to properties.

The following are the main methods. We will not cover methods related to events: the `ol.layer.Layer` inherits from `ol.Object` via `ol.layer.Base` (<http://openlayers.org/en/v3.0.0/apidoc/ol.html>). It's because we already explained how events works within *Chapter 2, Key Concepts in OpenLayers*.

Name	Description
<code>get('key')</code>	This method gets value for a key (inherited from <code>ol.Object</code>)
<code>set('key', 'value')</code>	This method sets value for a defined key (inherited from <code>ol.Object</code>)
<code>setProperties(object)</code>	This method sets values and keys from an object (inherited from <code>ol.Object</code>)
<code>getProperties()</code>	This method gets all property names and values for the layer within an object.

Let's try to play with the simplest cases.

Time for action – changing layer properties

Follow these steps to change layer properties:

Use the example derived from the first example from *Chapter 1, Getting Started with OpenLayers*, also available at chapter04/2360_04_01_changing_layer_properties.html:

```
<!doctype html>
<html lang="en">
  <head>
    <title>Simple example</title>
    <link rel="stylesheet" href="../assets/ol3/css/ol.css"
type="text/css" />
    <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
  </head>
  <body>
    <div id="map" class="map"></div>
    <script src="../assets/ol3/ol.js" ></script>
    <script>
      var osmLayer = new ol.layer.Tile({
        source: new ol.source.OSM(),
```

```
        opacity: 0.6,  
        brightness: 0.2  
    });  
    var view = new ol.View({  
        center: ol.proj.transform([-1.8118500054456526,  
52.4431409750608], 'EPSG:4326', 'EPSG:3857'),  
        zoom: 6  
    });  
    var map = new ol.Map({  
        target: 'map'  
    });  
    map.addLayer(osmLayer);  
    map.setView(view);  
</script>  
</body>  
</html>
```

1. Show `ol.source.Source` from the `osmLayer`:

```
console.log(osmLayer.getSource());
```

2. Execute the following code:

```
osmLayer.setProperties({opacity: 0.4, contrast:0.6});  
console.log(osmLayer.get('contrast'));  
console.log(osmLayer.get('opacity'));
```

3. See the results and redo a similar operation with:

```
osmLayer.setProperties({opacity: 0.7, contrast:0.3});  
console.log(osmLayer.getOpacity());  
console.log(osmLayer.getContrast());
```

4. Finish the code with these instructions:

```
osmLayer.set('opacity', 1);  
osmLayer.setContrast(1);  
osmLayer.setBrightness(0);  
osmLayer.set('myId', 'myUnique');  
console.log(osmLayer.get('myId'));
```

5. The console result will look like this:

```
> console.log(osmLayer.getSource());
  ▶ Ex {Qa: Ic, Se: Ex, pd: null, c: 1, i: Lt...} VM281:2
< undefined
> osmLayer.setProperties({opacity: 0.4, contrast:0.6});
console.log(osmLayer.get('contrast'));
console.log(osmLayer.get('opacity'));
  0.6 VM282:3
  0.4 VM282:4
< undefined
> osmLayer.setProperties({opacity: 0.7, contrast:0.3});
console.log(osmLayer.getOpacity());
console.log(osmLayer.getContrast());
  0.7 VM283:3
  0.3 VM283:4
< undefined
> osmLayer.set('opacity',1);
osmLayer.setContrast(1);
osmLayer.setBrightness(0);
osmLayer.set('myId', 'myUnique');
console.log(osmLayer.get('myId'));
  myUnique VM284:6
< undefined
```

What just happened?

We reviewed how to manage main methods attached to the `ol.layer.Layer` subclass (remember that `ol.layer.Tile` inherits from it).

The interesting thing here, is that you are able to manipulate and create generic properties for all the `ol.layer.Layer` subclasses.

The most common operations on layers have their custom getters/setters such as `setVisible() / setVisible(property)`, but you can replace them with the `ol.layer.Layer` getters/setters, `get('visible')/set('visible', property)`. These are inherited from `ol.Object`, and consequently, `ol.layer.Tile` inherits them too. In the normal case, you use these getters/setters only for arbitrary properties we want to add, such as a name.

Another benefit you may not be aware of is that when you add new properties to a layer object, you can attach information for new applications related to layers. For example, you can set a property to reference metadata for the layer (intellectual properties, license, link to a PDF file to download, or more). Some other ways to use it are to define groups, set a unique identifier, set a display name to reuse in a custom layer manager, and set a reference to a legend resource (URL, image, and so on).

The possibilities are endless.

Now, after this short introduction to manage layer properties, we will review different raster layers and also the source property. It's mainly these elements that make the difference between raster layers in the OpenLayers 3 library.

Tiled versus untiled layers

We mentioned earlier that there are two types of raster layers: tiled and untiled.

Before sharing ideas about tiling, the first thing to do is define tiling. According to Wikipedia, https://en.wikipedia.org/wiki/Tiled_rendering, it can be considered as *the process of subdividing an image by regular grid*.

So, why is this needed? Again, like for **Closure Tools**, it's for web performances. You can review about Closure tools in more detail in *Appendix B, More details on Closure Tools and Code Optimization Techniques*. Raster data and layers are built from other images or from vector data. The idea here with tiles is to balance the time for data processing and the time for transferring the resource (the image) through the network. It's also because using a regular tile grid can be cached, both by the browser and by the server.

Imagine that you require a complex layer. Would you want to wait for five minutes until it renders? (Rendering is the process to generate an image from geographic sources).

The following table shows a summary of pros and cons for using tiled, untiled resources:

Type of layer	Pros	Cons
Raster tiled layer	<ul style="list-style-type: none"> ◆ Speed: It only takes time to transfer an image. ◆ Stability: You don't need a backend after tiles generation, only to host web accessible map images files. ◆ Support for heavy load: Each tile is only a small image, which is light and will not overload your browser. ◆ Tiles URLs are predefined; so, these can be served through CDN. 	<ul style="list-style-type: none"> ◆ Heavy server consumption to preprocess (generate) the tiles. ◆ Loss of render freshness if pregenerated and not associated with a tile server. ◆ Heavy disk space consumption (Terabytes for world) when pregenerated tiles. ◆ Visual break effects when continuous zoom because tiles are conceived with view levels in mind. When you are not using the view levels, images will stretch and would seems blurry. ◆ Limited to serve multiple projections: a tileset has to be generated for each projection.
Raster untiled layer	<ul style="list-style-type: none"> ◆ Render freshness in all cases. ◆ Limited disk space consumption. ◆ Support for multiple projections. ◆ Image quality rendering at all scales and not only defined levels. 	<ul style="list-style-type: none"> ◆ Heavy load on server-side when there are a lot of users. ◆ Slow with complex layering (heavy process time).

To summarize, if you want performance with less flexibility, choose tiled raster, and if you need fresh data and your layers are based on one or two data sources, choose untiled raster. You can also make a mix of both solutions: use tiles at some levels and untiled content at other levels. Another difference we don't really show in the table for tiles, is that you can pregenerate image tiles for an upper level (such as the country level or lower) and choose to generate tiles on the fly only for lower levels (the street level). Depending on the context, you don't choose: you have to connect to a third-party map server where the choice is restricted to the available web services / images.

The purpose of this comparison is to help you understand how to make a good decision concerning the required layers you have to choose. OpenLayers 3 is only a client-side library; however, knowledge about the principle to provide layers is a requirement to use it well. Also, you may need to host, or own, your map server to serve raster data.

If you ever need to serve your own tiles or raster data, you can take a look at the following open source software:

Geoserver: <http://geoserver.org>

It is a server software that allows you to serve maps and data from a variety of formats to standard clients such as web browsers and desktop GIS programs.

Mapnik: <http://www.mapnik.org>

It's a toolkit for rendering beautiful maps, with clean, soft feature edges provided by quality anti-aliasing graphics, intelligent label placement, and scalable, SVG symbolization. Most popularly, Mapnik is used to render the OpenStreetMap main map layers.

Mapserver: <http://www.mapserver.org>

It is an open source geographic data rendering engine written in C. Beyond browsing GIS data, MapServer allows you to create *geographic image maps*, that is, maps that can direct users to web content. Like GeoServer, it allows map publications via Open Web Standards.

Degree: <http://www.deegree.org/>

Degree is open source software for spatial data infrastructures and the geospatial web. It shares with GeoServer and Mapserver the ability to serve map via Open Web Standards.

We can also mention that there are map proxy applications such as MapCache <http://mapserver.org/mapcache/>, GeoWebCache <http://geowebcache.org>, or MapProxy <http://mapproxy.org>.

Their important purposes are creating tiles for dynamic web server, caching requested map images using GeoServer, MapServer, Mapnik, Degree, or any other map servers.



Types of raster sources

So far, we focused on the differences between tiled and untiled, but you also have some differences coming from the `source` property.

Defining a source

So, how can we define a source? What is its purpose?

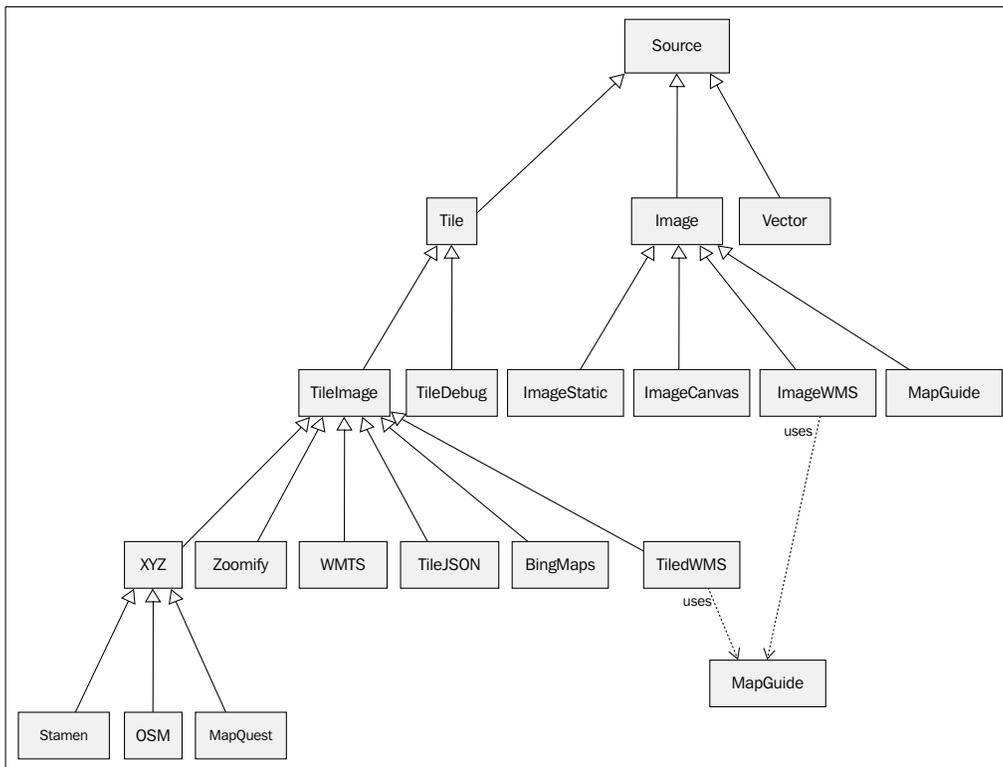
Sources in OpenLayers 3 language define how and where you can access the layer. You always need a source from an `ol.source` subclass in order to retrieve and display layers.

Why did OpenLayers 3 development team invent this concept?

It was mainly for the organization of the code and reusability of the same principles. You gain modularity because you have only three types of layers but more sources. It enables you to decouple the type of layer you are using from the data source and the way you call it. It's simpler to manage a new source than to create a new layer by example if a new source appears.

You can see in the following diagram that `ol.source.Source` has three main child subclasses, `ol.source.Vector`, `ol.source.TileSource`, and `ol.source.ImageSource`.

They are abstract classes. It means, they work as a skeleton for all types of sources but are never directly used:



A quick look at the history of API and tiles providers

Most of the layers we are manipulating are inherited from the past.

Web-based maps are commonplace today. The catalyst for the explosive growth of web maps was the introduction of Google Maps. Web maps existed before, but they were not quick or developer friendly. In June 2005, Google released an API for Google Maps, which provided a frontend client (the role OpenLayers plays), along with an access to the backend map server via their frontend client API.

This allowed anyone to insert not just a Google Map on their site, but also allowed them to add in their own point data and manipulate the map in other ways. Google Maps grew in popularity, and other companies such as Microsoft, Yahoo, MapQuest, MapBox, Nokia, and others followed in their footsteps, creating their own web mapping APIs.

Most of them are more likely to make mashups.

Map mashups

The term mashup refers to an application that combines various different data sources and functionality together. A map mashup is a map that combines different layers and data. Third-party mapping APIs, such as MapQuest and Microsoft Bing Maps, allow people to more easily create these map mashups. For example, a map with an OpenStreetMap base layer overlaid with markers that track places you've traveled to can be considered a map mashup.

OpenLayers did not introduce map mashups, but it allows us to create very powerful ones with ease. Combining an OpenStreetMap layer, a WMS layer, and a vector layer is pretty simple with OpenLayers.

OpenLayers and third-party APIs

OpenLayers 2 had some third-party mapping APIs embedded into its core, enabling you to use its maps inside your Openlayers-based application. Nowadays, for better decoupling of OpenLayers API from third-party APIs, the OpenLayers 3 team choose to have no support for other mapping APIs that tie together tiles and an associated JavaScript API library.

Why this decision?

One of the main goals of OpenLayers 3 was to rewrite OpenLayers 2, making its API cleaner. The support for Google Maps API in OpenLayers 2 has also put a significant maintenance burden on both library and application developers, to keep up with changes of the Google Maps API. To avoid this in OpenLayers 3, the support for Google Maps using Google Maps API is nonexistent. However, Google does provide its tiles independent from their API, but only to paying customers. Fortunately, you have more alternatives to Google Maps API. We will try to show you that **Bing (Microsoft) Maps** (with its tiles service) or **OpenStreetMap** and its derived map images' data services API such as MapQuest can fill the missing provider.

Now, it's time to review all the tiled layers, in particular, to use beautiful background layers for your maps.

Tiled images' layers and their sources

All tiled layers share some common properties. They inherit from the `ol.source.TileImage`. Those common properties are quite useful for other `ol.source.*` that inherit from it, for example, in some cases to put a logo or give attributions (also called credits) for the maps data and/or tiles. You have to be careful in the API docs online as these properties are considered unstable. You have to uncheck the **Stable Only** checkbox on the top banner. Unstable doesn't mean that you don't have to use those properties but that they may change with future OpenLayers releases. It's very useful for application developers to see what they may need to use or migrate in the future. See the following table for further information:

Name	Type	Description
attributions	<code>Array.<ol.Attribution></code> undefined	This gives the source attributions. It's a way to give credits for geographical data and/or tiles providers using an <code>ol.Attribution</code> object. You can provide an array to put multiple attributions.
crossOrigin	null string undefined	This property sets configuration for remote access using CORS (Cross Origin Resource Sharing) . CORS for security purpose sets rules for accessing remote content.
extent	<code>ol.Extent</code> undefined	This property defines the extent for the source.
logo	string undefined	This property defines the logo URL.
opaque	boolean undefined	This property sets the opacity.
projection	<code>ol.proj.ProjectionLike</code>	This property sets the projection.
tileClass	function undefined	This property sets a tile class. By default, it references the <code>ol.source.TileImage</code> function.
tileGrid	<code>ol.tilegrid.TileGrid</code> undefined	This property sets a tile grid.
tileLoadFunction	<code>ol.TileLoadFunctionType</code> undefined	This property is an optional function to load a tile to a given a URL.

Name	Type	Description
<code>tilePixelRatio</code>	<code>number undefined</code>	This property is the pixel ratio used by the tile service. For example, if the tile service advertises 256 px by 256 px tiles but actually sends 512 px by 512 px images (for retina / hdipi devices), then <code>tilePixelRatio</code> should be set to 2. The default value is 1.
<code>tileUrlFunction</code>	<code>ol.TileUrlFunctionType undefined</code>	This is an optional function to get the tile URL given a tile coordinate and the projection.

The most important functions are mostly those that do not start with the word *tile*. The `tileClass`, `tileGrid`, `tileLoadFunction` and `tilePixelRatio` exist but we choose to not cover them as they seem out of the scope for beginners; they help setting access to backend with particular tile grids. Along this book, we will sometimes refer to source as *layer* but it means a layer with the source adapted for a particular backend.

The OpenStreetMap layer

OpenStreetMap (OSM) is a free, Wikipedia style map of the world driven by user contributed content. You are able to use your own OSM tiles or ones provided through the OpenStreetMap servers.

Setting up an OpenStreetMap service and tiles yourself is not too difficult, but it is outside the scope of this book (visit <http://switch2osm.org> for more information on this). Accessing OSM with OpenLayers, however, isn't.

More information on the OpenStreetMap project can be found at <http://www.openstreetmap.org>. To access OpenStreetMap, only using the `ol.source.OSM` constructor without any options is enough. In the previous examples, we were already using this source, so we will not give you another similar example.

Accessing your own OSM tiles

Though using constructor without options can be enough, you can also use other properties. The default constructor code uses the publicly available OSM tiles, but it is easy to point it at your own tiles. To do so, create the layer in this format:

```
var osmLayer = new ol.layer.Tile({
  source: new ol.source.OSM({
    url: 'http://{a-c}.tile.opencyclemap.org/cycle/{z}/{x}/{y}.png'
  })
});
```

To use this, you will have to replace `http://{a-c}.tile.opencyclemap.org/cycle/` with the server hosting your OSM tiles. `{z}`, `{x}`, and `{y}` are variables that OpenLayers will replace with the appropriate values to reference specific map tiles.

The `{a-c}` parameters mean to say you can access tiles using these URLs:

```
http://a.tile.opencyclemap.org/cycle,  
http://b.tile.opencyclemap.org/cycle,  
http://c.tile.opencyclemap.org/cycle
```

This behavior comes from restrictions from your browser: you can't simultaneously ask images from a same domain. It can only request a certain number of resources from the same domain simultaneously, usually 2 or 4. Using subdomains is a way to bypass this limit and speed up the map displaying.

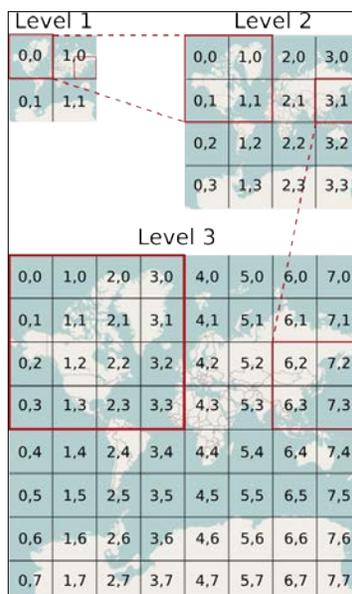
Understanding OSM tiling

If you have different sources for tiling, it is not only to provide different URLs to access different map images. The way tiling is done depends on established standards.

For example, Stamen layers, OpenStreetMap layers, and MapQuest layers are using the same tiling convention, whereas **WMTS (Web Map Tile Service)** can adopt other patterns to display tiles. These patterns are set with the `ol.tilegrid.TileGrid` object that describe for each arbitrary `zoomLevel` how the tiles are split.

The rules are the following. In reality, the Earth is not a sphere, but in this case, our planet is assimilated to a sphere because we are using Spherical Mercator projection (mainly known as EPSG 900913 or EPSG 3857). Do not worry about projections at the moment, we will review them in a later chapter as it can be a difficult topic to understand.

The entire sphere is projected on a single square at the 0 level. Then, for each zoom, you increase a level and for each tile at the previous zoom, we get 4 tiles at this one.



With the preceding diagram, you will know how to access a tile covering East Europe such as Poland at the 3 level. The URL always looks like `URL_TO_TILES/level_z/x_in_grid_for_level/y_for_grid_in_level.png`. So, for Poland that has a zoom level 3, x equal to 4, an y to 2, the URL could be `http://b.tile.openstreetmap.org/3/4/2.png` or `http://c.tile.openstreetmap.org/3/4/2.png` to get the right tile.

OpenStreetMap source class properties

This source enables your layer to consume OpenStreetMap data and customize OpenStreetMap specific properties.

The constructor is `ol.source.OSM` and its properties can use following options:

Name	Type	Description
<code>attributions</code>	<code>Array.<ol.Attribution> undefined</code>	This property can provide an array to put multiple attributions
<code>crossOrigin</code>	<code>null string undefined</code>	This property sets configuration for remote access using CORS (Cross Origin Resource Sharing)
<code>maxZoom</code>	<code>number undefined</code>	This property is the maximum zoom. By default, OpenStreetMap servers provide tiles until a maximum level 18. Some servers are able to work until level 20 for micromapping.

Name	Type	Description
url	string undefined	This property sets the URL referring to tiles. If not defined, the default value is <code>http://{a-c}.tile.openstreetmap.org/{z}/{x}/{y}.png</code> .
tileLoadFunction	ol.TileLoadFunctionType undefined	This is an optional function to load a tile given a URL.

The MapQuest layer

MapQuest was, until around 2008, the leading provider for web mapping API. With the entry of Google Maps, the leadership was lost. In 2010, the company chose to change its position concerning web mapping API, by choosing to exclusively rely on OpenStreetMap data to do the job.

Two layers are available freely. They also provide other services such as their own web mapping API. You can get further information at the Open developer part website at <http://developer.mapquest.com/web/products/open/>.

MapQuest source class properties

The MapQuest source class refers directly to the MapQuest tiles server URL.

The constructor is `ol.source.MapQuest`.

You are only required to use the source constructor included in an `ol.layer.Tile` object to add the layer. There are only two options' properties. The first one is the layer. It can take values such as `osm` (roads), `sat` (satellite), and `hyb` (hybride) depending on the tiles you want to display. The other property `tileLoadFunction` will not be covered here: it's not a common requirement for beginners and we already listed it in the `ol.source.OSM`. At least, you just need to know that it helps change call to tiles with rules defined in your code.

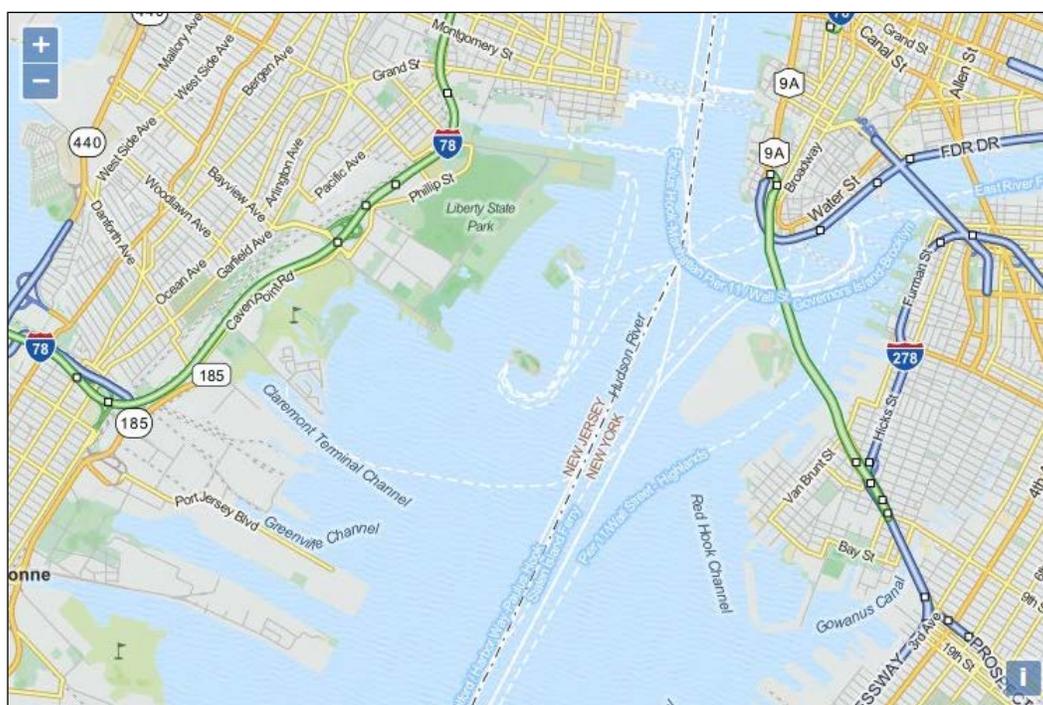
Have a go hero – using OSM layer and MapQuest layers to create a map

The assignment is quite easy:

1. Create a map with both MapQuest OSM and satellite layers.
2. Play with the layer used in particular methods such as `setVisible` to be able to see one layer and hide it to show the other underlying layer.

3. Find some alternative URLs that provide a URL to tiles coming from OpenStreetMap data too but not coming from the official website.
4. Find the real URL that MapQuest layers use, using the debugger and in the code of the library itself (available at <https://github.com/openlayers/ol3>).
5. Center your map on New York City, United States and choose the zoom you want or the part of the city you prefer. You can use <http://openstreetmap.org> to get the coordinates' center.

You will get something like the following screenshot if you center on the Statue of Liberty and use the MapQuest OSM layer:



Stamen layers

The Stamen layers were named so after a company. To cite the OpenstreetMap wiki, Stamen (<http://stamen.com>) is a *San Francisco design and development studio focused on data visualization and map-making*. These layers extensively use OpenStreetMap data in many of their map visualizations and have provided three CC-BY OpenStreetMap tilesets: Toner, Terrain, and Watercolor. You can see how the styles look at the official demo website, <http://maps.stamen.com>.

Time for action – creating a Stamen layer

Follow these steps to create a Stamen layer:

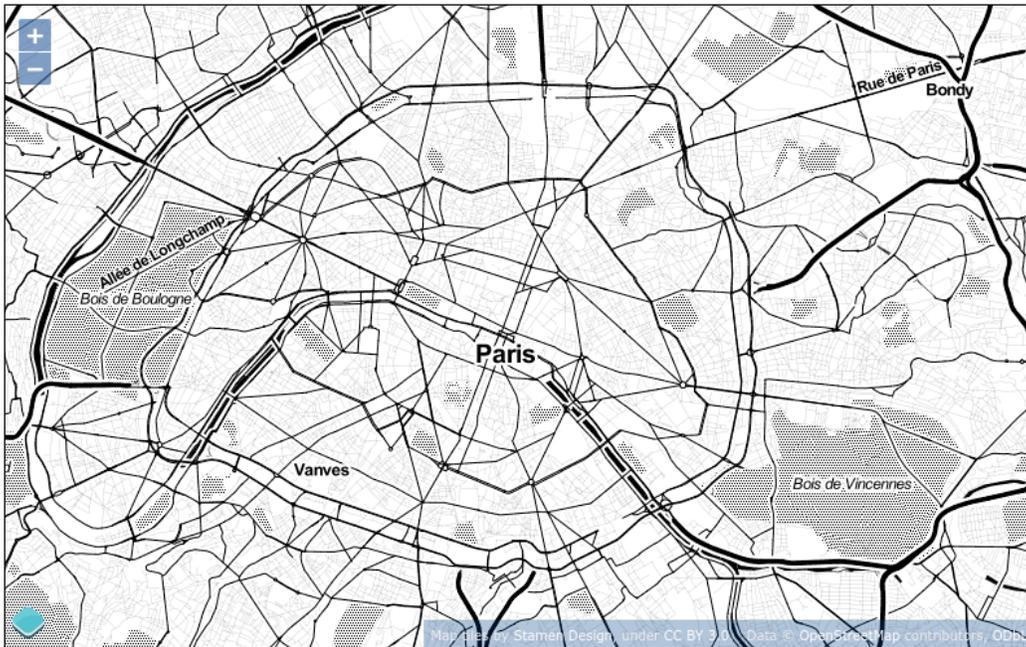
1. We can access the Stamen layer from the outside of the box. This will be pretty simple. First, we just need to create a layer object:

```
var stamenLayer = new ol.layer.Tile({
  source: new ol.source.Stamen({
    layer: 'toner'
  })
});
```

2. Then, we just construct the map directly, adding the view and the layer already configured at startup:

```
var map = new ol.Map({
  layers: [stamenLayer],
  target: 'map',
  view: new ol.View({
    center: ol.proj.transform([2.35239, 48.858391], 'EPSG:4326',
    'EPSG:3857'),
    zoom: 12
  })
});
```

3. You should see something like the following screenshot:



What just happened?

The map we've just created shows a black and white Stamen layer. You can look at other available layers for Stamen, the list is available just after the Stamen Layers' properties below.

Stamen source class properties

Stamen source class refers to the beautiful tiles from Stamen. You can declare their source using the following content.

The constructor is `ol.source.Stamen`.

We will not review all properties, as most of them are configured by default. You can refer to the API docs at <http://openlayers.org/en/v3.0.0/apidoc/ol.source.Stamen.html>.

The most important property to remember is the `layer` where you set the name of the available layer you want with:

```
new ol.source.Stamen({
  layer: 'toner'
})
```

You will find all the available layers names derived from the three Stamen layers in the following table, their image type, and their default state. Be careful, particularly when you are using the `.jpg` images and the `opaque` property option together, the `.jpg` image format is unable to work with transparency. Refer to the following table for further information:

Name	Extension	opaque
terrain	.jpg	true
terrain-background	.jpg	true
terrain-labels	.png	false
terrain-lines	.png	false
toner-background	.png	true
toner	.png	true
toner-hybrid	.png	false
toner-labels	.png	false
toner-lines	.png	false
toner-lite	.png	true
watercolor	.jpg	true

The Bing Maps layer

Microsoft provides an interface to their mapping services as well. Their mapping service previously was referred to as Virtual Earth, but they have since rebranded it as Bing Maps. The official Microsoft documentation can be found at <http://msdn.microsoft.com/en-us/library/dd877180.aspx>.

Time for action – creating a Bing Maps layer

Bing Maps tiles can be viewed using the official Bing Maps API, but they can also be used through an API that gives direct access to their tiles. This is what we will see now:

1. Go to the Microsoft Mapping API register website at <http://www.bingmapsportal.com> to get an official key.
2. Let's set up the source object now. We need to not only specify the `style` property but also the `key`. Contrary to the previous examples, a tile access control is done and works through an account associated with a key to use in your code:

```
var sourceBingMaps = new ol.source.BingMaps({
  key: 'AibU6zHqoTPYDuNRtHPMJq557poKb9AVTIJ0NWWnNZf8LfoRRwoigHTQ0
Frrsr5m',
  imagerySet: 'Road',
});
```

3. Now, create the first `ol.layer.Tile` layer:

```
var bingMapsRoad = new ol.layer.Tile({
  source: sourceBingMaps
});
```

4. Now, add another layer using the other type of image 'Aerial':

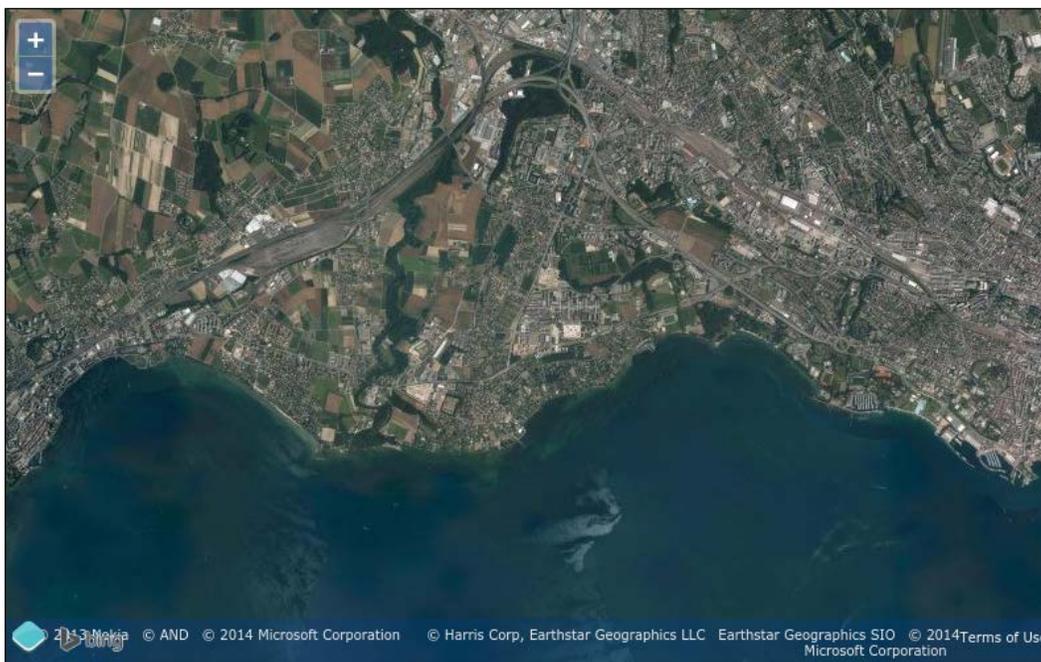
```
var bingMapsAerial = new ol.layer.Tile({
  source: new ol.source.BingMaps({
    key: 'AibU6zHqoTPYDuNRtHPMJq557poKb9AVTIJ0NWWnNZf8LfoRRwoig
HTQ0Frrsr5m',
    style: 'Aerial',
  })
});
```

5. Let's create the map and add the two layers and the view directly:

```
var map = new ol.Map({
  layers: [bingMapsRoad, bingMapsAerial],
  target: 'map',
  view: new ol.View({
    center: ol.proj.transform([6.562783, 46.517814], 'EPSG:4326',
'EPSG:3857'),
```

```
        zoom: 13
      })
    });
```

6. You should see something like the following image:



To make the example work, it's required to put your file on a web server. It can be Apache, but with Python, you can simply do it in the command line in your demo file root directory:

```
python -mSimpleHTTPServer
```

Next, open your browser to http://localhost:8000/sandbox/your_file_name.html.



Another way can be to use the `node index.js` command (if you downloaded the samples code) and open http://localhost:3000/sandbox/your_file_name.html.

Also, you don't have the obligation to create an API key when you are on your local machine. The one used in this book works only when using `localhost` or the official book website at <http://openlayersbook.github.io>.

What just happened?

We just made a map using the Microsoft Bing Map tiles' API. It works similar to the OpenStreetMap tiles layers but required to be authenticated. We can communicate with Microsoft tiles API server and use different properties. Let's go over the properties, as there are some that the other third-party sources do not provide.

Bing Maps source class properties

Bing Maps source helps you consume Bing tiles representing road and imagery in your layer.

The constructor is `ol.source.BingMaps` and the following table is for the options:

Name	Type	Description
<code>culture</code>	<code>string undefined</code>	It is the language and the localization you want to display for your labels. The supported Culture Codes for each style are listed in the official Microsoft documentation at http://msdn.microsoft.com/en-us/library/hh441729.aspx .
<code>key</code>	<code>string</code>	This is the Bing Maps API key. Get yours at http://bingmapsportal.com .
<code>imagerySet</code>	<code>string</code>	This is a type of imagery. It can be <code>Road</code> , <code>Aerial</code> , and <code>AerialWithLabels</code> . Some others are also available for local parts of the world, such as <code>collinsBart</code> or <code>ordnanceSurvey</code> .
<code>tileLoadFunction</code>	<code>ol.TileLoadFunctionType undefined</code>	This is an optional function to load a tile given a URL.

The TileJSON layer

The TileJSON format was invented by MapBox, another company providing OpenStreetMap related services. It relies on JSON notation.

According to the specification, **TileJSON** is an open standard for representing map metadata. Its main goal is to reference the name, the attribution, the server URL, the minimum and max zoom, the center, the bounds, and the scheme of the tile (for OSM, numbering go top to bottom but other tiles' systems start numbering upwards). You can see all available parameters looking at the official specification at <https://github.com/mapbox/tilejson-spec>.

As it is not the mainstream way to get tiles, although it's a smart way, we will not review it through an example but directly advise you to go the official demo available at <http://openlayers.org/en/v3.0.0/examples/tilejson.html> and look into the code.

TileJSON source class properties

TileJSON source permits you to display in a tiled layer custom tile. You can declare their source using the following constructor:

```
ol.source.TileJSON
```

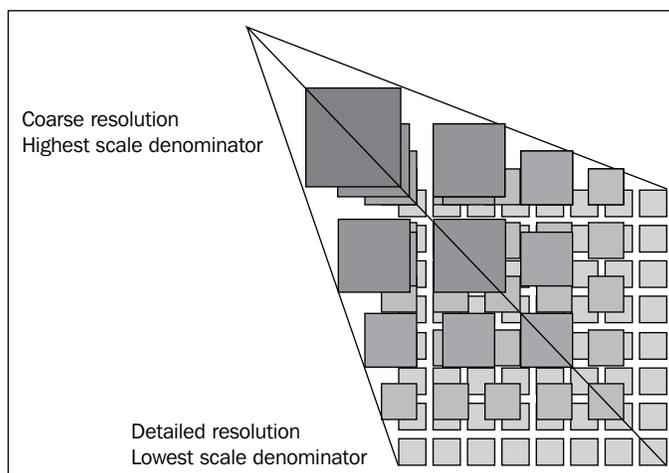
You can also review the available properties, particularly the required URL parameter on the official API docs at <http://openlayers.org/en/v3.0.0/apidoc/ol.source.TileJSON.html>.

WMTS layers

The WMTS layer is based on the WMTS standards. The specification defines it as **The Web Map Tile Service** *described in this standard builds on earlier efforts to develop scalable, high-performance services for web-based distribution of cartographic maps.*

A WMTS-enabled server application can serve map tiles of spatially referenced data using tile images with predefined content, extent, and resolution.

This type of layer is quite different from most of the previous tiled layers we've seen. WMTS layers are more customizable. You can make a request to get tiles in custom projection, you can also choose your grid without caring about the implicit rules, that each tile when you zoom it will give you four tiles, as illustrated with the following figure:



It's really not the most common tiles layer, but you can see it as the most efficient tile system for custom requirements. You can better choose your level of tiling or you can also use custom tile size. For example, for mobile, a smaller tile with 64 pixels for its side can be used instead of the standard 256 pixels size. We recommend, if you are curious, to see the official examples at <http://openlayers.org/en/v3.0.0/examples/> using the **WMTS** keyword. We will not be covering the details here. You can learn more about the standard itself by going to the official dedicated web pages at <http://www.opengeospatial.org/standards/wmts>.

You also need to understand that one of its main goals was to fill the issue for fast rendering contrary to OGC WMS standard as it can be cached.

WMTS source class properties

WMTS sources are complex to declare. They require more parameters than other sources because of their flexibility. For example, the ability to customize for each tile levels grid means also as a drawback, complexity.

The constructor is `ol.source.WMTS`. To see its options, we recommend that you visit the official API docs at <http://openlayers.org/en/v3.0.0/apidoc/ol.source.WMTS.html>.

The DebugTileSource source

The `DebugTileSource` source is only a way to debug tiles rendering in OpenLayers 3. It doesn't use the tile numbering from the source but the internal that OpenLayers use. We just mentioned it to be exhaustive. You use it into a `ol.layer.Tile` class. You can look at the demo to learn more about it at <http://openlayers.org/en/v3.0.0/examples/canvas-tiles.html>. It can really help you to debug special grid, for example, in WMTS.

TileDebugTile source class properties

The `TileDebugTile` source enables you to display numbered grids to show how tiles are regrouped in the OpenLayers Canvas rendering. Canvas is a renderer to display a map in your browser.

The constructor is `ol.source.TileDebug` and for the options, you should visit the official API docs at <http://openlayers.org/en/v3.0.0/apidoc/ol.source.TileDebug.html>.

OpenLayers tiled WMS

A **WMS** (Web Map Service) is a standard protocol for serving georeferenced map images over the Internet that are generated by a map server. You can watch the full reference at the official **OGC (Open Geospatial Consortium)** website, the organization managing this standard (<http://www.opengeospatial.org/standards/wms>).

The two versions of WMS available are 1.1.1 and 1.3.0.

WMS is dynamic: you can generate *on the fly* images.

So, why do I see a reference to a tiled WMS in OpenLayers 3?

It's just a way to lower charge on server-side—when you are generating small images, the process is faster, the memory cost does not really change as the number of requests increase, but you gain the ability to cache the tiles.

But wait, so why can't we use ImageWMS with WMS if we can have the advantage of both tiled (caching) and untiled system (freshness)?

We will not directly answer this right now, but will give you the hint in the section dedicated to ImageWMS.

You can refer to the official example to see a simple example as a reference at <http://openlayers.org/en/v3.0.0/examples/wms-tiled.html>.



To find out what projections a WMS service supports, you can make a `getCapabilities` request to the server. To make this request, specify the `request`, `service`, and `version` properties in the URL. For example, `http://suite.opengeo.org/geoserver/wms?service=WMS&version=1.1.1&request=GetCapabilities`.

You also have to be cautious. Here, we use the Version 1.1.1 version call but the specification supports two versions: 1.1.1 and 1.3.0. It's recommended to use 1.3.0 nowadays, but you can meet external WMS web services using only 1.1.1. Just use the `VERSION` parameter in the `params` options.

Tiled WMS source class properties

Tiled WMS source helps you set tiled WMS calls for your layer. The constructor is `ol.source.TiledWMS` and the options are listed in the following table:

Name	Type	Description
<code>attributions</code>	<code>Array.<ol.Attribution> undefined</code>	This property sets an attributions array for the source.
<code>params</code>	<code>Object.<string, *></code>	This property contains an object of WMS request parameters. At least, a <code>param layer</code> is required. Styles are set by default. The version is 1.3.0 by default. The width, height, BBOX, and CRS (SRS for WMS, version less than 1.3.0) will be set dynamically.
<code>crossOrigin</code>	<code>null string undefined</code>	This property sets the <code>crossOrigin</code> setting for image requests.
<code>extent</code>	<code>ol.Extent undefined</code>	This property sets the extent of your layer source.
<code>tileGrid</code>	<code>ol.tilegrid.TileGrid undefined</code>	This property enables you to declare a tile grid, a custom grid for your source layer.
<code>maxZoom</code>	<code>number undefined</code>	This property sets the maximum zoom level.
<code>projection</code>	<code>ol.ProjectionLike</code>	This property sets the projection.
<code>url</code>	<code>string undefined</code>	This property sets WMS service URL.
<code>urls</code>	<code>Array.<string> undefined</code>	This property sets an array of WMS service URLs. Use this instead of URL when the WMS supports multiple URLs for <code>GetMap</code> requests.

OpenLayers Zoomify

Contrary to most components that are useful only in a map context, this component helps you to display any arbitrary images. It's really useful when you need to display a large image and want performances associated with tiles displayed and the usual interactions of mapping such as panning and zooming.

Some use cases can be game maps, discovery of scanned historical documents such as birth certificates for genealogy, or the old maps with no referencing, meaning that they do not overlay well with existing imagery and geographical data.

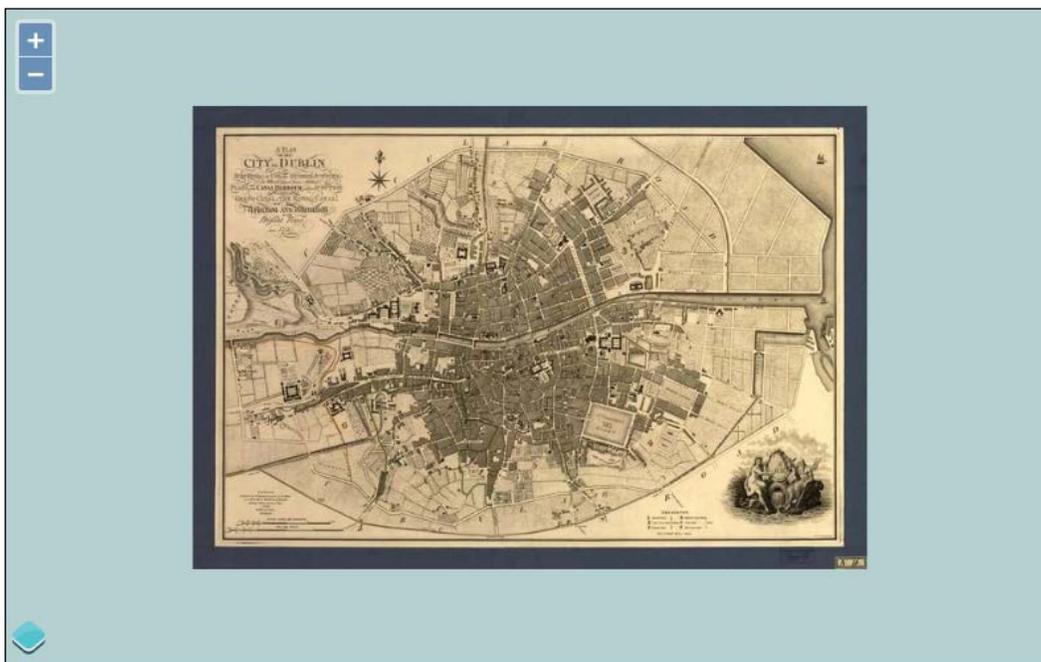
To make the `ol.source.Zoomify` component work, you will need to preprocess a large image to create tiles.

Time for action – creating tiles and adding Zoomify layer

1. With this example, the main goal is to manipulate images. Those images can lack geographic position, or overlay can't be possible or is not useful. In all cases, the image size has to be important as tiles' images are only useful in this use case.
2. Install Python 2.7 series, if you don't have it already installed, using the *Getting Started* from *The Hitchhiker's Guide to Python!* (<http://docs.python-guide.org/en/latest/#getting-started> or the instructions in the *Installing the OpenLayers development environment* section in *Appendix B, More details on Closure Tools and Code Optimization Techniques*).
3. Then, install **PIL (Python Image Library)** using Wikibooks documentation (https://en.wikibooks.org/wiki/Python_Imaging_Library/Getting_PIL).
4. Now, go to download the file, <http://sourceforge.net/projects/zoomifyimage/>, in order to get the software that will provide the way to split your image in tiles. You will need to install a software called **7-Zip** on Windows to decompress the downloaded content.
5. Retrieve the map of Dublin, Ireland, <https://en.wikipedia.org/wiki/File:1797-map-of-Dublin.jpg>, in the original size. We choose this document for its large size and Public Domain rights.
6. Go in the `ZoomifyImage` directory from the third step and generate the tiles for the image. It can take some time, so don't worry, although the program output is not verbose:


```
python ZoomifyFileProcessor.py path_to_dublin_map/1797-map-of-Dublin.jpg
```
7. Copy in the `ol3_samples/assets/data/` directory, the created folder from `path_to_dublin_map/1797-map-of-Dublin/`.
8. Prepare the usual OpenLayers 3 sample structure with no content between the `<script>` and `</script>` tags.
9. Copy the content from <http://openlayers.org/en/v3.0.0/examples/zoomify.js> in your script block.
10. Open the `ImageProperties.xml` from `ol3_samples/assets/data/1797-map-of-Dublin/` file and inspect the `WIDTH` and `HEIGHT` attributes from the `IMAGE_PROPERTIES` xml tag.
11. Copy those values to `imgWidth` and `imgHeight`.
12. Set the `url` variable to `/assets/data/1797-map-of-Dublin/` and change the `zoom` property in the view to 1 instead of 0.

13. Open your browser using the usual local server and you should see a result, similar to the following screenshot, to play a bit:



If you have some difficulty, do not hesitate to retrieve the file from samples.

What just happened?

We just made a map using images' tiles using Zoomify source with its particular grid.

The main particular thing to understand in the sample is to set a projection definition that uses image pixel coordinates, for example:

```
var proj = new ol.proj.Projection({
  code: 'ZOOMIFY',
  units: 'pixels',
  extent: [0, 0, imgWidth, imgHeight]
});
```

We use units' pixels instead of the more usual degrees or meters and the original image width and height are used to define the extent. Then, we use pixels as extent units, instead of meters or degrees.

The component retrieves each tile as we zoom in/out. To get an overview of this behavior, we recommend that you open the Network panel and play a bit with the demo.

Now, it's time to review untiled layers.

Image layers and their sources

Although there are really less image layers' sources available than a tiled one, they are also useful depending on your goal or your backend.

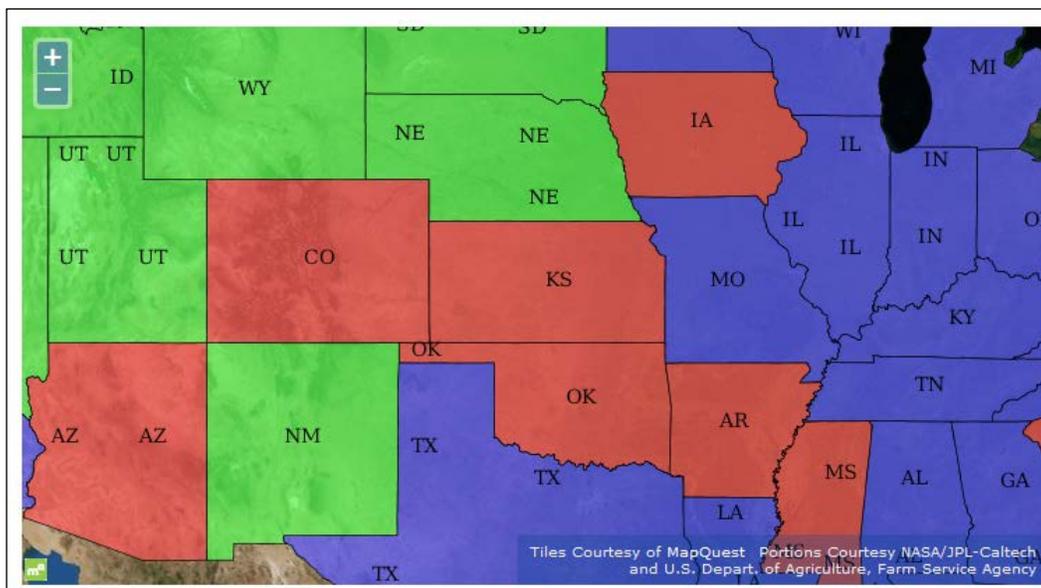
We will start with the image WMS layer and then cover other types.

OpenLayers' image WMS layer

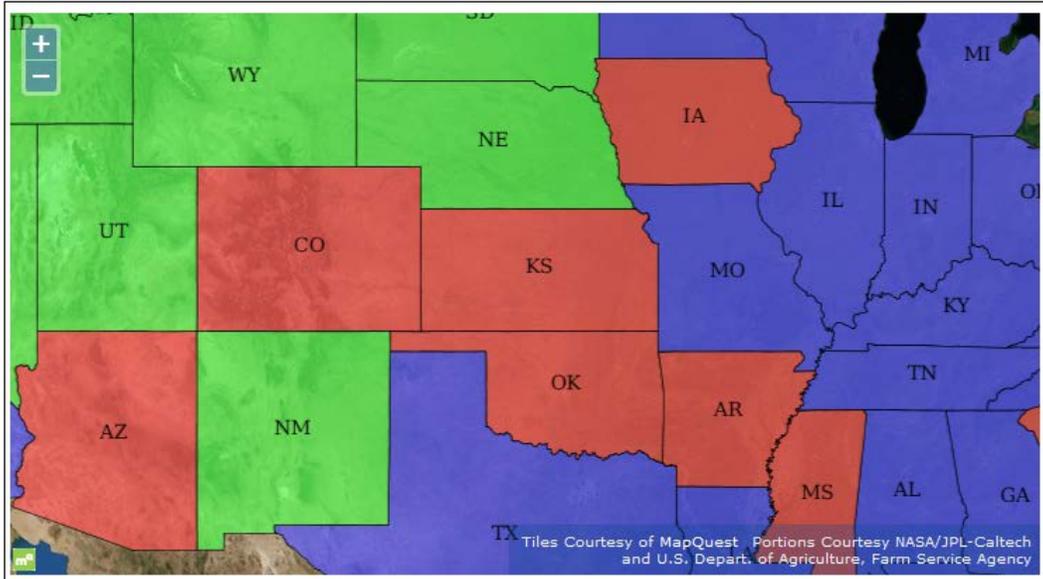
Like the tile layer WMS already reviewed, this component is also using the WMS standard to retrieve the map, `imager`. The thing that differs here is that you add a layer using an `ol.layer.Image` constructor instead of the now more usual `ol.layer.Tile` and, your `ol.source` is `ol.source.ImageWMS` instead. Next, you just have to complete the parameters like for a tiled WMS.

Now, let's see why we need to use untiled WMS.

See the two following images coming from the official example when you zoom in. The first one comes from <http://openlayers.org/en/v3.0.0/examples/wms-tiled.html>. See the following screenshot:



The second image, as shown here, is the untiled one from <http://openlayers.org/en/v3.0.0/examples/wms-image.html>:



You can see that, particularly for labels, they are duplicated. This behavior is quite simple: each tile is requested separately in a tiled WMS. Most of the time the position of the label depends on the position of the object, but here you can request it more than one time because of your tiles. In conclusion, be careful to not use tiled WMS when you are using automatic labeling in WMS or you will suffer from labels' duplications.

After this functional review, let's inspect the WMS layer `ImageWMS` source class properties:

The constructor is `ol.source.ImageWMS`. Contrary to the tiled version, you can't call multiple URLs. The options are available as follows:

Name	Type	Description
<code>attributions</code>	<code>Array.<ol.Attribution> undefined</code>	This property sets an array of attributions, for the layer source.
<code>crossOrigin</code>	<code>null string undefined</code>	This property sets <code>crossOrigin</code> for image requests.
<code>extent</code>	<code>ol.Extent undefined</code>	This property sets the extent of your layer source.

Name	Type	Description
params	Object.<string,*>	These are the WMS request parameters. At least, a layers param is required. The styles are by default. The version is 1.3.0 by default. The width, height, BBOX, and CRS (SRS for WMS version less than 1.3.0) will be set dynamically.
projection	ol.ProjectionLike	This property sets the projection.
ratio	number undefined	This property is the ratio regarding the image requests. 1 means image requests are the size of the map viewport, 2 means twice the size of the map viewport, and so on.
resolutions	Array.<number> undefined	This property is for resolutions. If specified, requests will be made for these resolutions only.
url	string undefined	This property uses the WMS service URL.

After this raster overview, it's time to review a bit more on how to combine those different layers in a big mashup. We will illustrate it combining the layers based on OpenStreetMap projection, the Spherical Mercator.

Using Spherical Mercator raster data with other layers

Getting other layers to play nicely with these layers involve three things. These rules are also available for others projections:

- ◆ Set up the correct map projection properties, in this case, the default is already the right projection.
- ◆ Make sure that projection layer is set to the right EPSG code (most tiles' layers also use the right projection) and are available on the third-party map layer.
- ◆ Ensure all raster layers (any non-Vector or Image layer), such as WMS, are in the map's projection. In this case, we'll need to make sure we ask our WMS server for map tiles in the EPSG:3857 projection.

Using what we've learned so far, let's make a mashup. We'll use OSM derived layers with Bing Maps layer and put at the top a WMS layer. We will also set a small layer switcher (as there is no available component in OpenLayers core code for this).

Time For action – playing with various sources and layers together

To achieve your task, combine our knowledge and just follow these instructions:

1. Let's make a map mashup that consists of a different tiles layer, a WMS layer. We will also play with the visibility to display a basic layer switcher.
2. First, we need to reuse the usual template that call OpenLayers 3 CSS and JavaScript for our code and put it on a local server:

```
<!doctype html>
<html lang="en">
  <head>
    <title>Playing with various sources and layers </title>
    <link rel="stylesheet" href="../assets/ol3/css/ol.css"
type="text/css" />
    <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
  </head>
  <body>
    <div id="map" class="map"></div>
    <script src="../assets/ol3/ol.js" ></script>
    <script>
    </script>
  </body>
</html>
```

3. Now, we can begin to add our layers between the empty `<script>` tag. We add together two Bing Maps layers and add to them a name using `set`. We will reuse this parameter later:

```
var bingMapsAerial = new ol.layer.Tile({
  source: new ol.source.BingMaps({
    key: 'AlQLZO-5yk301_ESrmNLma3LYxEKNSg7w-e_knuRfyYFtld-
UFvXVs38NOulku3Q',
    imagerySet: 'Aerial'
  })
});
bingMapsAerial.set(
  'name', 'Bings Maps Aerial'
);
var bingMapsRoad = new ol.layer.Layer({
  source: new ol.source.BingMaps({
```

```

        key: 'AlQLZ0-5yk301_ESrmNLma3LYxEKNSg7w-e_knuRfyYFtld-
UFvXVs38NOulku3Q',
        imagerySet: 'Road',
        culture: 'fr-FR'
    })
  });
bingMapsRoad.set(
  'name', 'Bings Maps Road'
);

```

- 4.** Now, let's add a MapQuest layer. You just need to use the constructor without an option. We add a layer name using a setter:

```

var mapQuestAerial = new ol.layer.Tile({
  source: new ol.source.MapQuest({layer: 'sat'})
});
mapQuestAerial.set('name', 'MapQuest Open Aerial');

```

- 5.** We'll create our WMS layer now and specify that we want the `topp:states` layer from the URL `http://demo.boundlessgeo.com/geoserver/wms` and various label layers back from the WMS server. We'll also set the opacity to `0.6`, that is 60 percent opaque. The projection is not specified: it comes from the view and we know that the remote layer service available has the right projection (using `getCapabilities`). Go ahead and create the WMS layer and add again a name:

```

var simpleWMS = new ol.layer.Image({
  opacity: 0.6,
  source: new ol.source.ImageWMS({
    url: 'http://demo.boundlessgeo.com/geoserver/wms',
    params: {
      'LAYERS': 'topp:states'
    },
    extent: [-13884991, -7455066, 2870341, 6338219]
  })
});
simpleWMS.set('name', 'USA layer from Geoserver WMS demo');

```

- 6.** Now, let's create an array of all the layers. You will soon discover why we do it like this:

```

var layers = [bingMapsAerial, bingMapsRoad, mapQuestAerial,
simpleWMS];

```

- 7.** Create the `map` object, add into the `layers` object and the view too.

```

var map = new ol.Map({
  layers: layers,
  target: 'map',

```

```
    view: new ol.View({
      center: ol.proj.transform([-90, 40], 'EPSG:4326',
        'EPSG:3857'),
      zoom: 3
    })
  });
```

8. Now, we just need to add the layers to the map.

Now, we'll create a function with a special purpose: creating an HTML label tag and also an HTML input checkbox. It will have three parameters: one for the name, one to create an id for the HTML input, and the planned place where we want to create this checkbox:

```
function generate_checkbox(id_checkbox, label_name, html_element)
{
  var checkbox = document.createElement('input');
  checkbox.type = "checkbox";
  checkbox.id = id_checkbox;
  var label = document.createElement('label');
  label.htmlFor = id_checkbox;
  label.appendChild(document.createTextNode(label_name));
  html_element.appendChild(checkbox);
  html_element.appendChild(label);
}
```

9. Finally, we just need to loop using the layers object from the end of the array to the beginning in order to see; first, our checkbox for the top layer and after the others. We will use two magic functions `ol.dom.Input` and `bindTo` but don't bother about it at the moment:

```
for (var i = layers.length - 1; i >= 0; i--) {
  var id = layers[i].get('id');
  var name = layers[i].get('name');
  generate_checkbox('layer_id_' + i, name, document.body);
  var visible = new ol.dom.Input(document.getElementById('layer_
    id_' + i));
  visible.bindTo('checked', layers[i], 'visible');
};
```

10. Open up your map now and pan on USA. You will see an image, as seen in the following section, and will be able to play with the layer switcher.

You just need to understand that this image source is unusual and is mostly used by people coming from the **CAD (Computer-aided design)** world because this software was released as open source by **AutoDesk**, the leading company for 2D/3D drawing software.

1. For an example, you should go to the OpenLayers official sample, <http://openlayers.org/en/v3.0.0/examples/mapguide-untiled.html>.
2. Contrary to cases where we review an example, we will also recommend that you go to the official link <http://openlayers.org/en/v3.0.0/apidoc/ol.source.MapQuest.html> for the API to discover more about how to achieve specific configuration if required.

Inserting raw images using ImageStatic class

After this short review, it's time to see `ol.source.ImageStatic`, a class that can be seen as the equivalent for the nonprojected image of TileWMS for ImageWMS. It can be also seen as a non-Zoomify source. We will see how to use it within an untiled layer.

Time For action – applying Zoomify sample knowledge to a single raw image

There are some quite important differences to make an equivalent map version of the Zoomify sample. Let's see how:

1. Copy the sample from the Zoomify example previously created into the usual sandbox directory.
2. Change the URL to `/assets/data/1797-map-of-Dublin.jpg`.
3. Set the `imgCenter` variable to `[imgWidth / 2, imgHeight / 2];`.
4. Remove the line code, `var crossOrigin = 'anonymous';`.
5. Replace the `ol.layer.Tile` with `ol.layer.Image`.
6. Then, change the source variable with the following code:

```
var source = new ol.source.ImageStatic({
  attributions: [
    new ol.Attribution({
      html: '&copy; <a href="https://commons.wikimedia.org/wiki/File:1797-map-of-Dublin.jpg#Summary">Wikipedia Commons</a>'
    })
  ],
  url: url,
  imageSize: [imgWidth, imgHeight],
  projection: proj,
  imageExtent: proj.getExtent()
});
```

- Open your browser and you will see the same image you already got from the Zoomify sample, but you will get a less smooth rendering, as you are manipulating only one large image.

What just happened?

You changed the center for the view by using a positive value for the second value in the `imgCenter` variable. It's because the `ol.source.ImageStatic` doesn't use the same origin as the `ol.source.Zoomify`.

We also set as an option, `attributions` referencing the credits to the Wikipedia Commons image.

The most important parts for configuration for the constructor are the `url`, `imageSize`, and `imageExtent`.

We also reused the projection based on pixels' units to set the projection for the source. As a reminder, you can inspect the available properties for the source.

ImageStatic source class properties

The class helps to use any image as a layer using a pixel-based projection.

Its constructor is `ol.source.ImageStatic`. The constructor options are as follows:

Name	Type	Description
<code>attributions</code>	<code>Array.<ol.Attribution> undefined</code>	This property sets an array of attributions for the layer source.
<code>crossOrigin</code>	<code>null string undefined</code>	This property sets the <code>crossOrigin</code> setting for image requests.
<code>extent</code>	<code>ol.Extent undefined</code>	This property sets the extent of your layer source.
<code>imageExtent</code>	<code>ol.Extent undefined</code>	This property sets the extent of the image.
<code>imageSize</code>	<code>ol.Size undefined</code>	This property sets the size of the image.
<code>logo</code>	<code>string undefined</code>	This property sets the logo.
<code>projection</code>	<code>ol.ProjectionLike</code>	This property sets the projection.
<code>url</code>	<code>string undefined</code>	This property sets the URL to image.

To be complete, an ultimate source to review is the `ol.source.ImageCanvas`.

ImageCanvas source class properties

The ImageCanvas source is already an advanced topic, which is out of this book's scope; so, we will only explain its purpose.

If you remember, the default OpenLayers 3 behavior is to generate an HTML Canvas element to display the map image.

The purpose of `ol.source.ImageCanvas` is to help you inject in the HTML Canvas map element any arbitrary Canvas element. It's more flexible but the main drawback is the requirement to manage conversions between map units and the canvas element you want to add.

So, if you want to go further, you will need to learn Canvas drawing and also some projection calculations. At best, you will be able to integrate Canvas produced by other libraries. You also need to understand that a Canvas element can be built from vector elements and not only from raster images. It's a silly use case compared to the ideal separation between raster and vector layers.

Its constructor is `ol.source.ImageCanvas`. If you need it for a special purpose, the best way is to refer to the official documentation at <http://openlayers.org/en/v3.0.0/apidoc/ol.source.ImageCanvas.html>.

You can see it in action with **D3** (another JavaScript library to generate graphic, charts, plots, and also maps), that can produce a canvas element you can use as a layer, as demonstrated in the official example at <http://openlayers.org/en/v3.0.0/examples/d3.html>.



For getting started with Canvas, use the Mozilla Developer part about the HTML 5 Canvas API at https://developer.mozilla.org/en-US/docs/Web/API/Canvas_API.

Summary

In this chapter, we quickly reviewed the layer structure inheritance, focusing on raster. Then, we talked about what raster data layers are, how they work, and what benefits you can get from using different sources to display your maps. We learned how to use the Microsoft Bing Maps layer, all API depending on tiles using OpenStreetMap data. We also discussed tiling in OpenStreetMap that use Spherical Mercator and how to create a map mashup with a layer switcher, mixing various layers and sources' types together. We didn't restrict the chapter to maps as it's possible to also use images unrelated to cartography.

In the next chapter, *Using Vector Layers*, we will see the concept of vector layer in-depth and the OpenLayers main classes for using them. Like for raster, you will discover not only their specific sources but also the various vector data formats and how to manipulate features and geometry.

5

Using Vector Layers

Having explored raster layers, it's time to explore the other layer type that OpenLayers supports—vector layers. In this chapter, we'll introduce the vector layer and discover how to display and interact with vector data on the fly. We'll see how we can use vector sources to load vector data in a variety of formats. Through several hands-on examples, we'll explore the Format, Feature, and Geometry classes that are the foundation of OpenLayers 3 vector support.

In this chapter, we will cover using the vector layer class, `ol.layer.vector`, and some related classes to display vector data. Specifically, we'll:

- ◆ Discuss what the vector layer class is and see how it works
- ◆ Cover the properties, methods, and events of the vector layer class
- ◆ Introduce the three subclasses of the vector layer class
- ◆ Discover and demonstrate the use of format classes
- ◆ Cover the Feature and Geometry classes
- ◆ Learn how to interact with features in vector layers

Understanding the vector layer

In OpenLayers, the vector layer is used to display vector data on top of a map and allow real-time interaction with the data. What does this mean? Basically, it means we can load raw geographic data from a variety of sources, including geospatial file formats such as KML and GeoJSON, and display that data on a map, styling the data however we see fit. For example, take a look at the map that follows:



It shows a map with a Bing satellite **raster layer** and a **vector layer** on top of it. The vector layer loads data using the OSM XML Vector source and draws it in real time with different styles based on the type and attribute of each feature (the individual points, lines, and polygons). In this example, a small subset of the OSM data has been requested and is styled by OpenLayers to highlight roads (white lines), parking lots (gray polygons), buildings (red polygons), green space (in green, of course) and the location of trees (the green dots). We'll cover vector styles in detail in *Chapter 6, Styling Vector Layers*.

Features of the vector layer

With a raster image, what you see is what you get. If you were to look at some close up satellite imagery on your map and see a bunch of buildings clustered together, you wouldn't necessarily know any additional information about those buildings. You might not even know they are buildings. Since raster layers are made up of images, it is up to the user to interpret what they see. This isn't necessarily a bad thing, but vector layers provide much more.

With a vector layer, you can show the actual geometry of the building and attach additional information to it—such as its address, who owns it, its square footage, and so on. As we'll see later in this chapter, it's easy to put a vector layer on top of your existing raster layers and create features in a specific location. We'll also see how we can get additional information about features just by clicking or hovering our mouse over them.

We can display any type of geometric shape with the vector layer—points, lines, polygons, squares, markers, any shape you can imagine. We can use the vector layer to draw lines or polygons and then calculate the distance between them. We can draw shapes and then export the data using a variety of formats, then import that data in other programs, such as Google Earth. These are just a few basic cases though, and throughout this chapter, you'll see how powerful the vector layer can be.

The vector layer is client side

Another fundamental difference is that the vector layer is a client side layer. This means that interaction with the actual vector data happens on the client side. When you display vector data, for instance, its visual representation is generated by OpenLayers in response to the rules you define in your code. Raster data looks the way it looks and you can't easily change the color of roads or decide not to display buildings. When you navigate your map, vector data is generally already available and can be displayed immediately. With raster layers, each time you zoom in or out, OpenLayers has to request more image tiles from the server and wait for them to arrive unless they are already in the browser cache.

Performance considerations

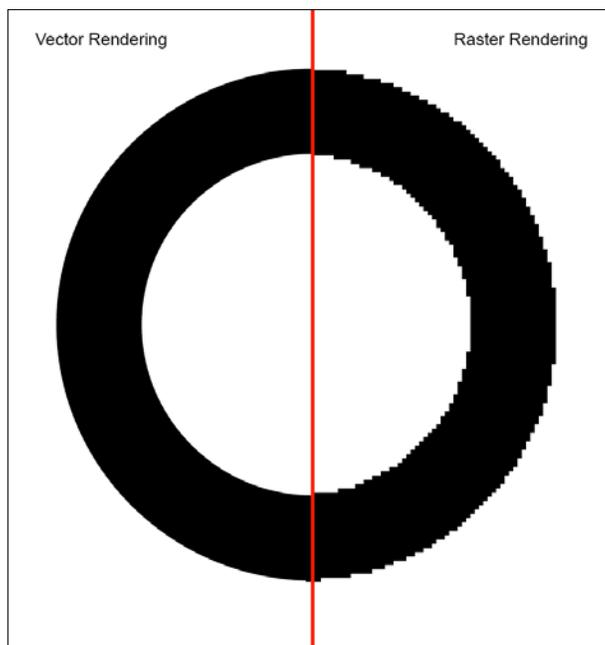
Since, in most cases, the vector data is loaded on the client side, presentation of and interaction with the vector layer usually happens nearly instantaneously. However, there are some practical limitations. Most vector sources make a lot more data available than can be loaded and rendered in the browser. Network bandwidth, memory and processor speed all have limits and, although computers and web browsers are getting faster and more powerful all the time, there are always practical boundaries to what can be done with vector data. The OpenLayers developers have worked hard to push these boundaries and many things that were impossible to consider even two years ago are now practical—we'll highlight some best practices along the way.

The difference between raster and vector

In computer graphics, there are essentially two types of data: **raster** and **vector**. The majority of image files—`.jpeg`, `.png`, `.gif`, and other bitmap image formats—are raster images. A photograph, for example, is a raster image. A raster image is a rectangular grid—like graph paper—of color information, and each color point in an image is called a pixel. When you look at a raster image on your computer, it interprets the color information in each pixel and maps this to physical pixels on your screen. As you zoom in on a raster image, there is a point at which each pixel in the raster image can be rendered to a single physical pixel on your screen. This is referred to as the resolution of the image, the most information that the image can accurately represent. As you zoom in further, each pixel in the raster image is drawn into more than one physical pixel and the quality of the image starts to degrade—we say it is *pixelated*. When you zoom out, each pixel in the raster image requires only part of a physical pixel on the screen and so several adjacent raster pixels are combined to compute a color to display in the physical pixel.

A vector, on the other hand, encodes information about how to draw a particular shape. There might be many ways of representing vector shapes—a straight line can be represented as a starting point and an ending point, or a starting point, direction and distance. When you display a vector on a computer screen, it has to be converted from its encoded format into colors for physical pixels—a process called rasterization. However, because the computer has detailed instructions on how to draw the shape, it can choose a resolution that exactly matches the physical pixels of your computer display every single time it draws it, regardless of how much you zoom in or out. In fact, the same vector information can be drawn on any other screen at the appropriate resolution. For this reason, we often call vector data resolution independent.

Here is an example of how a circle appears when drawn as a vector and a raster. The left side is rendered as a vector and the right side is rendered as a raster. When the image is zoomed, the vector remains sharp and clear but the raster becomes blocky.



Time for action – creating a vector layer

We'll begin by creating a basic vector layer. Start a new page using the sandbox template. We'll use some existing vector data (found in the `assets/data` folder of the sample code that comes with this book) that contains polygons outlining countries of the world and display it in a map:

1. Add the following code to the `<script>` tag to create our vector layer:

```
var vectorSource = new ol.source.GeoJSON({
  projection: 'EPSG:3857',
  url: '../assets/data/countries.geojson'
});
var vectorLayer = new ol.layer.vector({
  source: vectorSource
});
```

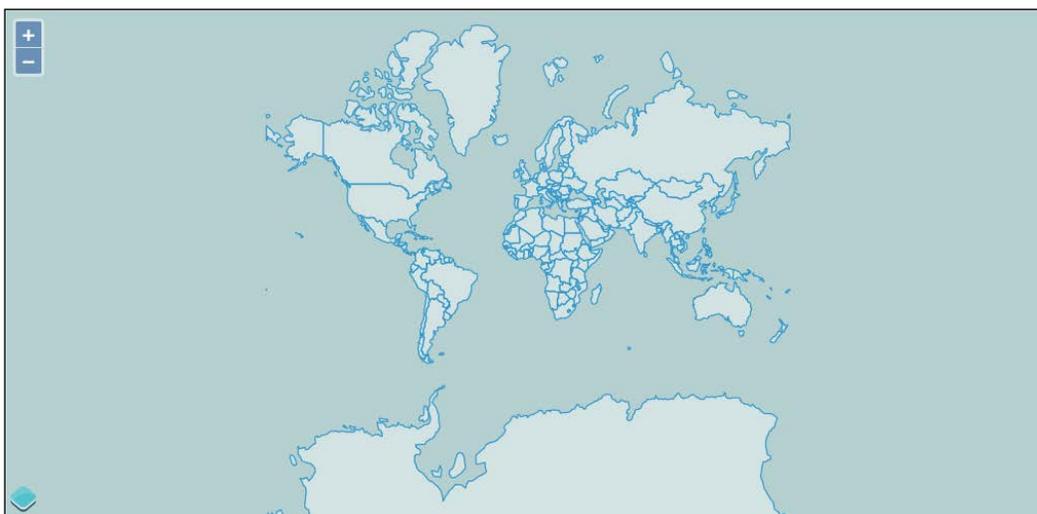
2. Next, create a view object:

```
var center = ol.proj.transform([0, 0], 'EPSG:4326', 'EPSG:3857');
var view = new ol.View ({
  center: center,
  zoom: 1,
});
```

3. Now, create a `map` variable and add the vector layer the same way you would add any other layer:

```
var map = new ol.Map({
  target: 'map',
  layers: [vectorLayer],
  view: view
});
```

4. Now load the page in your browser, you should see something like the following screenshot:



Zoom in on the countries and notice how quickly the map zooms and how sharp the outlines of the countries remain.

What just happened?

We just demonstrated how easy it is to incorporate vector data into a map. First, we created a source, specifically one that knows how to read features in the GeoJSON format. We told the source where to find the data (its `url` property) and what projection we need the data to be in (The view's projection is EPSG:3857, a standard Spherical Mercator projection used in many common commercial maps such as Google and Bing. We'll discuss projections in more detail in *Chapter 7, Wrapping Our Heads Around Projections*). Next, we created a vector layer and provided it with the source we just created. The view object centers the map at 0 degrees latitude and longitude, and we added all of this to the map in the same way we've used in all the other examples.

Pop quiz – why use a vector layer?

Vector layers tend to be very quick, as the data can be stored entirely on the client. Interaction happens instantly, which can greatly enhance the user's experience. Which of the following would be good choices for using vector layers?

- ◆ I want to highlight a building when the user moves their mouse over it.
- ◆ I want to display a topographic base map containing contours, shaded relief, water, and street networks.
- ◆ During a race, I want to visualize the location of boats using GPS data in real time.

Now, before we jump into more advanced uses of the vector layer, first, let's see how it actually works.

How the vector layer works

There are five things we need to cover to understand how the vector layer works:

- ◆ How the vector layer is rendered
- ◆ The vector layer class itself
- ◆ The vector source class and related format classes
- ◆ The Feature and Geometry classes
- ◆ The styling vector layers, which we won't look at until the next chapter

How the vector layer is rendered

Recall from *Chapter 3, Charting the Map Class* that OpenLayers supports three separate renderer technologies, WebGL, Canvas, and DOM. When OpenLayers draws the layers in a map, it uses one of these renderers to do the actual work of drawing. The renderer requests data from the layer's source for the area being displayed, and then transforms this into the final map image. For raster layers, images are fetched from a remote server and are composited into a Canvas element (for WebGL and Canvas renderers) or `` tags (for the DOM render). Vector layers work in the same way, but are only supported by the Canvas renderer at the time this book was written. The renderer asks the layer's source to fetch the data it needs and then applies algorithms for rendering the vector data to the Canvas element. As we mentioned earlier, the vector data is not just an image. It can contain additional information such as the coordinates of the data. This additional information can be used for styling features (which we'll cover in detail in the next chapter) or to provide interactive feedback (as we'll see in an example later in this chapter).



As of OpenLayers 3.1.0, vector rendering is now supported by the DOM renderer.

The vector layer class

The vector layer, by itself, is a layer like the other layers we've discussed so far. To really get the most out of the vector layer class, we'll be working mostly with other classes. For example, to get a basic example working (like the first one in this chapter), we will make use of at least one other class—the `ol.source.Source` class—to read features from a particular vector format. In fact, under the hood, OpenLayers was using a format, features, geometries, and some styles for this example. All of this happens automatically for the simplest case of drawing some vector data, but in practice, it's necessary to understand how these other classes function as well to get the most out of OpenLayers.

Before we get into too much detail, let's cover the vector layer class, `ol.layer.Vector`, itself. It is a direct subclass of `ol.layer.Layer` and inherits its methods and observable properties. Refer to *Chapter 2, Key Concepts in OpenLayers* if you need a refresher on those methods.

Creating a vector layer

The `ol.layer.Vector` class is used to create a vector layer instance:

```
var layer = new ol.layer.Vector(options);
```

The options can include all the options for `ol.layer.Layer` (see *Chapter 4, Interacting with Raster Data Source* for a refresher if necessary) plus the following additional options that are specific to a vector layer:

Name	Type	Description
source	<code>ol.source.Vector</code>	This is a source that provides vector features to the layer for rendering. We will cover sources later in this chapter.
style	<code>ol.style.Style</code> <code>Array.<ol.style.Style></code> <code>ol.feature.StyleFunction</code>	This is a style, or styles, to use when rendering features in this layer, or a function that returns a style for a given feature. Vector styling is covered in detail in the next chapter.

Vector layer methods

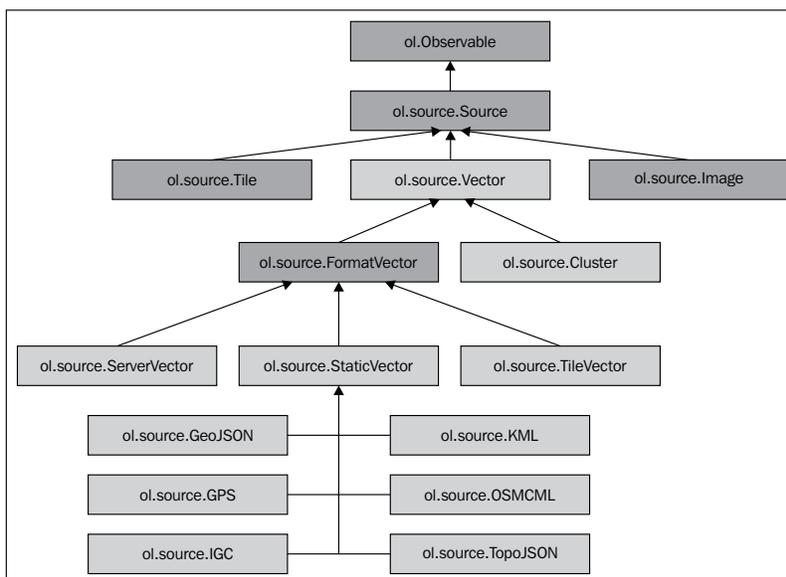
The vector layer class also has several methods in addition to those it inherits from `ol.layer.Layer`.

Method	Parameters	Description
<code>getStyle()</code>	none	This property returns the value provided as the <code>style</code> option in the constructor or to the last call to <code>setStyle()</code> .
<code>getSource()</code>	none	This property returns the source for this layer.
<code>setStyle(style)</code>	<code>ol.style.Style</code> <code>Array.<ol.style.Style></code> <code>ol.style.StyleFunction</code>	This property sets the style to be used when rendering this layer.
<code>getStyleFunction()</code>	none	This property returns a function that can be used to get the style of any given feature on this layer.

Vector sources

The vector layer class by itself isn't very useful—it relies on other classes to do all the interesting work. Let's look at the source class, `ol.source.vector`, and its subclasses first as it's the only thing that is absolutely needed to get a working vector layer.

The vector source class is named after its purpose—to be a source of vector features for a vector layer. It is responsible for fetching features when needed, providing them to the vector layer for rendering, and also for retrieving features based on various criteria. We won't actually use the vector source class as it is a base class for the classes we'll actually be using, such as `ol.source.GeoJSON` in the preceding example. The following diagram shows how the vector source classes fit together in the OpenLayers architecture:



As you can see, there are quite a few classes in the OpenLayers library that deal with vector formats. The classes that you can create new objects from are highlighted in green. We'll briefly describe each class before we get into more detail:

- ◆ `ol.source.Vector`: This is the base class for all vector sources. It provides a common API for accessing features in a vector source.
- ◆ `ol.source.Cluster`: This source automatically groups features together when they are close to each other, and represents the group as a single feature. The cluster source uses another vector source to access features to be clustered.
- ◆ `ol.source.FormatVector`: This class provides a common API for sources that use a format for reading and writing features. You cannot create an instance of this class.
- ◆ `ol.source.ServerVector`: This source uses a loader function that can retrieve vector features on the fly from a server, for example, a **WFS (Web Feature Service)** server.
- ◆ `ol.source.TileVector`: This source loads vector features in batches based on a tiling scheme similar to how raster layers load image tiles.
- ◆ `ol.source.StaticVector`: This source loads vector features from a file in a specific format. It is considered static in that all the available features are read from the file when it is loaded. Although you can create an instance of this class, you will normally use one of the format-specific subclasses.
- ◆ `ol.source.GeoJSON`: This source reads a file containing features in the **GeoJSON** format, a standardized encoding of geographic features using JSON.
- ◆ `ol.source.GPX`: This source reads a file containing features in the **GPX (GPS Exchange format)**, a common file format for GPS devices.
- ◆ `ol.source.IGC`: This source reads a file in the **IGC (International Glider Commission)** format, a standard format for recording glider flights.
- ◆ `ol.source.KML`: This source reads a file in the **KML (Keyhole Markup Language)**, an XML-based format used in Google Maps and related products.
- ◆ `ol.source.OSMXML`: This source reads a file using the **Open Street Map XML** schema.
- ◆ `ol.source.TopoJSON`: This source reads a file encoded in JSON using the **TopoJSON** specification, an extension of GeoJSON that encodes topology information.

The vector source class

The vector source class, `ol.source.vector`, not only provides a common API for all vector sources but is also be instantiated and used directly. All of its subclasses primarily deal with actually retrieving vector features, but all the useful methods for actually interacting with features once they have been processed exist in this class. You can use this class if you have an existing set of vector features or are getting features in some way not directly supported by the subclasses. Some examples might include:

- ◆ Using a mobile device's GPS to track the user's current location and creating waypoints or tracks based on changes in location
- ◆ Programmatically generating features
- ◆ Reading features from a legacy system that is not directly supported by OpenLayers

The vector source constructor takes the following options:

Name	Type	Description
<code>attributions</code>	<code>Array.<ol.Attribution> undefined</code>	This is an array of attribution objects that describe the provenance of the data. The attributions will be displayed on the map in the attribution area when features from this source are rendered on the map.
<code>features</code>	<code>Array.<ol.Feature> undefined</code>	This is an array of feature objects initially added to this source.
<code>logo</code>	<code>string olx.LogoOptions undefined</code>	This is a logo object that represents an image logo to be displayed on the map when features from this source are rendered on the map.
<code>projection</code>	<code>ol.proj.ProjectionLike</code>	This is the projection of the features in this source, or rather the projection of the features' geometries. The projection must be specified.
<code>state</code>	<code>ol.source.State undefined</code>	This is the state of the source, either one of loading, ready, or error.

The vector source also provides the following methods:

Method	Parameters	Description
<code>addFeature(feature)</code>	<code>ol.Feature</code>	This adds a single feature to this source, triggering the <code>addfeature</code> event. A redraw of the map will be scheduled if the feature should appear in the current map area being viewed.

Method	Parameters	Description
<code>addFeatures (features)</code>	<code>Array.<ol.Feature></code>	This adds an array of features to this source. The <code>addfeature</code> event will be triggered for each feature added. As with <code>addFeature</code> , a redraw of the map will be scheduled if any of the features need to be drawn.
<code>clear</code>	none	This removes all features from the source. This will trigger the <code>removefeature</code> event for each feature as it is removed and schedule a redraw of the map if any of the features were visible on the map.
<code>forEachFeature (callback, scope)</code>	<ul style="list-style-type: none"> ◆ <code>callback</code> - function ◆ <code>scope</code> - object null 	This method calls the callback function for each feature in the source. The callback function will be called with a feature as its only argument. Within the callback function, the value of this will be the <code>scope</code> , if provided.
<code>forEachFeatureInExtent (extent, callback, scope)</code>	<ul style="list-style-type: none"> ◆ <code>extent</code> - <code>ol.Extent</code> ◆ <code>callback</code> - function ◆ <code>scope</code> - object null 	This method works the same way as <code>forEachFeature</code> except that it first filters the features by the provided extent. Contrary to what the method name implies, the features may not actually be within the provided extent. Rather, features whose extent intersects the provided extent are included.
<code>getClosestFeatureToCoordinate (coordinate)</code>	<code>ol.Coordinate</code>	This method returns the feature that is closest to the provided coordinate. If there are several features equidistant to the coordinate, it is indeterminate which will be returned.
<code>getExtent ()</code>	none	This returns an <code>ol.Extent</code> object representing the extent all the features currently in this source.

Method	Parameters	Description
<code>getFeatureById()</code>	<code>id - string number</code>	This method returns a feature whose ID equals the passed value. For performance, the type of the <code>id</code> is not used to determine equality. This means that a string value of 2 will match a numeric value of 2. If multiple features have the same <code>id</code> , it is indeterminate which will be returned.
<code>getFeatures()</code>	<code>none</code>	This method returns all the features of this source as an array.
<code>getFeaturesAtCoordinate(coordinate)</code>	<code>ol.Coordinate</code>	This method returns an array of features whose extent contains the given coordinate.
<code>removeFeature(feature)</code>	<code>ol.Feature</code>	This method removes a single feature from the source and triggers the <code>removefeature</code> event. Removing a feature will schedule a redraw of the map if the feature is currently visible.

The vector source can trigger the following events:

- ◆ `addfeature`: This event is triggered when a feature is added to the source
- ◆ `removefeature`: This event is triggered when a feature is removed from the source

The cluster source

There are two subclasses of the vector source, `FormatVector` and `Cluster`. The `FormatVector` class is the basis for many subclasses that obtain features by reading them from some specifically formatted data such as GeoJSON or KML. We'll look into these classes shortly, but first let's take a brief look at the cluster source.

The cluster source dynamically groups (or **clusters**) features that are near each other based on the current resolution, or zoom level, of a map's view and represents those groups as individual features. It does this by finding features within a certain distance of each other and creating a new feature to represent them. The new feature contains a reference to the original features that are represented by the clustered feature.

Creating a cluster source is the same as creating a vector source except the constructor options include two additional properties:

Name	Type	Description
distance	number	This is the minimum distance, in pixels, between clusters. Features that are less than this distance apart at the current zoom level will be clustered into a single feature.
source	<code>ol.source.vector</code>	This is a vector source that provides the features to be clustered.

Time for action – using the cluster source

The cluster source may be used with any type of feature, but it is typically used with a set of point features. This example illustrates using the cluster source with some randomly generated points that are included with the sample files for this project in `assets / data / cluster.geojson`. We'll first show the original data, then modify the example to use the cluster source. The following are the steps:

1. Starting from the previous example, we will add a new vector source that loads the sample data:

```
var originalSource = new ol.source.GeoJSON({
  url: '../assets/data/cluster.geojson'
});
```

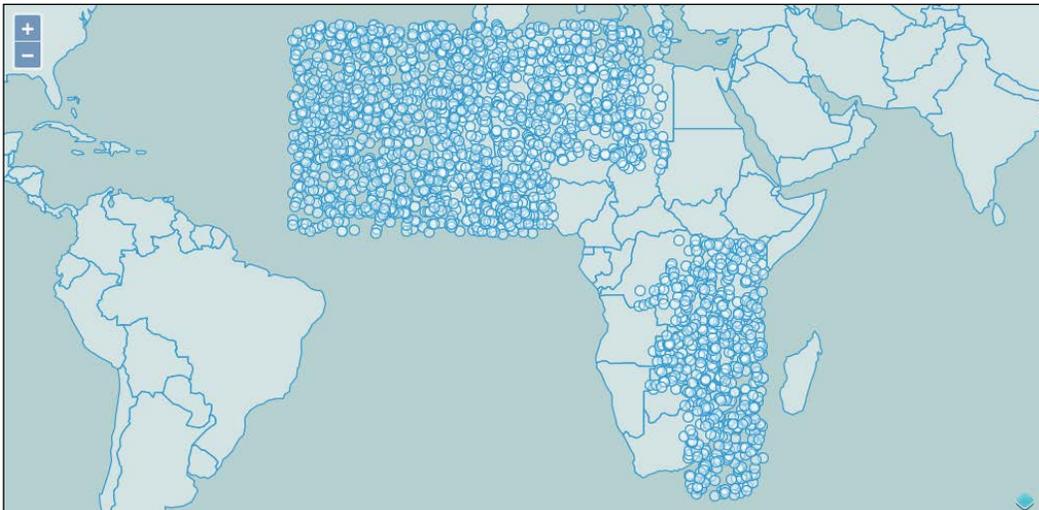
2. Next, we will create a cluster source to cluster these features:

```
var originalLayer = new ol.layer.vector({
  source: originalSource,
});
```

3. Then, add the new layer to the map's `layers` array:

```
var map = new ol.Map({
  target: 'map',
  layers: [vectorLayer, originalLayer],
  view: view
});
```

4. Load this in your browser and take a look:



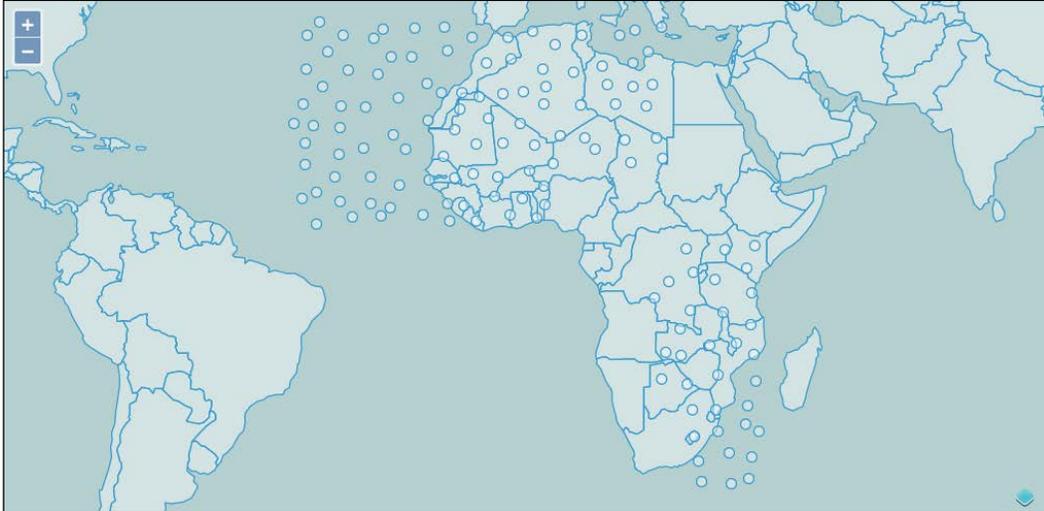
5. That's a lot of points—about 5000 actually. If these represented real data, it will be very hard to see individual points until we zoom way in. Now, let's see what the cluster source does with these features. Create a new source and layer after the `originalLayer`:

```
var clusterSource = new ol.source.Cluster({
  source: originalSource
});
var clusterLayer = new ol.layer.vector({
  source: clusterSource,
});
```

6. And replace `originalLayer` with `clusterLayer` in the map's layers:

```
var map = new ol.Map({
  target: 'map',
  layers: [vectorLayer, clusterLayer],
  view: view
});
```

7. Reload to see the effect of the cluster source. Try zooming in and out.



What just happened?

In this example, we discovered how the cluster source works. First, we created a vector layer containing about 5000 points and displayed it on the map. As we saw, it's very hard to see these points when zoomed out. Next, we added a cluster source and a new layer based on the cluster source. Now the number of points displayed on the map changes dynamically as we zoom in and out, and the number of points on the map at any one time is much more manageable.

Typically, when displaying a cluster of features, we would represent the cluster differently depending on how many features are in the cluster—perhaps by adding a text label or changing the size of the point. We'll revisit this example in the next chapter and deal with the styling options then.

The format sources

The other direct subclass of the vector source is the `FormatVector` source. This class cannot be directly created, rather it is an abstract class that adds a single method, `readFeatures`, to the API of all its concrete subclasses. This means that all the other source classes provide a `readFeatures` method that gets features from some data structure such as a string, array, or JavaScript object. The type of the data structure is determined by the format.

What are formats?

A feature format is responsible for reading features from a structured format that organizes spatial features in a structured way. Each feature format is based on a recognized specification document that defines how that format represents the geospatial data it contains. The feature formats are organized into three distinct groups:

- ◆ **JSON-based formats**, which use the **JavaScript Object Notation** format
- ◆ **XML-based formats**, which use the **Extensible Markup Language** format
- ◆ Text formats, which do not rely on another markup language but rather define their own structure

The JSON formats

There are two JSON-based formats, **GeoJSON** and **TopoJSON**. The GeoJSON format defines a schema used to represent spatial data as JSON data. JSON looks a lot like JavaScript object literals, but it has specific rules for formatting. The main differences between JSON and JavaScript object literals are:

- ◆ JSON strings, including object property keys, must be wrapped with the double quote character
- ◆ Property values in JSON may only be JSON objects, arrays, strings, numbers, and Boolean values
- ◆ JSON may only contain one top-level thing and it must be either an object or an array

To find out more about the JSON format, see <http://www.json.org>.

A GeoJSON file may contain either a `Feature` or `FeatureCollection`. A `Feature` is represented in JSON as an object with three keys: `type`, `geometry`, and `properties`. The `type` is always `"Feature"`. The `geometry` is an object with a `type` and `coordinates`, where the `type` can be one of `"Point"`, `"MultiPoint"`, `"LineString"`, `"MultiLineString"`, `"Polygon"`, `"MultiPolygon"`, or `"GeometryCollection"`, and the `coordinates` are an array containing the coordinates in a structure dependency on the `type`. The `properties` key is an object that contains keys and values representing nonspatial data associated with the feature.

A `FeatureCollection` is represented as an object containing two keys: `type` and `features`. The `type` is always `"FeatureCollection"` and `features` is an array of GeoJSON features structured as in the preceding paragraph.

An example of a `Feature` looks like the following:

```
{
  "type": "Feature",
  "geometry": {
```

```
    "type": "Point",
    "coordinates": [125.6, 10.1]
  },
  "properties": {
    "name": "Dinagat Islands"
  }
}
```

A FeatureCollection looks like the following:

```
{ "type": "FeatureCollection",
  "features": [
    { "type": "Feature",
      "geometry": {"type": "Point", "coordinates": [102.0, 0.5]},
      "properties": {"prop0": "value0"}
    },
    { "type": "Feature",
      "geometry": {
        "type": "LineString",
        "coordinates": [ [102.0, 0.0], [103.0, 1.0], [104.0, 0.0],
[105.0, 1.0] ]
      },
      "properties": {
        "prop0": "value0",
        "prop1": 0.0
      }
    },
    { "type": "Feature",
      "geometry": {
        "type": "Polygon",
        "coordinates": [ [ [100.0, 0.0], [101.0, 0.0], [101.0,
1.0], [100.0, 1.0], [100.0, 0.0] ] ]
      },
      "properties": {
        "prop0": "value0",
        "prop1": {"this": "that"}
      }
    }
  ]
}
```

As you might imagine, this structure is quite easy to use with JavaScript applications and GeoJSON is a popular format for web mapping applications. Read more about this format at <http://geojson.org>.

The TopoJSON format is an extension of the GeoJSON format that encodes topology. A discussion of topology is beyond the scope of this book; briefly, topology defines rules for representing spatial features in a region. The most common example of this is adjacent polygons sharing a common border. Topological rules require two adjacent polygons sharing a common boundary will share the points that define the common boundary between them such that moving one point changes the boundary of both polygons simultaneously. You can find out more about the TopoJSON format at <https://github.com/mbostock/topojson>.

The XML formats

The XML formats are based on XML, a metalanguage that describes structured content using tags denoted by the < and > signs. HTML, which we've seen many times in this book already, looks like XML, and the tags in HTML instruct a web browser how to render the page.



Most HTML is not valid XML. HTML does not follow the strict formatting rules required by XML— particularly, there are many tags in HTML that do not require a closing tag. The tag is an example of this. There is a variant of HTML, called XHTML, that defines a valid XML schema for HTML. While there are some advantages to using XHTML, it has not gained widespread adoption because it is more work for developers to ensure a valid document and the perceived benefits are low.

Structured documents based on XML have a specific set of tags and a set of rules on tag content and nesting. Collectively, the tags and rules are called a schema. There are several geospatial formats based on XML and each defines a specific schema. The schema allows developers to write code to parse the spatial information out of the structured document in the same way that the GeoJSON format proscribes a specific JSON object structure.

The XML-based formats are GML, GPX, KML, OSM XML, and WFS. Let's describe each briefly:

- ◆ **GML (Geography Markup Language):** This is based on a standard published by the Open Geospatial Consortium. This standard was developed in collaboration with many companies that were interested in developing a standard format for describing geospatial information to facilitate exchange of data between different proprietary and open source systems. While GML is very expressive and represents a wide range of geospatial data, it is also quite complicated to support consuming GML as there are several versions and vendor-specific extensions to the schema.
- ◆ **GPX (GPS Exchange Format):** This is a schema supported by many GPS vendors as a common format for representing data generated by GPS devices. Its primary purpose is to describe routes, tracks, and waypoints in a vendor-neutral way. In addition to geographic locations, it can store time, speed, and elevation data.

- ◆ **KML (Keyhole Markup Language)**: This was popularized by Google as the format for representing spatial data rendered in Google Earth. It is less expressive than GML, but contains additional information about how to view the data it represents.
- ◆ **OSM XML (OpenStreetMap XML)**: This schema is used for representing the core data structures in the OpenStreetMap system, particularly nodes, ways, and relations.

The text formats

While all the formats we've discussed so far can be represented in a plain text file, the text formats differ in that they are not based on standard representation. Rather, they define their own unique structure. There are currently two text formats supported by OpenLayers—IGC and WKT.

- ◆ **IGC (International Gliding Commission)**: This format is a specification produced for recording glider flight information. Unless you are part of the gliding community, you probably won't have much need for this format. It is part of OpenLayers, partly because someone had an interest in it and contributed the code, and partly as an example of implementing support for text-based formats. There is a sample IGC file included in `assets/data` if you are interested.
- ◆ **WKT (Well Known Text)**: This is a standard first developed by the Open Geospatial Consortium. It has since been expanded and included in **ISO (International Standards Organisation) 13249-3:2011**. The WKT format is well supported by many open source and commercial GIS applications.

The StaticVector source

Now, we know something about formats, let's look at the next class in the vector source hierarchy—`StaticVector`. OpenLayers provides the `StaticVector` source and some format-specific subclasses designed to simplify loading vector features from the supported formats. They are as follows:

- ◆ `ol.source.GeoJSON`
- ◆ `ol.source.TopoJSON`
- ◆ `ol.source.GML`
- ◆ `ol.source.GPX`
- ◆ `ol.source.KML`
- ◆ `ol.source.OSMXML`
- ◆ `ol.source.IGC`
- ◆ `ol.source.WKT`

Each of these is a vector source that works in exactly the same way, the only difference between them is the format they use internally to read features.

The `StaticVector` source, as the name suggests, loads a set of vector features from a source that does not change. This means the features are loaded, and parsed, just once. The actual features in the source never change in response to panning or zooming. In all other respects, the `StaticVector` source works in the same way as the other vector sources.

You can create an instance of `StaticVector` directly and pass it a format and a source of data, or you can use one of the format-specific subclasses. Let's look first at creating `StaticVector` instance. Note that several of the options only apply for particular formats, as noted in the description.



It is worth emphasizing at this point that for all the OpenLayers formats, the data stored in files are actually text files. Loading these files in a browser will result in the data being loaded as a JavaScript string. Some libraries will automatically convert data from its text-based representation into another type of object for you. For instance, loading XML data from a text file will often give you a reference to a Document Object after it is loaded. In OpenLayers, every format supports loading data from a string value, but the string must contain data that is in the structure expected by the format.

Name	Type	Description
attributions	<code>Array.<ol.Attribution></code>	As with <code>ol.source.vector</code> , this is an optional array of attributions to display when features from this source are displayed on the map.
doc	<code>Document undefined</code>	This is a browser Document Object, typically returned from parsing an XML document. This option is used by the GML, GPX, KML, and OSMXML formats.
format	<code>ol.format.Format</code>	This is the format to use for extracting features from the provided data. The option that provides the data for the format depends on the type of the format, as noted in the relevant options.
logo	<code>string olx.LogoOptions undefined</code>	This is a logo to display when features from this source are displayed on the map.
node	<code>Node undefined</code>	This is a browser node object, typically returned by querying the browser's document or a document parsed from an XML string. This option is used by the GML, GPX, KML, and OSMXML formats.

Name	Type	Description
object	Object undefined	This is a JavaScript object, typically obtained by programmatically creating an object using object literal syntax or by parsing a JSON string. This option is used by the GeoJSON and TopoJSON formats.
projection	ol.proj. ProjectionLike	This is the projection for feature geometries after parsing. Some formats support identifying the projection of the data, or have a default projection. If a projection is passed to the <code>StaticVector</code> constructor and it is different from the projection of the features coming from the format, the geometries of the features will be transformed into this projection.
text	string undefined	This is a string representing the data to load. All formats support reading from a string as long as it is properly structured for that format.
url	string undefined	This is an optional URL to load the data from. If provided, then OpenLayers will attempt to load the URL and parse it using the source's format. The actual format of the data when loaded must match what the format expects. For instance, if the format is <code>ol.format.GeoJSON</code> , then the URL must return valid JSON when loaded.
urls	Array.<string> undefined	These are multiple URLs to load data from. These are treated the same way as the <code>url</code> option, and data will be loaded from each URL in turn.

The actual format-specific source classes generally work the same way and support only those options that make sense from the `StaticVector` class. However, there are some important differences that are worth noting. All the following source constructors support the `attributions`, `logo`, `text`, `url`, and `urls` options listed in the preceding table. For the sake of brevity, these options have been omitted from the following tables.

The JSON formats

The two JSON formats, `ol.source.GeoJSON` and `ol.source.TopoJSON`, support the two additional constructor options. These are shown in the following table:

Name	Type	Description
<code>defaultProjection</code>	<code>ol.proj.ProjectionLike</code> undefined	This is the GeoJSON format specification. This indicates that data is, by default, in the EPSG:4326 projection. Newer versions of the specification allow you to identify the projection of the data as something other than EPSG:4326. If the data is not in EPSG:4326 and the projection is not stored with the data, this option allows you to override the default value.
<code>object</code>	Object undefined	This is a JavaScript object containing the data, usually parsed from a JSON string using the <code>JSON.parse</code> method.

`ol.source.GPX`

The GPX format constructor has no additional options, but will read data from the `node` and `doc` options.

`ol.source.IGC`

The IGC format constructor supports one additional option. Refer to the following table:

Name	Type	Description
<code>altitudeMode</code>	<code>ol.format.IGCZ</code> undefined	This is the mode to use for altitude measurements when parsing data. Possible values are <code>barometric</code> , <code>gps</code> , and <code>none</code> . The default value is <code>none</code> .

`ol.source.KML`

The KML format specification requires that the geometry data for features be represented in EPSG:4326. In addition to supporting the `node` and `doc` options, the KML format supports two other options. Refer to the following table:

Name	Type	Description
<code>defaultStyle</code>	<code>Array.<ol.style.Style></code>	The default style to use for features that do not have embedded style information, or if extraction of styles is disabled.

Name	Type	Description
<code>extractStyles</code>	<code>boolean</code>	KML documents contain embedded style information. If this option is set to <code>true</code> (the default value), then OpenLayers will attempt to extract style information from the KML document for each feature.

ol.source.OSMXML

The GPX format constructor has no additional options, but will read data from the `node` and `doc` options.

Have a go hero

Time to put our new knowledge into action. There are sample files included with the book's code samples in `assets / data` in each of the formats discussed earlier. Try adding each of them to a map. Remember, you will need to create an appropriate source and a vector layer, and add the vector layer to the map. As with earlier examples, you should be able to use the `url` option to load the data without having to load and parse it yourself.

The ServerVector source

The `ServerVector` source requests features from a server by sending the geographic coordinates of some region it needs features for to a server. As you might imagine, there are many different ways of doing this based on what a particular server understands. Each server has its own unique language for requesting features. Many servers implement a common language based on an open standard called **WFS (Web Feature Service)** that can simplify the job. Even so, there are different versions and different flavours of WFS that make it difficult to support them all. To avoid this problem, OpenLayers provides a generic mechanism for requesting features for the `ServerVector` source; specifically it requires that you implement the loader function yourself!

Time for action – creating a loader function

Creating a loader function isn't as hard as it might sound, let's walk through a concrete example that loads features from a WFS server. In this example, we will be using the popular jQuery library to help us load data. If you are not familiar with jQuery, see <http://jquery.com> for more information.

1. Start by creating a new HTML page using the same structure we've used before. We'll start from this for each of the vector source examples. Note the addition of a `<script>` tag to load jQuery:

```
<!doctype html>
<html>
```

```
<head>
  <title>vector Examples</title>
  <link rel="stylesheet" href="../assets/ol3/ol.css" type="text/
css" />
  <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
</head>
<body>
  <div id="map" class="map"></div>
  <script src="../assets/ol3/ol.js" type="text/javascript"></
script>
  <script src="//code.jquery.com/jquery-1.11.0.min.js"></script>
  <script>
    var tiledRaster = new ol.layer.Tile({
      source: new ol.source.OSM()
    });
    var center = ol.proj.transform([-72.6, 41.7], 'EPSG:4326',
'EPSG:3857');
    var view = new ol.View({
      center: center,
      zoom: 12,
    });
    var map = new ol.Map({
      target: 'map',
      layers: [tiledRaster],
      view: view
    });
  </script>
</body>
</html>
```

Next, we'll need to create a style object for displaying our vectors. Don't worry too much about what this is, we'll cover it in detail in *Chapter 6, Styling Vector Layers*. Add this after the `tiledRaster` and before the `center`:

```
var fill = new ol.style.Fill({
  color: 'rgba(0,0,0,0.2)'
});
var stroke = new ol.style.Stroke({
  color: 'rgba(0,0,0,0.4)'
});
var circle = new ol.style.Circle({
  radius: 6,
  fill: fill,
  stroke: stroke
```

```
});  
var vectorStyle = new ol.style.Style({  
  fill: fill,  
  stroke: stroke,  
  image: circle  
});
```

2. Save this file as `vector_template.html` and make a copy of it to use for the rest of this example. We'll be using `vector_template.html` as the starting point for several examples.
3. Now, add the following code after the `vectorStyle` object, which will handle loading features from the remote server:

```
var vectorLoader = function(extent, resolution, projection) {  
  var url = 'http://demo.boundlessgeo.com/geoserver/  
wfs?service=WFS&' +  
    'version=1.1.0&request=GetFeature&typename=osm:builtup_area&' +  
    'outputFormat=text/javascript&format_  
options=callback:loadFeatures' +  
    '&srsname=EPSG:3857&bbox=' + extent.join(',') + ',EPSG:3857';  
  $.ajax({  
    url: url,  
    dataType: 'jsonp'  
  });  
};  
var loadFeatures = function(response) {  
  var features = vectorSource.readFeatures(response);  
  vectorSource.addFeatures(features);  
};
```

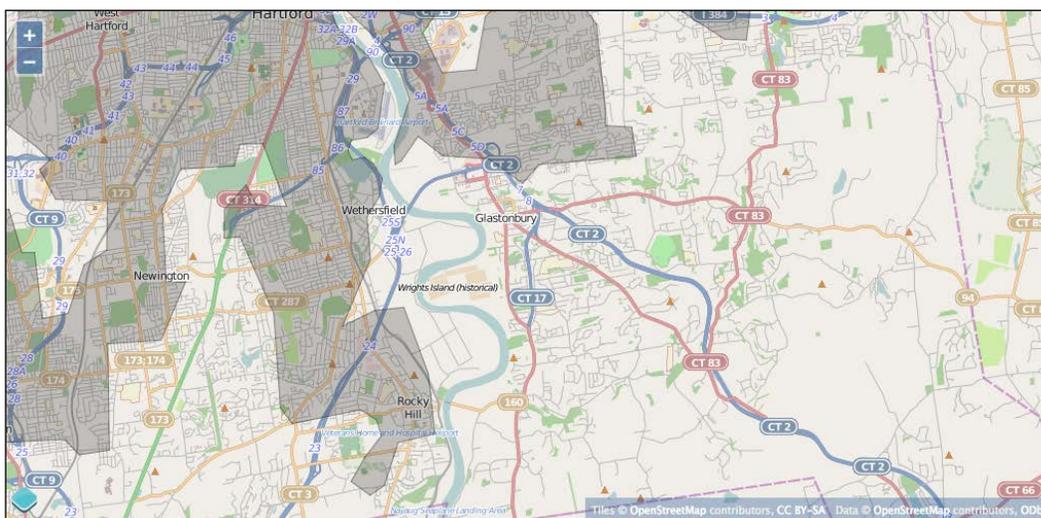
4. We now have everything needed to create the source and layer objects; so, add this code immediately following the `loadFeatures` function:

```
var vectorSource = new ol.source.ServerVector({  
  format: new ol.format.GeoJSON(),  
  loader: vectorLoader,  
  strategy: ol.loadingstrategy.createTile(new ol.tilegrid.XYZ({  
    maxZoom: 19  
  })),  
  projection: 'EPSG:3857',  
});  
var serverVector = new ol.layer.vector({  
  source: vectorSource,  
  style: vectorStyle  
});
```

5. Finally, add the `serverVector` layer to the map's layers:

```
var map = new ol.Map({
  renderer: 'canvas',
  target: 'map',
  layers: [tiledRaster, serverVector],
  view: view
});
```

6. Load the page in your browser and you should see something like the following screenshot:



7. Pan and zoom the map and observe what happens.

What just happened?

We just created a vector layer that reads features from a remote WFS server as the map is panned and zoomed. A lot just happened, so let's review each step in detail.

In step 1, we set up a new OpenLayers application using the same structure as we've used for all the other examples so far. Nothing new here, except we've chosen a center for the map view somewhere in the north eastern United States and named our base layer `tiledRaster` to help differentiate it from the vector layers we will be working with.

In step 2, we created a simple vector style object to use with all our vector layers. A vector style consists of several components, in this case, we are defining the style to use for `fill` (polygons), `stroke` (lines), and `image` (points). The color for each is defined using the `rgba()` syntax, which stands for red, green, blue, and alpha (opacity). In this case, we are using a simple black color and 20 percent opacity. We'll cover styles in much more detail in the next chapter.

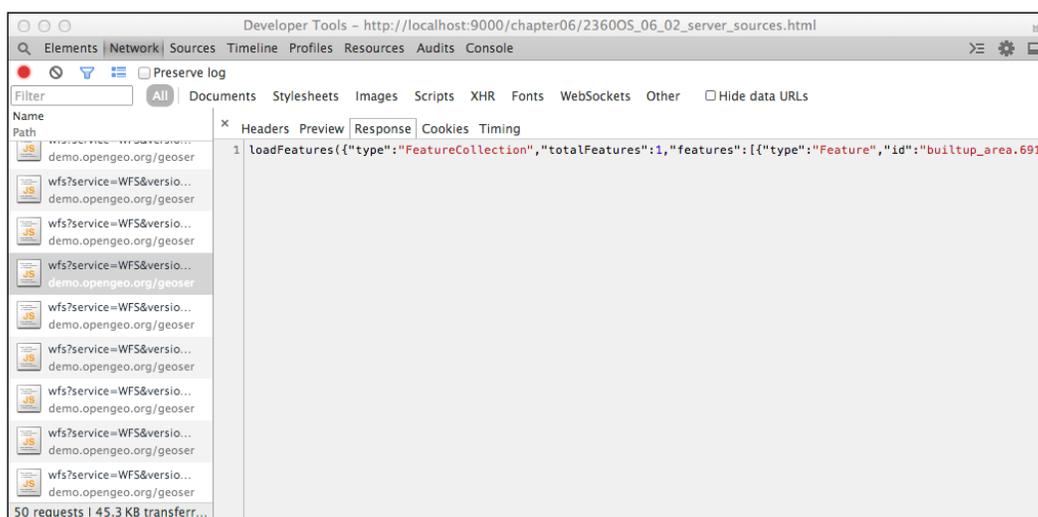
Step 4 is really the heart of this example. First, we defined a `vectorLoader` function. This function is used by `ol.source.ServerVector` to fetch features from a remote server. The `vectorLoader` function declares a URL that points to a WFS server. You might think the URL looks a bit complicated, and you are right. For now, just trust that it does the right thing, which is to ask the server for all the vector features contained within the current extent. The jQuery `ajax` function is used to actually trigger loading the URL. The `jsonp` data type tells jQuery to request the data by inserting it as a `<script>` tag, and the callback option in the URL identifies the function that will be executed when the `<script>` tag is loaded; in this case, the `loadFeatures` function.

The `loadFeatures` function takes the features provided by the server, reads them using the vector source (which has a GeoJSON format for parsing the data), and adds them to the layer.

In step 5, we combined all the previous pieces to create the source and layer objects. To define the source, we used `ol.source.ServerVector` and provided it with a format (GeoJSON in this case), the loader function we defined in the previous step, a loading strategy, and a projection. We'll discuss the loading strategy a bit later. Finally, we created the actual layer object using `ol.layer.vector` and provide it with our source and style.

After we added this to the map's layers in step 5, we can see it in action. Every time the map is panned or zoomed, the vector layer checks its source for features. The `ServerVector` source requests data from a remote server using a function that we provide. This gives you a lot of flexibility, but also means that you have to understand how to load data from a remote server. Fortunately, libraries such as jQuery have very good convenience methods for doing just this. The `ServerVector` source uses its loading strategy to decide how to divide up the requests to the server and passes the appropriate parameters to your loader function. We'll talk a bit more about loading strategies in some time. Once the features are loaded, you can parse them and add them to the source directly. The vector layer then draws the features using the provided style.

To see what happens when features are requested from the server, open Web Inspector, switch to the **Network** tab, and make sure **All** is selected, then reload the page.



You can identify the feature requests because they start with **wfs?service=WFS**. Click on a request to view its response. Notice how some requests have no features, and some have features. Notice how the response is formatted—it looks like a JavaScript function call to `loadFeatures()` with an object literal as the argument. The `loadFeatures()` function is the one we specified and that we implemented. This is an example of how `jsonp` works.

Now that we've seen it in action, let's review the constructor options for a `ServerVector` source:

Name	Type	Description
<code>attributions</code>	<code>Array.<ol.Attribution></code>	As with <code>ol.source.Vector</code> , this is an optional array of attributions to display when features from this source are displayed on the map.
<code>format</code>	<code>ol.format.Format</code>	This is the format that the server features are represented in.
<code>loader</code>	<code>function</code>	This is a function that creates an appropriate request to the server for a given extent, resolution and projection. If the server responds successfully with data to be parsed, then the source's format should be used by the loader function to read the features from the data returned by the server.

Name	Type	Description
logo	string olx. LogoOptions undefined	This is a logo to display when features from this source are displayed on the map.
strategy	function	<p>This is a function that determines how the source will split up requests to the server. There are two built-in strategy functions:</p> <ul style="list-style-type: none"> ◆ <code>ol.loadingstrategy.all</code>: This strategy loads all the available data in a single request by specifying an infinite extent. ◆ <code>ol.loadingstrategy.bbox</code>: This strategy loads data for the visible map extent. Panning or zooming the map can trigger additional calls to the loader function, possibly overlapping previously loaded regions. <p>There is one additional option available, <code>ol.loadingstrategy.createTile</code>. You do not use this as a loading strategy directly, instead it is a function you call to create a loading strategy function based on a tile-grid specification. The return value from this is a function to be used as a loading strategy that triggers requests based on regular tile boundaries. Unlike the BBOX strategy, the extent for each call to the loader function will not overlap previous extents.</p>
projection	ol.proj. ProjectionLike	This is the projection for feature geometries after parsing.

The TileVector source

The final vector source is `TileVector`. This source loads features by requesting them in batches based on a tile grid exactly the same way that the raster sources work. The job of a tile grid is to divide the world up into rows and columns and convert geographic coordinates for the current view into row and column references.

If you were following closely in the previous section, you might wonder how `TileVector` is different from a `ServerVector` configured with a loading strategy based on `ol.loadingstrategy.createTile`. The main differences are as follows:

1. The `TileVector` source has its own loading functionality—you do not need to provide one.
2. The `TileVector` source uses the row, column, and zoom level rather than geographic coordinates to request features from the server.

- The `TileVector` source provides convenient options for working with tile-based servers.



There are several ways of producing and serving vector tiles. One way is to use a program that splits vector data up into tiles based on a particular tile grid and save the tiles to disk in a directory structure based on the zoom level, column, and row. Another way is to use a server that can split up vector data on the fly. The OpenStreetMap wiki has a page dedicated to vector tiles and related resources at http://wiki.openstreetmap.org/wiki/vector_tiles.

Time for action – working with the `TileVector` source

The use of a tile grid removes the need to implement a loader function; so, there is less work involved in setting it up. Let's see how easy it is to use the `TileVector` source:

- Starting from the previous example, add the following after the `serverVector` layer is defined:

```
var tiledSource = new ol.source.TileVector({
  format: new ol.format.TopoJSON({
    defaultProjection: 'EPSG:4326'
  }),
  projection: 'EPSG:3857',
  tileGrid: new ol.tilegrid.XYZ({
    maxZoom: 19
  }),
  url: 'http://{a-c}.tile.openstreetmap.us/vectiles-water-areas/
{z}/{x}/{y}.topojson'
});
```

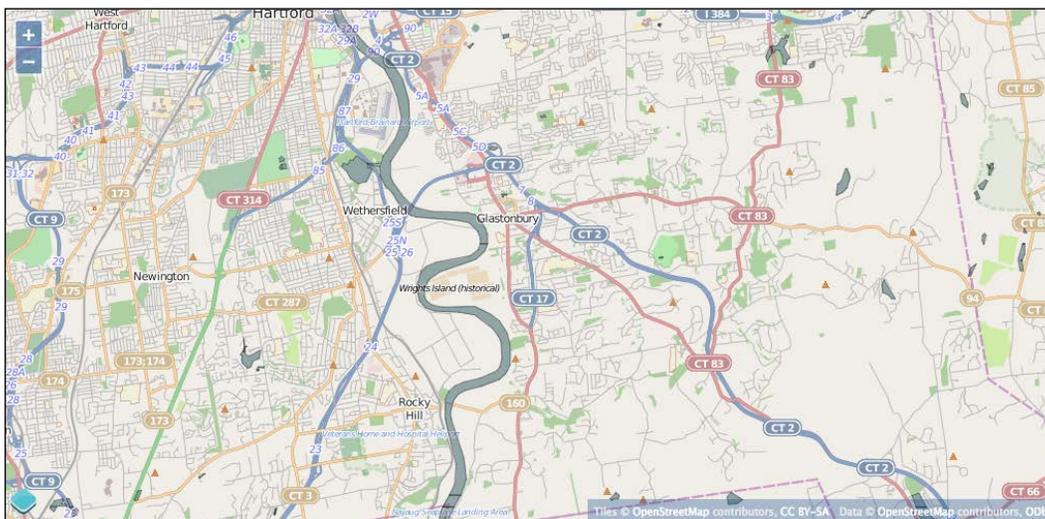
- Now, add create a vector layer using this source:

```
var tiledVector = new ol.layer.vector({
  source: tiledSource,
  style: vectorStyle
});
```

- And finally, change the map to load the `tiledVector` layer instead of the `serverVector` layer:

```
var map = new ol.Map({
  renderer: 'canvas',
  target: 'map',
  layers: [tiledRaster, tiledVector],
  view: view
});
```

4. Load this in your browser and you should see something like the following screenshot:



What just happened?

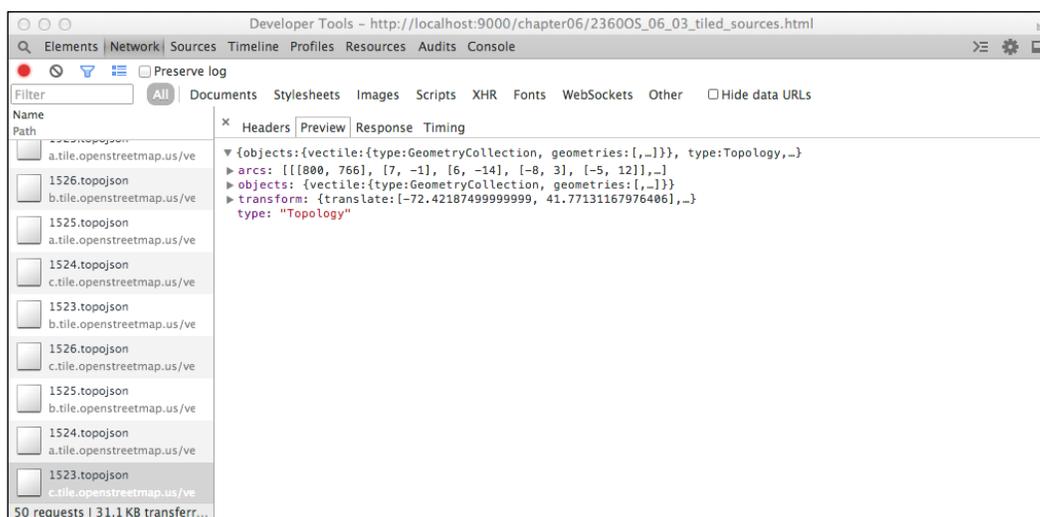
As you can see, the `TileVector` source is quite a bit simpler than the `ServerVector` source. For the `TileVector`, we provided a `format`, a `projection` to convert vector features into (typically, the projection used with the map's view), a `tileGrid`, and a `url`. The `format` specifies what format the features will be in, which tells OpenLayers how to read features from the tiles sent by the server. It also can specify the projection used for the features. In this example, the server provides files in the TopoJSON format, a variant of GeoJSON that encodes topology, in a projection of EPSG:4326 (latitude and longitude). The `tileGrid` tells OpenLayers how to convert geographic coordinates into rows and columns that the server will understand. You can't just use any `tileGrid` with any server—it's very important that the `tileGrid` matches what the server expects. The XYZ tile grid, however, is a very common grid used by most tile servers, both raster and vector. The `url` property tells OpenLayers where to request each tile from. There are some special placeholders that you can put into a `url` that OpenLayers will replace on the fly when requesting a specific tile:

- ◆ `{z}`: This will be replaced by the current zoom level.
- ◆ `{y}` or `{-y}`: This will be replaced by the row of the tile. The `{-y}` option inverts the y axis, this is needed for some servers.
- ◆ `{x}`: This will be replaced by the column of the tile.

After defining the source, it can be used with the vector layer in the same way the `ServerVector` source was used, and the layer is added to the map in the same way too.

The result is that when you load the browser, OpenLayers will request vector tiles from the server and render them using the style we defined.

To see what happens when vector tiles are requested, open Web Inspector, switch to the **Network** tab, and make sure **All** is selected, then reload the page. You will see the requests that fetch the vector tiles end with the `.topojson` extension:



Click on some requests and view the responses. Do you see the difference between this and the `ServerVector` responses? Here, the features are returned directly as a JavaScript object while in the previous example, they were wrapped in a JavaScript function call.

Look through the requests for the raster tiles they are the ones that end with `.png`. You should be able to find a raster tile for each vector tile because they are using the same `tileGrid`.

One of the side effects of using vector tiles is that vector features such as lines and polygons may cross more than one tile and will be split up into different features. If you are rendering polygons with a stroke, or lines with dashed styles, you will see some interesting effects at the edges of the tile boundaries. We can see an example of this when first loading the `TileVector`, in this particular case. The river that runs vertically through the center of the map has several horizontal lines in it that coincide with the tile boundaries. Line features are typically less affected and point features shouldn't be affected at all. You can use polygon features, but you will probably want to render a fill style only to avoid artifacts at the tile boundaries.

Now, we've seen it in action, let's review all the options available when using a `TileVector` source:

Name	Type	Description
<code>attributions</code>	<code>Array.<ol.Attribution></code>	As with <code>ol.source.vector</code> , this is an optional array of attributions to display when features from this source are displayed on the map.
<code>format</code>	<code>ol.format.Format</code>	This is the format that the features are represented in.
<code>logo</code>	<code>string olx.LogoOptions undefined</code>	This is a logo to display when features from this source are displayed on the map.
<code>projection</code>	<code>ol.proj.ProjectionLike</code>	This is the projection for feature geometries after loading.
<code>tileGrid</code>	<code>ol.tilegrid.TileGrid</code>	The tile grid specifies how the world is divided up into tiles. The most popular is <code>ol.tilegrid.XYZ</code> .
<code>tileUrl</code> Function	<code>function undefined</code>	This is a function that returns a URL given a tile coordinate and the projection. This is required if both <code>url</code> and <code>urls</code> are not provided.
<code>url</code>	<code>string undefined</code>	This is a string representing the URL from which to request tiles. The string must contain placeholders identifying the tile coordinates as row (<code>{y}</code> or <code>{-y}</code>), column (<code>{x}</code>) and zoom (<code>{z}</code>).
<code>urls</code>	<code>Array.<string> undefined</code>	This is an array of URL strings following the same convention as the <code>url</code> option. Some servers provide multiple domain names to access tiles from to allow browsers to request many tiles in parallel.

Time for action – a drag and drop viewer for vector files

Loading static sources programmatically is very useful, but let's say you want to look at a new GeoJSON file you just found. Opening up your text editor and coding up a quick viewer is pretty easy, but it takes some time, and perhaps, you'll need to check the API documentation (or this chapter!) to recall the exact details. Wouldn't it be nice if you could just drag your new GeoJSON file onto a map and view it without writing any code? Guess what, you can!

1. Make a copy of the `vector_template.html` file and add a `DragAndDrop` interaction after the `vectorStyle` is defined:

```
var dragAndDrop = new ol.interaction.DragAndDrop({
  formatConstructors: [
```

```
    ol.format.GPX,  
    ol.format.GeoJSON,  
    ol.format.IGC,  
    ol.format.KML,  
    ol.format.TopoJSON  
  ]  
});
```

2. When a file is dropped on the map, the `DragAndDrop` interaction will fire an event that can be used to actually add the features to the map:

```
dragAndDrop.on('addfeatures', function(event) {  
  var vectorSource = new ol.source.vector({  
    features: event.features,  
    projection: event.projection  
  });  
  map.getLayers().push(new ol.layer.vector({  
    source: vectorSource,  
    style: vectorStyle  
  }));  
  view.fitExtent(vectorSource.getExtent(), map.getSize());  
});
```

3. Lastly, we need to get the map to use our interaction since its not enabled by default. Add this after the map object is declared, at the end of our `<script>` tag.
`map.addInteraction(dragAndDrop);`
4. Open `assets | data` in your file browser and try dragging one of the vector files onto the map.

What just happened?

With a few lines of code, we've created a pretty cool vector file viewer. Let's look at how we accomplished this.

In step 1, we created an instance of `ol.interaction.DragAndDrop`. This class turns the map into a drop target. When you drag a file from the operating system onto a drop target, the browser emits an `ondrop` event. The `DragAndDrop` interaction listens for this browser event and attempts to read features from the file using one of the formats. The `DragAndDrop` interaction allows you to customize the list of formats to be tried through the `formatConstructors` option. In this case, we've added all the formats.

In step 2, we add a listener for the `DragAndDrop` interaction's `addfeatures` event. This event is triggered when the interaction parses features from a file dropped on the map. The event passed to our handler gives us an array of features and the projection of the features. We take the array of features passed to the event handler and create a new vector source with the features and the projection of the features, then create a new vector layer with this source and our style and add it to the map.

The last thing to do is make sure that the map knows about our interaction, which we did in step 3.

Features and geometries

We've been using feature objects throughout the chapter so far without really talking about the `Feature` class itself. We also hinted at the `Geometry` class, but we haven't gone into any detail so far. This section will cover both classes in a bit more detail so that you can gain a bit more confidence working with them. Don't worry—it's easy, you've already been exposed to both classes.

Before we get into the `Feature` class, we should go over the `Geometry` class, as it's used to create the actual geometry objects that make up a feature object.

The Geometry class

Although it is perfectly valid to create features without geometries, they can't be represented on a map. Therefore, the `Geometry` class is, from the map's point of view, the foundation of the feature object. The `Feature` class uses the `Geometry` class to store geometry information about the feature.

However, what exactly is the `Geometry` class? In a nutshell, it stores geographic information in the form of one or more coordinate pairs. Remember the examples from *The feature formats* section of this chapter where we added features using the `Format` subclasses? We briefly saw geometries while reprojecting the features into the map view's projection:

```
for (var i = 0, ii = features.length; i < ii; ++i) {
  var feature = features[i];
  var geometry = feature.getGeometry();
  geometry.applyTransform(transform);
}
```

In this example, we will transform the feature's geometry from its original projection into the map view's projection so that the loaded feature will align with the raster base map correctly. This is just one part of what we can do with geometries.

When working with the `Geometry` class, we always use one of its subclass. What do we mean? Think about the `Format` classes we've used earlier in this chapter—we've talked about `format` but actually used subclasses of the base `Format` class the entire time (`ol.format.GeoJSON`, `ol.format.KML`, and so on are all subclasses of the `ol.format.Format` class).

Coordinates

We mentioned before that a geometry object stores geographic information as coordinate pairs. A coordinate pair is simply an array of two, three, or four numbers (we'll get to this in a moment) representing a single location on the earth in a given projection. You're already familiar with coordinates, it's the value that we use to set the center of a view in all of the examples. In the OpenLayers documentation, you'll see coordinates represented with the type `ol.Coordinate`. This looks like a classname, but really it's a type definition specifying an array of numbers representing a location. There are four different ways, called layouts, of representing a coordinate:

- ◆ **XY**: This is a coordinate with two values, X and Y
- ◆ **XYZ**: This is a coordinate with three values, X, Y, and Z (elevation)
- ◆ **XYM**: This is a coordinate with three values, X, Y, and M (the measurement dimension)
- ◆ **XYZM**: This is a coordinate with four values, X, Y, Z, and M

To get maximum performance, OpenLayers' `Geometry` classes store coordinates in so-called flat arrays, meaning all the values of all the coordinates are stored in a single array of numbers. Because the individual coordinates can have two, three, or four values, all the `Geometry` classes need to know the layout of the coordinates they are storing.

Geometry methods

Before we cover the subclasses, let's quickly go over some of the methods available to all of the subclasses via the base `Geometry` class. All these methods are available to any `Geometry` subclass, as all the subclasses inherit from the `Geometry` class:

Method	Parameters	Description
<code>applyTransform</code> (<code>transformFn</code>)	<code>ol.Transform</code> Function	This applies a transform function to the geometry. Most often, this will be used to reproject features but it can actually apply any transformation to a <code>Geometry</code> .
<code>clone()</code>	None	This creates a copy of the geometry and returns it.

Method	Parameters	Description
<code>getClosestPoint(point, out_point)</code>	<code>point</code> - <code>ol.Coordinate</code> <code>out_point</code> - <code>ol.Coordinate</code>	This finds the closest point in this geometry to the provided point and returns it. The second argument, <code>out_point</code> , is optional. If provided, its coordinates will be updated with the closest point.
<code>getExtent(opt_extent)</code>	<code>opt_extent</code> - <code>ol.Extent</code>	This returns the bounding box of the geometry.
<code>getSimplifiedGeometry(sqTolerance)</code>	number	This returns a simplified geometry. The <code>sqTolerance</code> represents a distance squared, in projection units, that guides the simplification algorithm.
<code>getType()</code>	None	This returns a string indicating the type of the geometry. Geometry types are discussed further in this chapter.
<code>transform(source, destination)</code>	<code>source</code> - <code>ol.proj.ProjectionLike</code> <code>destination</code> - <code>ol.proj.ProjectionLike</code>	This transforms a geometry from one projection to another.

Geometry subclasses

There are two direct subclasses of `ol.geom.Geometry`—`ol.geom.SimpleGeometry` and `ol.geom.GeometryCollection`. The `GeometryCollection` class, as the name suggests, treats several geometries as a single geometry object. The `SimpleGeometry` class is the base class for geometries we can actually use to represent specific shapes—points, lines, polygons, and so on. Let's look at the `SimpleGeometry` class and its subclasses first.

The SimpleGeometry class and subclasses

We don't use the `SimpleGeometry` class directly, but it is the base class for all the basic geometry types that OpenLayers understands. We'll look first at the methods provided by `SimpleGeometry` to all the subclasses, then look at the subclasses themselves:

Method	Parameters	Description
<code>getFirstCoordinate()</code>	None	This returns the first coordinate in the geometry.
<code>getLastCoordinate()</code>	None	This returns the last coordinate in the geometry.
<code>getLayout()</code>	None	This returns the layout (XY, XYZ, XYM, or XYZM) of the geometry.

Point, MultiPoint, and Circle classes

The Point class represents a single point, and MultiPoint is a collection of points. A Circle class is a special case of the Point class that includes a radius property. All take coordinates as the first argument to the constructor. Both Point and Circle expect a single coordinate, while MultiPoint expects an array of coordinates. A Circle takes a second argument, the radius. All take an optional final argument, the layout, which defaults to XY. Here are some examples of creating each type:

```
var point = new ol.geom.Point([1, 2]);
var multipoint = new ol.geom.MultiPoint([ [1,2], [2,3] ]);
var circle = new ol.geom.Circle([1,2], 2);
```

LineString and MultiLineString classes

The LineString class represents a sequence of two or more coordinates that are connected to form a line. As with MultiPoint, MultiLineString is a collection of lines. A LineString is constructed with an array of coordinates, while MultiLineString is created with an array of arrays of coordinates. Both take the layout as an optional final argument, the layout, which defaults to XY. Here are some examples of each:

```
var line = new ol.geom.Line([ [1, 2], [2,3], [3,4] ]);
var multipoint = new ol.geom.MultiPoint([ [ [1,2], [2,3], [3,4], [4,5], [5,6] ] ]);
```

Polygon, MultiPolygon, and LinearRing classes

The Polygon class is composed of one or more LinearRing classes. A linear ring is a sequence of three or more coordinates that forms a closed ring, that is, the last coordinate is the same as the first coordinate. When a polygon contains multiple linear rings, the first is called the outer ring and the rest are interior rings. Interior rings define holes in the polygon. And as you might expect, a MultiPolygon is a collection of polygons. Let's see how to make a linear ring and polygon. As with the other geometry types, the layout can be specified as an optional last argument:

```
var linearRing = new ol.geom.LinearRing([ [1,2], [2,3], [3,4], [1,2] ]);
var polygon = new ol.geom.Polygon([ [ [-20,-20], [-20,20], [20,20], [20,-20], [-20,-20] ] ]);
```

Time for action – geometries in action

The last example only used one linear ring for the polygon. Let's use the Web Inspector's console to create a polygon and then add a linear ring to see what happens. Open the `vector_template.html` file in your browser and then open the Web Inspector's **Console**. We'll be typing the commands into the console directly and observing the result on the map.

1. First, create a polygon using the preceding example:

```
var polygon = new ol.geom.Polygon([ [ [-20, -20], [-20, 20], [20, 20], [20, -20], [-20, -20] ] ] );
```
2. We'll need to project the coordinates into our view's projection:

```
polygon.transform('EPSG:4326', 'EPSG:3857');
```
3. Now, we'll need a source and a layer:

```
var source = new ol.source.vector({
  features: [new ol.Feature(polygon)],
  projection: 'EPSG:4326'
});
var layer = new ol.layer.vector({
  source: source,
  style: vectorStyle
});
```

4. And add it to the map:

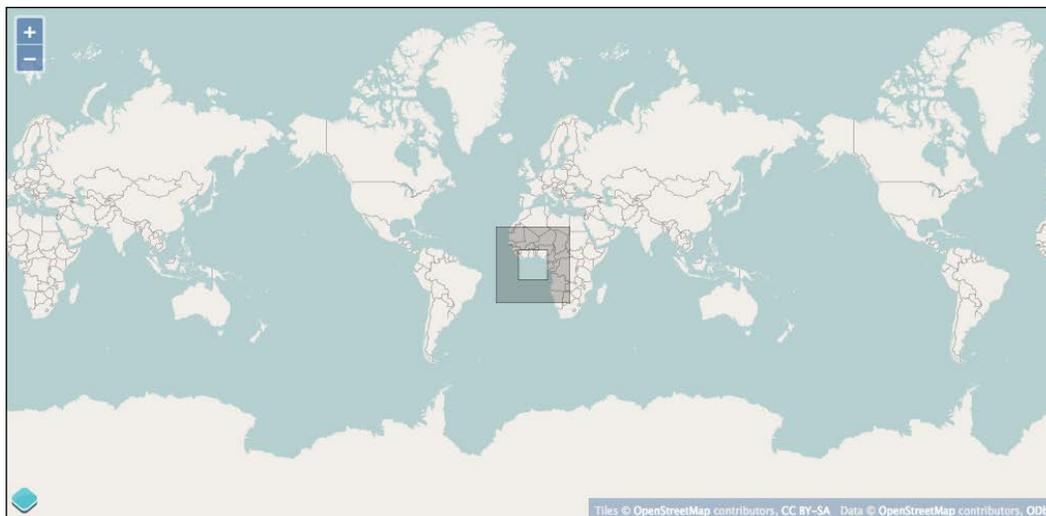
```
map.addLayer(layer);
```
5. You should see something like the following screenshot:



6. Now create a linear ring that will make a hole in our polygon.

```
var linearRing = new ol.geom.LinearRing([ [-10,-10], [10,-10], [10,10], [-10,10], [-10,-10] ]);
linearRing.transform('EPSG:4326', 'EPSG:3857');
polygon.appendLinearRing(linearRing);
```

7. Now, it should look like the following screenshot:



What just happened?

We've just seen linear rings in action. When you create a polygon, the first linear ring is the outer boundary of the polygon and any other linear rings you create define holes in the outer ring.

Have a go hero

Try the last example again, only this time add two or more linear rings to the polygon and observe what happens.

The GeometryCollection class

The `GeometryCollection` class, as the name suggests, is a collection of geometry objects. Unlike the `MultiPoint`, `MultiLine`, and `MultiPolygon` classes, a `GeometryCollection` can contain any type of geometry. You can create an instance of `ol.geom.GeometryCollection` by passing an array of geometries to it, for example:

```
var geomCollection = new ol.geom.GeometryCollection([geom1, geom2, geom3]);
```

The GeometryCollection methods

Although you can use a `GeometryCollection` as an `ol.geom.Geometry` class anywhere, you can't use any of the `SimpleGeometry` methods on a `GeometryCollection`. Instead there is a separate API for accessing the geometries managed by the collection.

Method	Parameters	Description
<code>getGeometries()</code>	None	This returns an array of geometries managed by the collection.
<code>setGeometries</code>	<code>Array.<ol.geom.Geometry></code>	This sets the array of geometries managed by the collection.

The Feature class

To complete our discussion of vector layers, we'll finish with the `Feature` class. We've already seen features in action—in fact, you can't display vector data without them—but we haven't really talked about what they are and what they do.

In the previous section, we explored the various OpenLayers `Geometry` classes. They contain the geospatial coordinates that represent a particular shape. However, to display a shape on the map, we need to work with features. When we model things in the real world and build data structures to represent their position, we also want to capture other information about them. A polygon representing the outline of a building is an interesting thing to display on a map, but when we click on it, it's pretty reasonable to expect to get some information about the building such as its address, its height, and building type (that is, commercial, industrial, or residential). These nonspatial properties of a feature can also be used to change the style of a shape on the map.

A feature combines these two concepts—the spatial location of a thing, and nonspatial properties of the thing that we are interested in.

Creating a feature

Creating a new feature is pretty straightforward; you just need to provide a geometry object (to create a feature with no extra properties) or an object literal containing the geometry and other properties of the feature. For instance, given a point geometry, we can construct a simple feature like this:

```
var point = new ol.geom.Point([x, y]);
var feature = new ol.Feature(point);
```

To create a feature with information associated with the point, we do it this way:

```
var feature = new ol.Feature({
  geometry: point,
  name: 'My Cottage'
});
```

By convention, the `geometry` key is used to specify the geometry associated with the feature. It's possible, though, to use a different key and the `setGeometryName()` method to change this. For our purposes, we'll be doing it the default way.

The Feature class properties

We refer to this extra, nonspatial information associated with a feature as properties. The properties associated with a feature are almost completely free-form and contain any value. The `geometry` property is really the only exception.

You might wonder why we care about the nonspatial properties of a feature since we can create a feature without them and things work just fine. There are essentially two reasons:

1. We want to provide users with information about the feature when they interact with them in some way. For instance, if we are displaying the country layer, we might want to show some information about the country – its name or population for instance.
2. We want to style features based on some property. For instance, if we are displaying earthquake locations, we might draw circles of varying radii and intensity of color based on the magnitude of the earthquake recorded at that location.

We'll look at the first case—interactive information—in the last example for this chapter. We'll explore the second case in the next chapter when we look more closely at styling vector layers.

Feature methods

Before we jump into our last example, let's look at the methods available on a feature object. Note that `Feature` class is a subclass of `ol.Object` and inherits all the `Event` class and `KVO` properties, methods, and events. We won't include them here, but if you need a refresher jump back to *Chapter 2, Key Concepts in OpenLayers* for a moment.

Method	Parameters	Description
<code>getGeometry()</code>	None	This returns the geometry associated with this feature. This uses the <code>geometry</code> name to decide which property contains the geometry.

Method	Parameters	Description
<code>getGeometryName()</code>	None	This returns the name of the property, which contains the geometry for this feature. By default, this will be <code>geometry</code> , unless <code>setGeometryName</code> has been used to change it.
<code>getId()</code>	None	This returns the unique ID associated with this feature, if any has been set.
<code>getProperties()</code>	None	This returns an object literal containing all the properties of this feature.
<code>getStyle()</code>	None	This returns the style, if any, associated with this feature.
<code>getStyleFunction()</code>	None	This returns the function that will be used to style the feature.
<code>setGeometry(geom)</code>	<code>geom - ol.geom.Geometry</code>	This sets the geometry of this feature. This will set a property based on the current geometry name (see <code>setGeometryName</code>)
<code>setGeometryName(name)</code>	<code>name - string</code>	This sets the property name to be used for getting the geometry associated with this feature.
<code>setId(id)</code>	<code>id - number or string</code>	This sets the ID of this feature, a value that uniquely identifies it.
<code>setProperties(values)</code>	<code>values - object</code>	This sets properties for this feature.
<code>setStyle(style)</code>	<code>style - ol.style.Style Array.<ol.style.Style> function</code>	This is a style to be used for this feature.

While we are not including the `ol.Object` methods in this list, it is relevant and important to note that feature properties are treated as object properties. This means that you can:

- ◆ Change or create a property using `feature.set(key, value)`
- ◆ Get the value of a property using `feature.get(key)`
- ◆ Observe changes to a property using `feature.on('change:<key>', observerFunction)`, where `<key>` is the name of a property
- ◆ Change several properties at once using `feature.setProperties(values)`

One last thing before our final example—feature objects can have their own styles. Normally, styles are assigned to the vector layer and all features that are rendered as part of that layer use the layer's style. It is possible, however, to assign styles to individual features and that style will be used instead of the layer's style. Because a feature comes from a source, and a source can be used for more than one vector layer, this means that a feature without a style can be rendered differently depending on the layer's style while a feature with a style will be rendered the same way regardless of the different styles on different layers.

Time for action – interacting with features

To wrap up our chapter on vector layers, let's combine our knowledge of layers, sources, and features and create a small application that displays the name of a country when we hover over it with the mouse:

1. Let's start with a simple vector layer based on the GeoJSON file containing the country data. This is how we started the chapter!

```
var source = new ol.source.GeoJSON({
  projection: 'EPSG:3857',
  url: '../assets/data/countries.geojson'
});
var countries = new ol.layer.vector({
  source: source
});
var center = ol.proj.transform([0, 0], 'EPSG:4326', 'EPSG:3857');
var view = new ol.View({
  center: center,
  zoom: 1,
});
var map = new ol.Map({
  target: 'map',
  layers: [countries],
  view: view
});
```

2. Next, we'll hook up to the `pointermove` event provided by the map object. If you don't remember anything about map events, review *Chapter 3, Charting the Map Class*:

```
map.on('pointermove', onMouseMove);
```

3. Now, add the `onMouseMove` function:

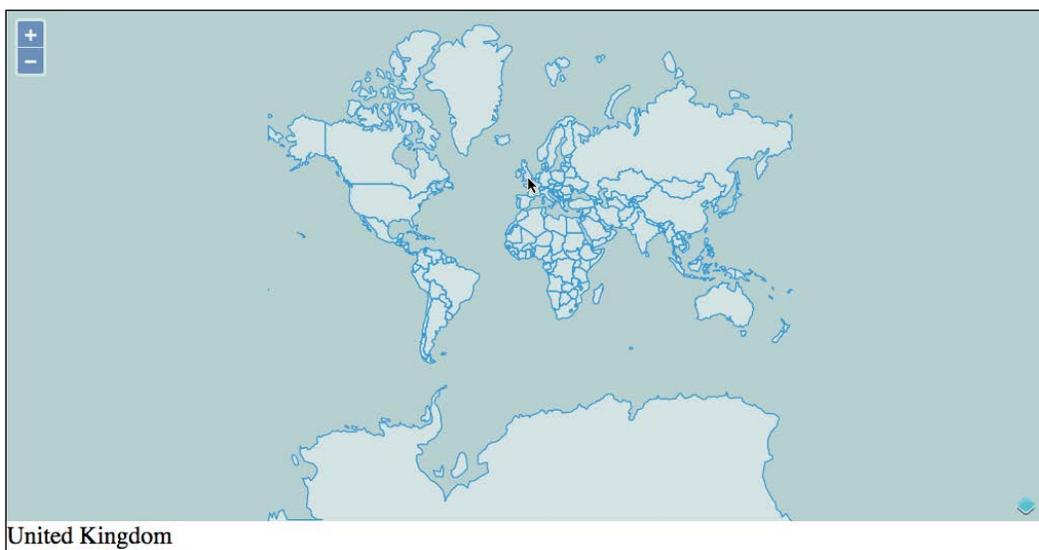
```
function onMouseMove(browserEvent) {
  var coordinate = browserEvent.coordinate;
  var pixel = map.getPixelFromCoordinate(coordinate);
  var el = document.getElementById('name');
  el.innerHTML = '';
```

```
map.forEachFeatureAtPixel(pixel, function(feature) {  
  el.innerHTML += feature.get('name') + '<br>';  
});  
}
```

4. Finally, add a `<div>` element to display the country name, just after the `<div>` that holds the map:

```
<div id="name"></div>
```

5. Load this in your browser and move the mouse around. You should see the name of the country that the mouse is over appear below the map.



What just happened?

We've just saw how easy it is to interact in real time with vector data sources.

Step 1 just created a vector layer using a static GeoJSON source and added it to the map.

In step 2, we registered for the `pointermove` event. Recall from *Chapter 3, Charting the Map Class* that the `pointermove` event is fired by the map whenever the mouse moves over the map, and it passes a `BrowserEvent` object that contains, among other things, the map coordinate of the mouse position. Next, we implemented our event handler function. It gets the coordinate from the browser event and finds all features at that coordinate in our country layer's source. If there are any features, we get the `name` property from the first one and display this in the `<div>` added in step 4. You may wonder exactly how interactions with your map work behind the scene. Don't worry! We will see them more thoroughly in *Chapter 8, Interacting with Your Map*.

Summary

Vector layers are extremely useful for developing interactive web mapping applications. In this chapter, we've discussed what a vector layer is and its potential limitations. We've explored the various vector data sources that OpenLayers provides, and looked in detail at features and geometries. Through a series of examples, we learned how to load dynamic data from a remote server such as a WFS server, load tiled vector data, load vector data stored in static files, even by dragging them to the map from our file browser, work with geometries and features, and dynamically interact with vector data.

We covered a lot about vector layers, but we're not done yet. It's time to take control of the presentation of our vector data; so, keep reading to learn all about how to use styles with vector layers to really make your maps pop!

6

Styling Vector Layers

By now you should be getting pretty comfortable creating simple OpenLayers maps with a combination of raster and vector data. With raster data, there is no control over presentation, as the saying goes—what you see is what you get. Vector data, on the other hand, gives you direct control over presentation details. We've already alluded to vector styles, and used them in the previous chapter. Now, it is time to take full control of how we present our vector data!

In the last chapter, you saw how powerful the vector layer can be. In this chapter, we'll go a bit deeper and talk about how to customize the appearance of the features within a vector layer. We'll explore the following:

- ◆ The basic style object
- ◆ Fill, stroke, image, and text styles
- ◆ Composing multiple styles
- ◆ Using style functions
- ◆ Applying styles interactively

What are vector styles?

So, what is a vector style? Quite simply, it is a set of instructions about how to draw graphic primitives—the points, lines, polygons, and text that make up our vector features. OpenLayers provides a basic default style that renders features in various shades of blue. While this is quite nice, it's probably not what you'll want to use all the time.

You've already seen an example of a basic vector style in the previous chapter. Let's review it here:

```
var fill = new ol.style.Fill({
  color: 'rgba(0,0,0,0.2)'
});
var stroke = new ol.style.Stroke({
  color: 'rgba(0,0,0,0.4)'
});
var circle = new ol.style.Circle({
  radius: 6,
  fill: fill,
  stroke: stroke
});
var vectorStyle = new ol.style.Style({
  fill: fill,
  stroke: stroke,
  image: circle
});
```

This code defines specific rules for the `fill`, `stroke`, and `image` properties of a new `ol.style.Style` object. The fill and stroke rules specify a color and opacity using the **RGBA (Red, Green, Blue, and Alpha)** format. The circle style is a special style that draws points as circles of a specific radius with a fill and stroke property. Together, these form a style object that OpenLayers uses to determine how to draw a feature. The fill property is used for filling polygons and circles. The stroke property is used to draw the outline of polygons, lines, and circles. The image property is used for drawing points. There is also a text property that we haven't seen yet.

The vector layer's style property accepts three different ways of specifying styles:

- ◆ An instance of `ol.style.Style`
- ◆ An array of `ol.style.Style` instances
- ◆ A style function

What is a style function?

We'll look at style functions in more detail in the second half of this chapter, but briefly, a style function is one that returns an array of style objects to be used for a specific feature and resolution. In combination with feature properties, a style function allows for the implementation of advanced custom styling. Before we can run, we'd better learn how to walk.

Time for action – basic styling

We'll start with an example that shows off most of the basic style properties. We'll start with a new HTML page setup the same way we usually start off.

1. Make a copy of our `sandbox` template and add the standard setup for a map to the main `<script>` tag:

```
var center = ol.proj.transform([0, 0], 'EPSG:4326', 'EPSG:3857');
var view = new ol.View({
  center: center,
  zoom: 1
});
var map = new ol.Map({
  target: 'map',
  view: view
});
```

2. In this example, we'll be purely using vector layers. No need for rasters here! Go ahead and create a vector layer for countries, then add it to the map:

```
var countries = new ol.layer.Vector({
  source: new ol.source.GeoJSON({
    projection: 'EPSG:3857',
    url: '../assets/data/countries.geojson'
  })
});
var map = new ol.Map({
  target: 'map',
  layers: [countries],
  view: view
});
```

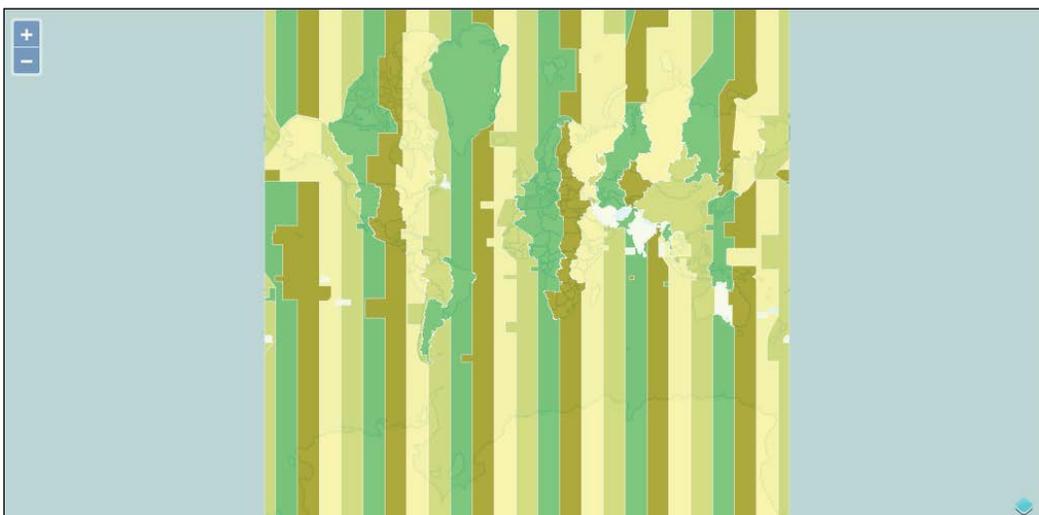
3. Load the HTML file to your browser to see the basic styling that OpenLayers provides:



4. Make it a bit more interesting by adding another vector layer, time zones. Don't forget to add it to the map's layers property:

```
var timezones = new ol.layer.Vector({
  source: new ol.source.KML({
    projection: 'EPSG:3857',
    url: '../assets/data/timezones.kml'
  })
});
```

5. Now, the map looks like the following. The time zone KML file is drawn in different colors because KML files often contain style information for each feature.



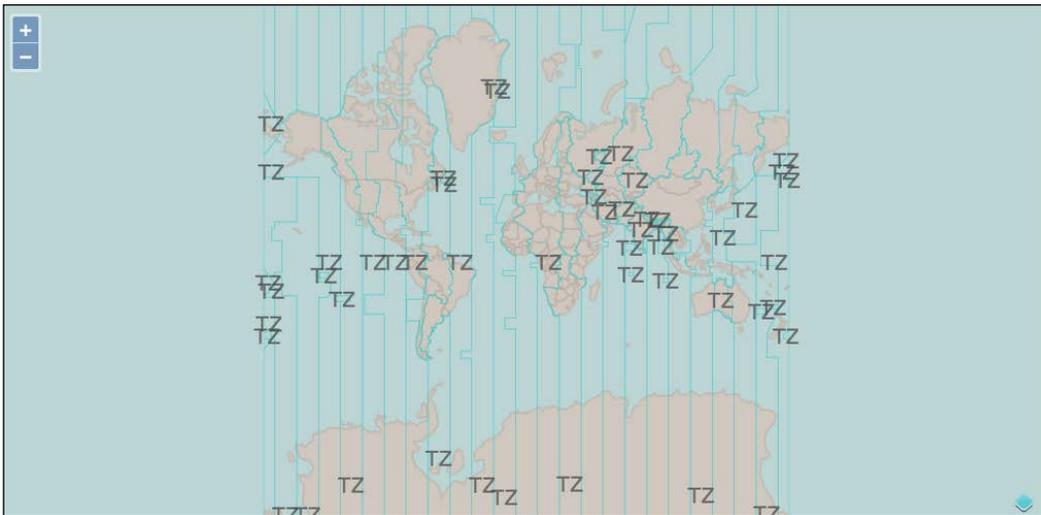
6. We'd like to have more control over the appearance of our map; so, let's create some rules for styling. First, create two style objects—one for each layer:

```
var countryStyle = new ol.style.Style({
  fill: new ol.style.Fill({
    color: [203, 194, 185, 1]
  }),
  stroke: new ol.style.Stroke({
    color: [177, 163, 148, 0.5],
    width: 2
  })
});
var timezoneStyle = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: [64, 200, 200, 0.5],
  }),
  text: new ol.style.Text({
    font: '20px Verdana',
    text: 'TZ',
    fill: new ol.style.Fill({
      color: [64, 64, 64, 0.75]
    })
  })
});
```

7. Don't forget to add a `style` property to each of the vector layers so they know which style to use. Also, we'll need to tell the KML source not to extract the default feature styles stored in the KML document:

```
var countries = new ol.layer.Vector({
  source: new ol.source.GeoJSON({
    projection: 'EPSG:3857',
    url: '../assets/data/countries.geojson'
  }),
  style: countryStyle
});
var timezones = new ol.layer.Vector({
  source: new ol.source.KML({
    projection: 'EPSG:3857',
    url: '../assets/data/timezones.kml',
    extractStyles: false
  }),
  style: timezoneStyle
});
```

8. Take a look at the result. Not arguably better, perhaps, but we now have full control!



What just happened?

With this example, we are illustrating some of the basic styling capabilities of OpenLayers. We combined two static vector sources—countries and time zones—and some simple styles to create our map.

Step 1 set up the same structure we've been using for all our examples. In step 2, we added the country data using a static GeoJSON source and added it to the map with the default styling. Next, we added the time zone data in step 4 and developed some basic styles for the two layers in step 6. The country data is composed of polygons, so we created a fill style and a stroke style for styling the country layer. The time zone data also contains polygons, but we want to see the countries underneath so we created a separate style with just the stroke and text properties for it.

The text property in this example is somewhat contrived to keep things simple. Showing the same text string for each time zone is not what we'd really want to do. Ideally, we'd display information specific to each time zone—perhaps, the name or number of hours from **Greenwich Mean Time**. We'll cover how to do this a bit later in the chapter though. The last thing is to assign our custom styles to the appropriate vector layer and turn off the automatic extraction of styles from the KML layer, which happened in step 7.

Now that we've reviewed how basic styles work, let's take a closer look at the style object and the properties we can assign to it. Along the way, we'll illustrate each with a specific example.

The style class

The style class, `ol.style.Style`, contains the drawing instructions to be used when rendering a feature. There are five properties we can use when creating a style property:

Name	Type	Description
<code>fill</code>	<code>ol.style.Fill</code>	This style is used when filling polygons. To draw unfilled polygons, leave this property out or set to <code>null</code> .
<code>stroke</code>	<code>ol.style.Stroke</code>	This style is used when drawing lines and drawing the outline of polygons. To draw polygons without an outline, leave this property out or set to <code>null</code> .
<code>image</code>	<code>ol.style.Image</code>	This style is used when drawing points.
<code>text</code>	<code>ol.style.Text</code>	This style is used when drawing text.
<code>zIndex</code>	<code>number</code>	The z-index determines the order in which features are drawn. To ensure that certain features are drawn on top of other features—for instance, points on top of polygons—assign a higher <code>zIndex</code> value. Note that this only affects features within the same layer.

As you can see, a style is really a composite of several specific types. Including a property turns on drawing of the relevant type and excluding it turns it off. When you specify the `style` property for a vector layer, this replaces all the default styles; so, you don't need to override all the properties all the time—just specify the ones that are needed and the rest will not be drawn at all. For example, creating a style with just a stroke property will draw polygons with an outline and no fill:

```
var style = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: [127,127,127,1]
  })
});
```

Now, let's look at each specific property type with some examples.

Fill styles

The fill style—`ol.style.Fill`—is used to fill shapes with a solid color. The fill style is used by `ol.style.Style` as well as a couple of other objects we'll see shortly. It has a single property, `color`, of the type `ol.Color` that is used when drawing filled shapes.



Colors may be specified in three ways:

- ◆ An array of four values representing the red, green, blue, and alpha components of the color. The color components are numbers between 0 and 255, while the alpha value is between 0 (transparent) and 1 (opaque). For example, black is represented as `[0, 0, 0, 1]`, white is represented as `[255, 255, 255, 1]`, and a semitransparent blue green is `[0, 255, 0, 0.5]`.
- ◆ A CSS RGBA string expression, written as `"rgba(red, green, blue, alpha)"`, where `red`, `green`, `blue`, and `alpha` are the same as the preceding array form; for example, our semitransparent green color will be `"rgba(0, 255, 0, 0.5)"`.
- ◆ A CSS hexadecimal, or hex, color value written as `#RRGGBB`, where `RR` is the red value, `GG` is the green value, and `BB` is the blue value. The values are a hexadecimal equivalent of the numeric values between 0 and 255, written as 00 to FF. The alpha value is assumed to be 1 in this case.

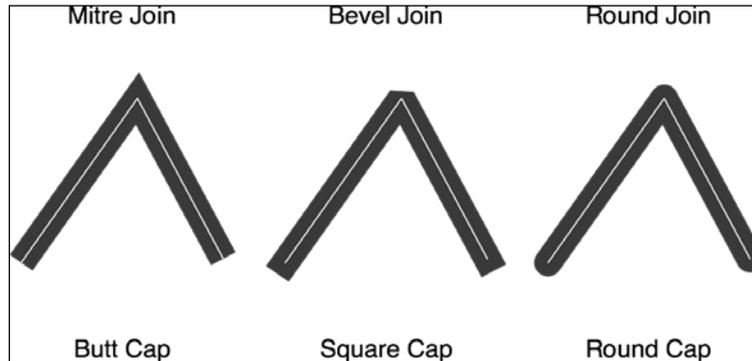
These different representations are equivalent (except for the missing alpha control in hex colors) and you can use whichever is more convenient.

Stroke styles

The stroke style—`ol.style.Stroke`—is used to draw lines. The line style is used by `ol.style.Style` as well as a couple of other objects we'll see shortly. A stroke style has the following options.

Name	Type	Description
<code>color</code>	<code>ol.Color</code>	This is the color to use when drawing lines.
<code>lineCap</code>	<code>string</code>	<p>This is the style to draw the end of lines in. This may be one of the following:</p> <ul style="list-style-type: none"> ◆ <code>butt</code>: These finish lines squarely right at the exact point the line ends at. ◆ <code>round</code>: These finish lines by rounding them, radius depends on <code>width</code> at the bottom. This is the default value if not specified. ◆ <code>square</code>: These finish lines with a square the size of <code>width</code> (line extends past the last point by the line width) <p>See the diagram following this table for an example of each <code>lineCap</code> style.</p>
<code>lineJoin</code>	<code>string</code>	<p>The line join style is used when drawing segments that are part of the same line. This may be one of the following:</p> <ul style="list-style-type: none"> ◆ <code>bevel</code>: This joins lines with a bevel. ◆ <code>round</code>: This joins lines by rounding them. This is the default value if not specified. ◆ <code>miter</code>: This joins lines by mitering them (see <code>miterLimit</code> below). <p>See the diagram following this table for an example of each <code>lineJoin</code> style.</p>
<code>lineDash</code>	<code>Array.<number></code>	This is an array of numbers that define the on-off pattern for drawing lines with a dash pattern. The default is none (no dash pattern).
<code>miterLimit</code>	<code>number</code>	This is the limit for drawing miter joins; the default is 10.
<code>width</code>	<code>number</code>	This is the width, in pixels, to draw the line. This number may be a floating point number.

The following diagram illustrates the effect of the various values for `lineJoin` (top) and `lineCap` (bottom).



Have a Go Hero – fill and stroke styles

Modify the last example and try out some `fill` and `stroke` style properties. In particular, try changing the `lineJoin` and `lineCap` properties. Use a wider stroke width to see the effect it produces. Note that the `lineCap` style won't be apparent when drawing polygons—to see it in action, you'll need a line layer, perhaps, using the `fells_loop.gpx` file we saw in the previous chapter.

Here are a couple of examples:

```
var countryStyle = new ol.style.Style({
  fill: new ol.style.Fill({
    color: [0, 255, 255, 1]
  }),
  stroke: new ol.style.Stroke({
    color: [127,127,127,1.0],
    width: 10,
    lineJoin: 'bevel',
  })
});

var timezoneStyle = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: [64, 200, 200, 0.5],
    lineJoin: 'round',
    width: 10
  })
});
```

Image styles

The image style—`ol.style.Image`—is used to style point data. You won't be using it directly though. Instead, there are two subclasses that you'll be using: `ol.style.Icon` and `ol.style.Circle`. Let's look at the icon style first.

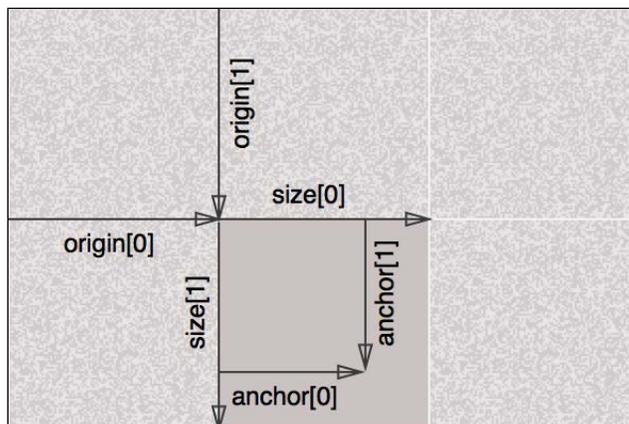
The icon style

The icon style displays an image at the location of a point. There are quite a few properties associated with the icon style that allow you to align the placement of the image relative to the precise geographic location being represented.

Name	Type	Description
<code>anchor</code>	<code>Array.<number></code>	This property states where to position the image relative to the geographic location of the point specified as an array of two numbers. The default value is <code>[0.5, 0.5]</code> and assumes units of <code>fraction</code> (see <code>anchorXUnits</code> and <code>anchorYUnits</code>). This will specify aligning the center of the image to the geographic location. The position within the image is measured relative to the <code>anchorOrigin</code> property, which defaults to <code>top-left</code> .
<code>anchorOrigin</code>	<code>string</code>	This specifies where the anchor value is measured from. One of the following values can be used: <ul style="list-style-type: none"> ◆ <code>top-left</code> (the default) ◆ <code>top-right</code> ◆ <code>bottom-left</code> ◆ <code>bottom-right</code>
<code>anchorXUnits</code>	<code>string</code>	This specifies the units of the X anchor value, either <code>pixels</code> or <code>fraction</code> . The default value is <code>fraction</code> . When <code>fraction</code> is used, the value of the associated value is a floating point number between 0 and 1 as a percentage of the width or height of the image.
<code>anchorYUnits</code>	<code>string</code>	This specifies the units of the Y anchor value.
<code>crossOrigin</code>	<code>string</code>	The <code>crossOrigin</code> setting for the image allows you to leverage CORS (Cross Origin Resource Sharing) when loading an image.
<code>img</code>	<code>Image</code>	This is an image object to use for the icon. This may be used instead of the <code>src</code> property but the provided image object must already be loaded.

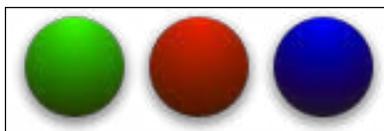
Name	Type	Description
<code>offset</code>	<code>Array.<number></code>	This is the top-left corner of the image to draw the icon from. When combined with the <code>size</code> property, this would allow you to use an image sprite and selecting a portion of the sprite to display for a specific icon. The default is <code>[0, 0]</code> .
<code>offsetOrigin</code>	<code>String</code>	This sets the origin of the <code>offset</code> property, one of the following: <ul style="list-style-type: none"> ◆ <code>bottom-left</code> ◆ <code>bottom-right</code> ◆ <code>top-left</code> (the default) ◆ <code>top-right</code>
<code>scale</code>	<code>number</code>	This is a scale factor to use when drawing the image, the default is 1 (do not scale the image). A value of 2 will double the size of the icon and a value of 0.5 will half the size of the icon.
<code>snapToPixel</code>	<code>Boolean</code>	If <code>true</code> , this property will cause images to be snapped to integer pixel values and result in sharper display of images. If <code>false</code> , the image will be placed more accurately but may appear blurry. The default value is <code>true</code> . You may want to set this to <code>false</code> if you are animating an icon's position, as snapping to pixels would cause noticeable jitter.
<code>rotateWithView</code>	<code>Boolean</code>	If <code>true</code> , the icon will rotate when the map's view is rotated. The default is <code>false</code> (always stay upright).
<code>rotation</code>	<code>number</code>	This is a rotation (in radians) to apply to the icon.
<code>size</code>	<code>ol.Size</code>	This is the size of the icon in pixels as an array of two values— <code>width</code> and <code>height</code> . The default value is the size of the image being used. Using a different value, when combined with <code>origin</code> , allows the use of image sprites.
<code>src</code>	<code>string</code>	This is the URL to load the image from.

The following diagram illustrates the meaning of the `origin`, `size`, and `anchor` options:



Time for action – using the icon style

As we haven't seen the `Icon` style before, let's build an example. As we'll need some point data for this example, the `earthquake.kml` file should be perfect! We'll use the following image sprite and pick the middle dot. This file is included with the code samples that come with the book; you can find it at `assets/img/dots.png`.



1. Starting from the previous example, first, we'll create an icon style using our sprite:

```
var earthquakeStyle = new ol.style.Style({
  image: new ol.style.Icon({
    anchor: [0.5, 0.5],
    size: [52, 52],
    offset: [52, 0],
    opacity: 1,
    scale: 0.25,
    src: '../assets/img/dots.png'
  })
});
```

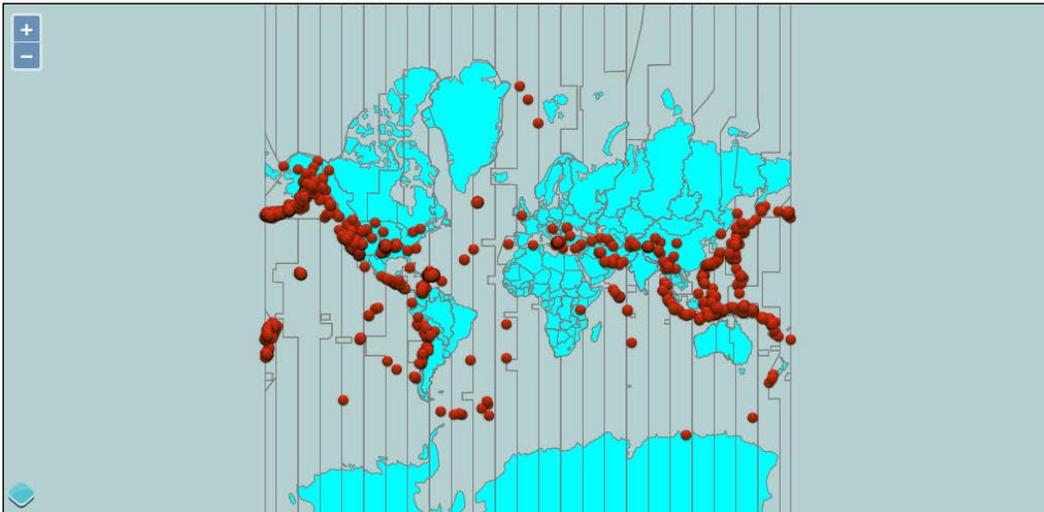
2. Next, create the earthquake layer and assign it the style. Because it is a KML file, we'll need to tell OpenLayers to not extract the embedded style information:

```
var earthquakes = new ol.layer.Vector({
  source: new ol.source.KML({
    projection: 'EPSG:3857',
    url: '../assets/data/earthquakes.kml',
    extractStyles: false
  }),
  style: earthquakeStyle
});
```

3. Now, add the layer to the map's layers array:

```
var map = new ol.Map({
  target: 'map',
  layers: [countries, timezones, earthquakes],
  view: view
});
```

4. The result should look something like this:



What just happened?

Using the icon style properties, we displayed an image at the location of each of the points in the `earthquakes.kml` file.

First, we created an icon style pointing at our sprite image and supplied values for offset, anchor, size, and scale to ensure our red dot is used. The sprite is 156 pixels wide and 52 pixels high, and each image in the sprite is 52 by 52 pixels, so we provided a size of `[52, 52]`. An offset value of `[52, 0]` moved the frame of reference 52 pixels in from the left edge. The anchor position of `[0.5, 0.5]` specified the middle of the image since the default anchor units is fraction. We can also have specified pixels for anchor units and changed our anchor position to `[26, 26]`. Given the density of the earthquakes, using a 52 by 52 pixel image will overwhelm the map; so, we provided a scale value of 0.25, which effectively shrunk the resulting image to 25 percent of its size, or 13 by 13 pixels.

After creating a new vector layer that used our icon style, we added it to the map.

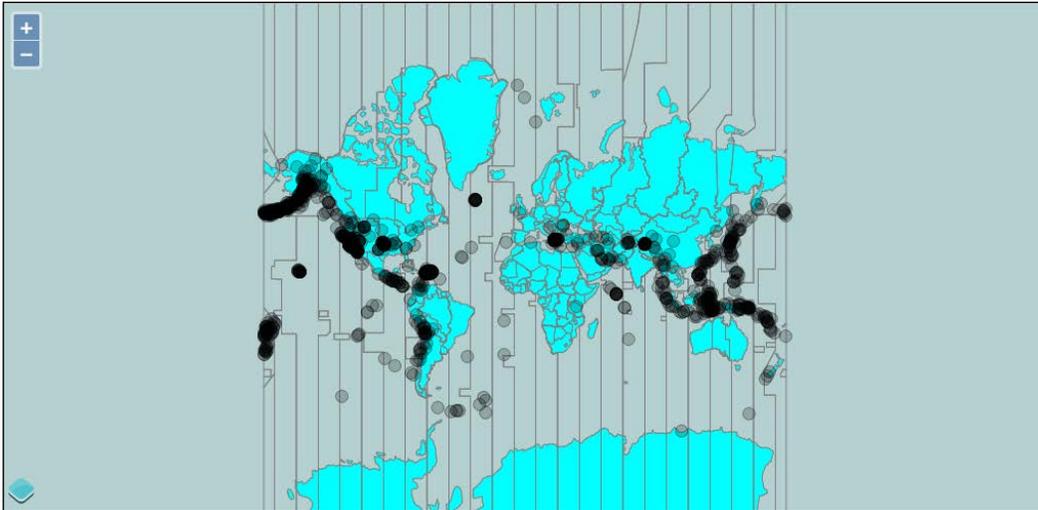
The circle style

Like the icon style, the circle style is used for point geometries. It's a much simpler object, though with only four configurable properties:

Name	Type	Description
<code>radius</code>	<code>number</code>	This is the radius, in pixels, to draw the circle.
<code>fill</code>	<code>ol.style.Fill</code>	This is the style to fill the circle with.
<code>snapToPixel</code>	<code>Boolean</code>	If <code>true</code> , this property will cause the circle to be snapped to integer pixel values and result in sharper display of the circle. If <code>false</code> , the circle will be drawn more accurately but may appear blurry. The default value is <code>true</code> . You may want to set this to <code>false</code> if you are animating the circle's position as snapping to pixels may cause noticeable jitter.
<code>stroke</code>	<code>ol.style.Stroke</code>	This is the style to draw the circumference of the circle with.

Have a go hero – using the circle style

To round out our understanding of the image styles, redo the previous example using `ol.style.Circle` instead of `ol.style.Icon` as the image property of the earthquake style. Your result should look something like this (depending on what values you choose):



Text styles

We saw the text style in action in the first example, and we also saw that it wasn't very useful to include a static text style—at least in that example. In general, text styles will be much more useful when the text that is displayed is derived from some property of the feature being displayed. We'll look at how to do that at the end of the chapter, so for now, let's finish up the basic style section with the properties available to text styles:

Name	Type	Description
<code>font</code>	<code>string</code>	This is a string containing the font size and name of the font to use for rendering the text. The size is typically given in pixels, for example: <code>"18px Verdana"</code>
<code>offsetX</code>	<code>number</code>	This is the horizontal offset, in pixels, to move the text. A positive number will move the text to the right, while a negative number will shift it left. The default value is 0.

Name	Type	Description
<code>offsetY</code>	<code>number</code>	This is the vertical offset, in pixels, to move the text. A positive number will move the text down while a negative number will move it up. The default value is 0.
<code>scale</code>	<code>number</code>	This is an amount to scale the rendered text. A value of 2 will double the size of the text while a value of 0.5 will halve it. The default is 1 (no scaling).
<code>rotation</code>	<code>number</code>	This is an angle, in radians, to rotate the text. The rotation is clockwise, and the default is 0 (no rotation).
<code>text</code>	<code>string</code>	This is the text to be rendered.
<code>textAlign</code>	<code>string</code>	This is the alignment of the text, one of <code>start</code> , <code>left</code> , <code>center</code> (default), <code>right</code> , or <code>end</code> .
<code>textBaseline</code>	<code>string</code>	This is the baseline of the text, one of <code>top</code> , <code>hanging</code> , <code>middle</code> , <code>alphabetic</code> (default), <code>ideographic</code> , or <code>bottom</code> .
<code>fill</code>	<code>ol.style.Fill</code>	This is the style to use to fill text characters.
<code>stroke</code>	<code>ol.style.Stroke</code>	This is the style to use to draw the outline of text characters.

Multiple styles

Remember, from the beginning of the chapter, that we said there were three different ways of specifying styles:

- ◆ An instance of `ol.style.Style`
- ◆ An array of `ol.style.Style` instances
- ◆ A style function

We've looked at the first, using `ol.style.Style`, in detail. The second, an array of styles, is really not much different from the first, that is, you are still dealing with the basic styles. The difference is that when you provide an array of styles, features are rendered once for each style. This means each feature is rendered more than once, which can provide some interesting effects. An example is probably the best way of illustrating this.

Time for action – using multiple styles

In this example, we'll use the country data again and draw each polygon with two styles to create a shadow effect around the continents.

1. You can start from any of the examples in this chapter. We've started from the first example and removed the time zones for clarity. First, modify the `countryStyle` to provide a somewhat darker stroke:

```
var countryStyle = new ol.style.Style({
  fill: new ol.style.Fill({
    color: [203, 194, 185, 1]
  }),
  stroke: new ol.style.Stroke({
    color: [101, 95, 90, 1],
    width: 1
  }),
  zIndex: 2
});
```

2. Next, we'll add our second style for the shadow effect:

```
var shadowStyle = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: [0, 0, 127, 0.15],
    width: 8
  }),
  zIndex: 1
});
```

3. Finally, use both styles for the countries layer:

```
var countries = new ol.layer.Vector({
  source: new ol.source.GeoJSON({
    projection: 'EPSG:3857',
    url: '../assets/data/countries.geojson'
  }),
  style: [shadowStyle, countryStyle]
});
```

4. The result should look something like the following screenshot:



What just happened?

By combining two styles, we achieved the desired effect. In the first step, we modified our starting style slightly to sharpen the country outline—this makes them easier to see over the shadows. In the second step, we added another style for the country layer with a wide, mostly transparent stroke and no fill. Lastly, we provided an array as the `style` property for our countries layer.

There is one thing you really need to be aware of when using arrays of styles—each feature is drawn once for each style. This can have dramatic performance implications when dealing with a lot of features. If you create a style array with two styles, you are effectively doubling the number of features being rendered. This will have no visible effect on a small number of simple features, but will start to have a noticeable effect when rendering lots (say hundreds or thousands) of features, or a smaller number of highly complex features.

In practice, it doesn't really double the rendering time as their efficiencies are built into OpenLayers that try to avoid expensive operations as much as possible. For example, the same effect can be achieved using two vector layers. This will be more inefficient as OpenLayers has to process the geometries twice, while they only have to be processed once when using an array of styles.

Have a go hero – understanding zIndex

If you have been paying attention, you will have noticed that we added a `zIndex` property to each style in the previous example. Try removing the `zIndex` from both the styles and observe the result. This should give you an appreciation of what the `zIndex` property does. Without it, OpenLayers renders the features one at a time with their complete style, which would mean that the shadow from one country will overlap an adjacent country rather than just forming a shadow around each continent.

Style functions

Now that we've seen all the basic style properties and how to combine them as arrays of styles, it's time to learn how to use them in conjunction with feature properties to achieve dynamic styles. This is actually the last of our three ways of specifying the style property—the style function.

We said at the beginning of the chapter that *a style function is one that returns an array of style objects to be used for a specific feature and zoom level.*

What does this mean? It's really quite straightforward, but extremely powerful. A style function is nothing more than a JavaScript function that receives two parameters—the feature being styled, and the resolution of the map's view. It is required to return an array of `ol.style.Style` objects when it is called. For instance, we could have written our country style example using a style function like this:

```
var countryStyleFunction = function(feature, resolution) {
    return [countryStyle]; // the basic style we already defined
};
var countries = new ol.layer.Vector({
    source: countrySource,
    style: countryStyleFunction
});
```

This example doesn't use the feature or the resolution arguments, but does illustrate how simple the concept of a style function is. In fact, when you provide a style or an array of styles as the style property of a vector layer, OpenLayers creates a style function internally that looks exactly like this.

You might be wondering if it's this simple, then how can we claim that it's extremely powerful? The power really comes when you use the feature and the resolution to dynamically create styles.

At the end of the previous chapter, we introduced the concept of feature properties and the methods used to retrieve them. Now, we can make practical use of this knowledge by using properties to create styles on the fly.

Time for action – using properties to style features

For this example, we will render the country layer by styling each country based on income level by associating its country code to income level data provided by the world bank. There are quite a few brackets; so, we've simplified it to four levels: `high`, `medium`, `low`, and `poor`. We'll draw each country in a color associated with its income level based on these brackets. Let's start from the previous example.

1. At the beginning of the `<script>` tag, before anything else, we will define colors for the four brackets. Use any colours you like:

```
var high = [64,196,64,1];
var mid = [108,152,64,1];
var low = [152,108,64,1];
var poor = [196,32,32,1];
```

2. The income levels for each feature are indicated by a code. We need a way to look up the color to use for each code. You don't need to include the comments, they are there to show how we are grouping the income levels:

```
var incomeLevels = {
  'HIC': high, // high income
  'OEC': high, // high income OECD
  'NOC': high, // high income, non-OECD
  'UMC': mid, // upper middle income
  'MIC': mid, // middle income
  'LMC': mid, // lower middle income
  'LIC': low, // low income
  'LMY': low, // low and middle income
  'HPC': poor // heavily indebted poor country
};
```

3. It's good practice to have a default style to use if something goes wrong:

```
var defaultStyle = new ol.style.Style({
  fill: new ol.style.Fill({
    color: [250,250,250,1]
  }),
  stroke: new ol.style.Stroke({
    color: [220,220,220,1],
    width: 1
  })
});
```

- 4.** Our style function will create styles as needed and cache them. Here's the cache and the style function. We'll discuss what it does at the end of the code.

```
var styleCache = {};  
function styleFunction(feature, resolution) {  
  var level = feature.get('incomeLevel');  
  if (!level || !incomeLevels[level]) {  
    return [defaultStyle];  
  }  
  if (!styleCache[level]) {  
    styleCache[level] = new ol.style.Style({  
      fill: new ol.style.Fill({  
        color: incomeLevels[level]  
      }),  
      stroke: defaultStyle.stroke  
    });  
  }  
  return [styleCache[level]];  
}
```

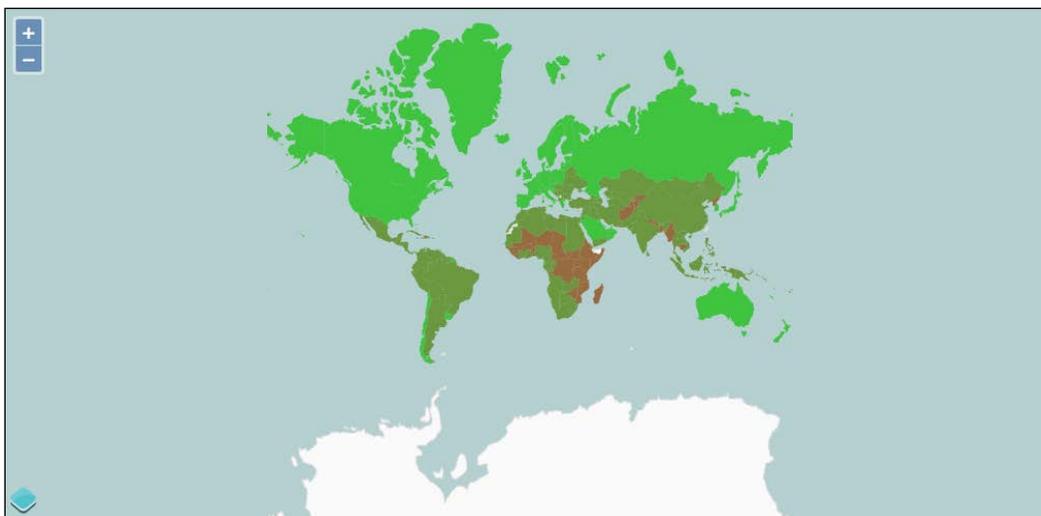
- 5.** Modify the countries layer to use the style function. While you are at it, make sure the source is specified as a separate object. We'll need this in a moment:

```
var source = new ol.source.GeoJSON({  
  projection: 'EPSG:3857',  
  url: '../assets/data/countries.geojson'  
});  
var countries = new ol.layer.Vector({  
  source: source,  
  style: styleFunction  
});
```

- 6.** Now, we come to the part where we load the income data and associate it with our features. Add the following somewhere after the source is defined:

```
var key = source.on('change', function(event) {  
  if (event.target.getState() == 'ready') {  
    source.unByKey(key);  
    $.ajax('../assets/data/income_levels.json').  
done(function(data) {  
  source.forEachFeature(function(feature) {  
    var code = feature.get('iso_a2');  
    if (data[code]) {  
      feature.set('incomeLevel', data[code]);  
    }  
  });  
});  
});  
});
```

7. Give it a whirl, you should see something like the following screenshot:



What just happened?

Let's review what is happening in this example. We are using a standard setup for vector layers, and combining some extra data into our features dynamically. The data is used to style, or classify, the country polygons by the income level as recorded by the world bank. Some interesting things are happening in this example; so we'll look at each step and highlight what's going on.

In step 1, we created some colors to be used to fill countries that fall into one of the four income categories. The number of categories is arbitrary—you can create colors for each of the income levels, or decide to group them differently.

In step 2, we created an object that we can use to look up a color based on an income level, and in step 3, we defined a default style. It's usually good practice when dealing with data that can change to have some kind of fallback so that your code doesn't break. We'll use the default style if we can't find a income level in our lookup object.

In step 4, we created our style function. Another best practice is to reuse style objects as much as possible. Since several countries might be drawn in the same style, we created an empty object (the `styleCache`) to store previously created styles. The actual function comes next. When the style function is called, it gets a reference to the feature being styled and the current resolution of the view on which it is being rendered. We aren't using the resolution in this example. We are using the feature, however. The feature should have a property called `incomeLevel` that matches the values in our lookup tables, so we grab that value and assign it to a variable. If the income level wasn't set or if it doesn't exist in the lookup table, we'll return the default style. Otherwise, we can check to see whether the `styleCache` object already has a style for this income level. If it doesn't, we need to create a new style using the color from our lookup table. In this case, we are using the default style's stroke for everything, but you could easily change the stroke for each feature too. Because we've assigned the new style to the correct slot in the cache, we can then return it directly.

 Note that in both cases, we return an array containing the style. This is required for a very important reason: performance! The style functions are executed a lot of times when rendering vector features and if OpenLayers had to check the return type of each call to see if it was a style object or an array of style objects, this would add significant overhead to the rendering pipeline. For individual features, the difference is so tiny that it's probably not measurable even with the best of tools. For many features, this tiny difference adds up to a lot and it is measurable. The OpenLayers developers have put a lot of effort into this kind of detail and it shows!

In step 5, we modified the layer to use the style function we just created and defined a separate variable for the source. This was to make the next step a little easier.

In step 6, we loaded the income level data. The goal of the code in this step is to load the income data and associate it with the appropriate country feature. To do this, we need to make sure that the country features have been loaded. Once the countries are loaded, then, we need to load the income data. Then we can create a new property on each country feature with the appropriate income level. There are a few important things happening in this step, so we'll review each line:

- ◆ **Line 1:** This registers for the change event on the source and assigns the return value to a variable. The sources inherit from `ol.Observable` and so they provide the `on()` method for this. Recall from *Chapter 2, Key Concepts in OpenLayers*, that the `on()` method returns a key that can be used later to deregister an event handler (using the `unByKey()` method)—we'll need it in just a moment. The change event on a vector source is triggered when the source changes state.

- ◆ **Line 2:** This checks the state of the source to see if the source is ready. There are three states—loading, ready, and error—for a vector source, and we are interested to know when the state changes to ready as that's when we can load our income data safely.
- ◆ **Line 3:** This unregisters the event handler by using the `unByKey()` method so that the handler doesn't get called again. This is very important. A source triggers the change event when its state changes, but also when any of its features change. This means that our event handler will get called again when we add properties to the feature. Since the state of the source will already be ready, our code will try to load the income data again and will create an infinite loop.
- ◆ **Line 4:** This line loads the income data using jQuery's `ajax()` method. The data loaded from this file is passed to the function we register using `done()`.
- ◆ **Line 5:** This line starts a loop over each of the features in the source by calling `forEachFeature()` and providing a function that will be called with each feature.
- ◆ **Line 6:** This line gets the `iso_a2` property of the feature, which is a two letter code associated with each country. The income data in our file is organized by this code so we can use this code to get the income level for each country.
- ◆ **Line 7:** This checks to see if the income data has a value for the current country and line 8 adds the income level as a property of the feature if it does. As we add the property to each feature, the map responds to the change by redrawing itself. You might think that it seems inefficient to redraw the map for each feature change. What actually happens though, is that the map schedules a redraw for the next available render cycle. This won't happen until the current JavaScript process completes, so all the features will be changed and the map will only be redrawn once at some (very short) time later.

These eight lines of code accomplish quite a bit and combine concepts from other chapters of this book, including *Chapter 2, Key Concepts in OpenLayers* (event registration and deregistration) and *Chapter 5, Using Vector Layers* (vector layers, vector sources, and feature properties).

Interactive styles

To round off our chapter on vector styles, let's explore combining vector styles with user interaction. In the previous chapter, we responded to the mouse moving over a country by displaying the country's name in an HTML element outside the map. We'll build on this example and take it one step further. As the mouse moves, we'll highlight the country under the mouse and draw its flag and name in the center of the country using a **feature overlay**. The feature overlays are something new; so, we'll need to learn something about them before we go ahead with our example though.

The feature overlays

The `FeatureOverlay` class, `ol.FeatureOverlay`, is a special type of vector layer designed to render a small number of temporary features in a specific style. It isn't a full-fledged vector layer, but it is highly optimized for the specific case of highlighting features in a temporary way. This sounds ideal for our use case!

Creating a new feature overlay is just like creating any other class in OpenLayers, just pass some options to configure it. Here are the options that can be passed to the `ol.FeatureOverlay` constructor:

Name	Type	Description
<code>features</code>	<code>ol.Collection</code> <code>Array.<ol.Feature></code> <code>undefined</code>	This is an array or collection of features to be added to the feature overlay initially. You may omit this parameter if you don't have any features to add right away.
<code>map</code>	<code>ol.Map</code> <code>undefined</code>	This is the map on which the feature overlay will be rendered. You may omit this and attach the overlay to a map later.
<code>style</code>	<code>ol.style.Style</code> <code>Array.<ol.style.Style></code> <code>function</code> <code>undefined</code>	This is a style, an array of styles or style function respectively to use when rendering the features in this feature overlay. You may omit this and set the style later.

The `FeatureOverlay` class has several methods to manage its features, map, and styles as follows:

Method	Parameters	Description
<code>addFeature(feature)</code>	<code>feature - ol.Feature</code>	This adds a single feature to the feature overlay. You may also add features by adding them to the collection returned from <code>getFeatures()</code> .
<code>getFeatures()</code>	<code>none</code>	This returns the <code>ol.Collection</code> object used to manage features in this feature overlay. Modifying this collection directly affects the features in the overlay.
<code>getStyle()</code>	<code>none</code>	This returns whatever was passed as the <code>style</code> option when constructing the feature overlay or from the last call to <code>setStyle</code> .

Method	Parameters	Description
<code>getStyleFunction()</code>	none	This returns a function representing the active styles for this feature overlay.
<code>removeFeature(feature)</code>	<code>feature - ol.Feature</code>	This removes a single feature from the feature overlay. You may also remove features by removing them from the collection returned by <code>getFeatures()</code> .
<code>setFeatures(collection)</code>	<code>collection - ol.Collection</code>	This replaces the features for this feature overlay by using the provided collection of feature objects.
<code>setMap(map)</code>	<code>map - ol.Map</code>	This sets the map object that this feature overlay will be rendered on, maybe <code>null</code> to remove the feature overlay from a map.
<code>setStyle(style)</code>	<code>style - ol.style.Style Array.<ol.style.Style> function</code>	This sets the style to be used when rendering features.

Feature overlays are pretty simple and most of what you will want to do with a feature overlay once it is configured with a style and map is manage features. Let's see how that's done!

Time for action – creating interactive styles

Now we have the knowledge we need to build our final example. We will add some interactivity to our countries layer by highlighting the country under the mouse with a different style—specifically, we will:

- ◆ Draw the highlighted country with a red outline and semitransparent fill
- ◆ Draw an icon at the center of the highlighted country representing its flag
- ◆ Draw the country's name next to the flag

1. First, we'll need a new file. Let's start again with the basic country vector layer:

```
var countries = new ol.layer.Vector({
  source: new ol.source.GeoJSON({
    projection: 'EPSG:3857',
    url: '../assets/data/countries.geojson'
  })
});
```

```
var center = ol.proj.transform([0, 0], 'EPSG:4326', 'EPSG:3857');
var view = new ol.View({
  center: center,
  zoom: 1,
});
var map = new ol.Map({
  target: 'map',
  layers: [countries],
  view: view
});
```

- 2.** Next, we'll set up some styles for our highlighted features. This code can go right after the map is defined. Don't worry if you don't remember what everything does—we'll review the code at the end:

```
var baseTextStyle = {
  font: '12px Calibri,sans-serif',
  textAlign: 'center',
  offsetY: -15,
  fill: new ol.style.Fill({
    color: [0,0,0,1]
  }),
  stroke: new ol.style.Stroke({
    color: [255,255,255,0.5]
    width: 4
  })
};
var highlightStyle = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: [255,0,0,0.6],
    width: 2
  }),
  fill: new ol.style.Fill({
    color: [255,0,0,0.2]
  }),
  zIndex: 1
});
```

- 3.** We'll be using a style function with our feature overlay because we need to dynamically create styles for the feature being rendered:

```
function styleFunction(feature, resolution) {
  var style;
  var geom = feature.getGeometry();
  if (geom.getType() == 'Point') {
    var text = feature.get('text');
```

```

    baseTextStyle.text = text;
    var isoCode = feature.get('isoCode').toLowerCase();
    style = new ol.style.Style({
      text: new ol.style.Text(baseTextStyle),
      image: new ol.style.Icon({
        src: '../assets/img/flags/'+isoCode+'.png'
      }),
      zIndex: 2
    });
  } else {
    style = highlightStyle;
  }
  return [style];
}

```

- 4.** We also need to create the feature overlay itself. It's pretty straightforward as the style function is doing all the work for us:

```

var featureOverlay = new ol.FeatureOverlay({
  map: map,
  style: styleFunction
});

```

- 5.** Finally, the interactive part. We'll add a handler for the map's `pointermove` event and manage the features in our feature overlay based on where the mouse is. This is a pretty big function that exercises our knowledge of geometries from the previous chapter:

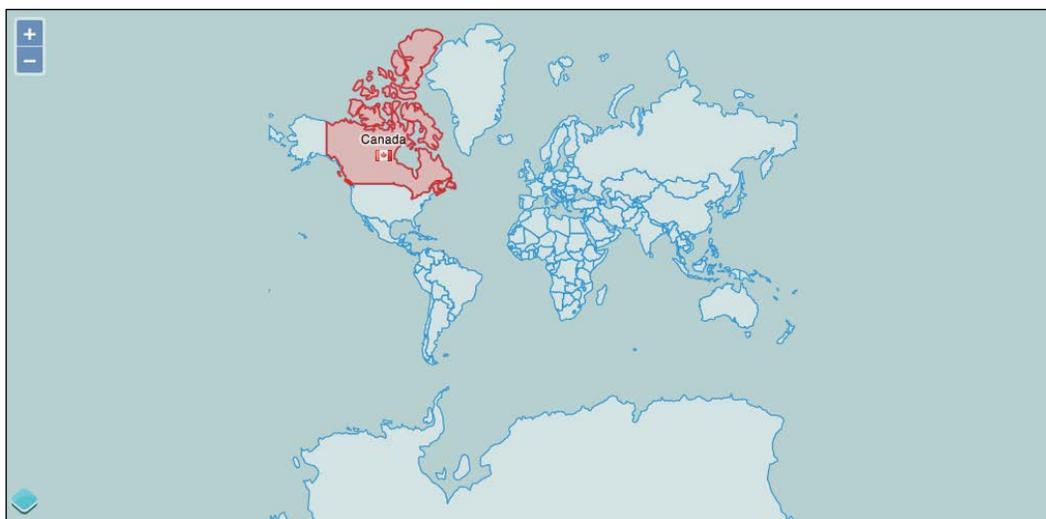
```

map.on('pointermove', function(browserEvent) {
  featureOverlay.getFeatures().clear();
  var coordinate = browserEvent.coordinate;
  var pixel = browserEvent.pixel;
  map.forEachFeatureAtPixel(pixel, function(feature, layer) {
    if (!layer) {
      return; // ignore features on the overlay
    }
    var geometry = feature.getGeometry();
    var point;
    switch (geometry.getType()) {
      case 'MultiPolygon':
        var poly = geometry.getPolygons().reduce(function(left,
right) {
          return left.getArea() > right.getArea() ? left : right;
        });
        point = poly.getInteriorPoint().getCoordinates();
        break;
    }
  });
});

```

```
case 'Polygon':
    point = geometry.getInteriorPoint().getCoordinates();
    break;
default:
    point = geometry.getClosestPoint(coordinate);
}
textFeature = new ol.Feature({
    geometry: new ol.geom.Point(point),
    text: feature.get('name'),
    isoCode: feature.get('iso_a2').toLowerCase()
});
featureOverlay.addFeature(textFeature);
featureOverlay.addFeature(feature);
});
}
```

6. Load this in your browser and try it out! You should see something like the following screenshot when you move the mouse over a country:



What just happened?

As you can see, feature overlays make it very simple to create an interactive experience with vector layers. There are a few new concepts in this example, as well as some old ones, so let's review the code step by step.

Step 1 should be pretty familiar to you now—we are creating a vector layer with a GeoJSON source, and adding it to a map with a view centered on 0, 0.

In step 2, we set up some styles for our feature overlay to use. There are two styles—one for text and one for polygon highlighting. Notice that the `baseTextStyle` is an object literal, not a new instance of `ol.style.Text`. When you create an instance of `ol.style.Text`, the text to be drawn needs to be passed to that object and you can't change the text after it has been created. The style function allows us to create text styles with the text of the current feature, but we'll need to specify the other options. Since all labels will share the other text options, we can set them up once and just refer to them later in the style function. The options we've specified here are to center align the text, offset it up by 15 pixels (recall that a positive `offsetY` moves the text down), and provide a fill and stroke color. For the text, the stroke is rendered around the outside of each character so we set a wide, semitransparent stroke to make the text stand out from the map beneath it.

The `highlightStyle` is straightforward— a fill and stroke style for the highlighted polygon.

The style function needs to be defined before we can use it to create the feature overlay, so in step 3, we defined it. Recall that the style function receives the feature being rendered as the first argument. We drew two types of features, points, and polygons, with two different styles. So, the first thing we did was get the feature's geometry and check to see whether it was a point. If it is a point, we create a new text style and a new icon style specific to the current feature. We got the feature's `text` property and combined it with the `baseTextStyle` object to create the text style. Next, we got the `isoCode` property and used it to create a URL to the flag for the country (the flag icons are conveniently named using the two-letter ISO country code) for a new icon style. Then, we created a new style object for the current feature. If the feature is a polygon, it's much simpler—all we need to do is return the `highlightStyle` object. Finally, we returned an array containing the style (recall that style functions are required to return arrays for performance reasons).

Step 4, by comparison, was very short! We created a new feature overlay and configured it with the map object and style function. It's really the style function, and step 5, that do all the work.

Step 5 added a handler for the map's `pointermove` event; so, we could find the feature closest to the mouse and add it to the feature overlay. We actually wanted to highlight two features— the polygon itself and a point at the center of the polygon. It turns out that getting this center point is a bit tricky. Let's review the code carefully.

Line 1 of code in the handler clears any existing features in the feature overlay. It is much easier to retrieve the collection and clear it than to remove individual features in our case.

The `browserEvent` object provides us with the map coordinate and pixel that the event happened at. We used the pixel location with `ol.Map` classes `forEachFeatureAtPixel` function on the next line to retrieve all features at that location from our vector layer. This function invokes a callback function for every feature at the pixel location, providing both the feature and the layer that the feature was found on. The layer parameter may be null if the feature was found on a `FeatureOverlay`.

Inside our callback function, we tested first to see if the feature was actually on a layer before proceeding. Then we needed to find both the geometry and the center point of the geometry. If all the country features were polygons, we could simply call `getInteriorPoint()` to retrieve the center and we would be done. Unfortunately, we didn't know what type of features we were dealing with—some of the features in the country data were actually `MultiPolygons`, and we needed to handle them differently. The switch statement chooses a path based on the type of the feature. Let's look at each case separately.

The first case was for `MultiPolygon`. As the name suggests, a `MultiPolygon` class contains multiple polygons (a country and some islands perhaps) and there isn't a convenient way to determine the center of a group of polygons. Instead, a `MultiPolygon` class has several centers, one for each of its constituent polygons. The `getInteriorPoints()` method returns the center points for us. We only really wanted a single label though. One way is to get all the interior points and use the first one. The problem with this approach is that there is no particular order to the polygons, and it looks odd to label some random island off the coast rather than the major landmass of a given country. To get around this, we wanted our label to appear at the center of the largest polygon. To get the largest polygon, we first got the array of polygons and then reduced that array to a single value with a function that compared two polygons based on their area. The reduce method is a standard method of JavaScript arrays. Once we've found the largest polygon, we can ask for its interior point.

The second case is for polygon, and was much simpler— we just needed the interior point of the polygon and we were done!

The final case was the default case. While it isn't strictly needed, it is good practice to include a default case in switch statements. The `getClosestPoint()` method is available on all geometry types and is a safe fallback for our default case.

Now that we had a point coordinate at the best location we could determine for the feature under the mouse, we created a new `Feature` and provided the point geometry for its location. We also added two properties—text (that we displayed at the point) and `isoCode` (that we will use to find the flag icon for the country).

Finally, we added both features to the feature overlay so that when the map is next rendered, the country under the mouse will be highlighted in red and display the flag and country name at the center.

Summary

This concludes our chapter on styling vector layers. OpenLayers' styling capabilities are quite simple to implement, but can be incredibly powerful. The basic styles are easy to set up and give you a lot of flexibility in styling your vector features. More complex styling is readily implemented through the use of a style function by allowing you to create basic styles tailored to a specific feature and current zoom level of the map. The building blocks—basic styles and the style function—are simple, but the combination of them allows you to create highly custom cartographic representations for your vector data.

In the next chapter, we will dig into projections and discover how to use them to display both vector and raster layers in different projections.

7

Wrapping Our Heads Around Projections

When you look at a map, you are looking at a two-dimensional representation of a 3D object (the Earth). Because we are, essentially, 'losing' a dimension when we create a map, no map is a perfect representation of the Earth. All maps have some distortion.

The distortion depends on what projection (a method of representing the earth's surface on a two dimensional plane) you use. In this chapter, we'll talk more about what projections are, why they're important, and how we can use them in OpenLayers. We'll also cover some other fundamental geographic principles that will help make it easier to better understand OpenLayers.

In this chapter, we will cover the following topics:

- ◆ Concept of map projections
- ◆ Types of projections
- ◆ Latitude, longitude, and other geographic concepts
- ◆ The OpenLayers projection class
- ◆ Transforming coordinates
- ◆ Projections in context of raster layers
- ◆ Projections using vector layers

Let's get started!

Map projections

No maps of the earth are truly perfect representations; all maps have some distortion. The reason for this, is because they are attempting to represent a 3D object (an ellipsoid: the Earth) in two dimensions (a plane: the map itself).

A **projection** is a representation of the entire, or parts of a surface of a 3D sphere (or more precisely, an ellipsoid) on a 2D plane (or other types of geometry).

Why on earth are projections used?

Every map has some sort of projection—it is an inherent attribute of maps. Imagine unpeeling an orange and then flattening the peel out. Some kind of distortion will occur, and if you try to fully fit the peel into a square or rectangle (like a flat, two-dimensional map), you'd have a very hard time.

To get the peel to fit perfectly onto a flat square or rectangle, you can try to stretch out certain parts of the peel or cut some pieces of the peel off and rearrange them. The same sort of idea applies while trying to create a map.

There are literally an infinite amount of possible map projections; an unlimited number of ways to represent a three-dimensional surface in two dimensions, but none of them are totally distortion free.

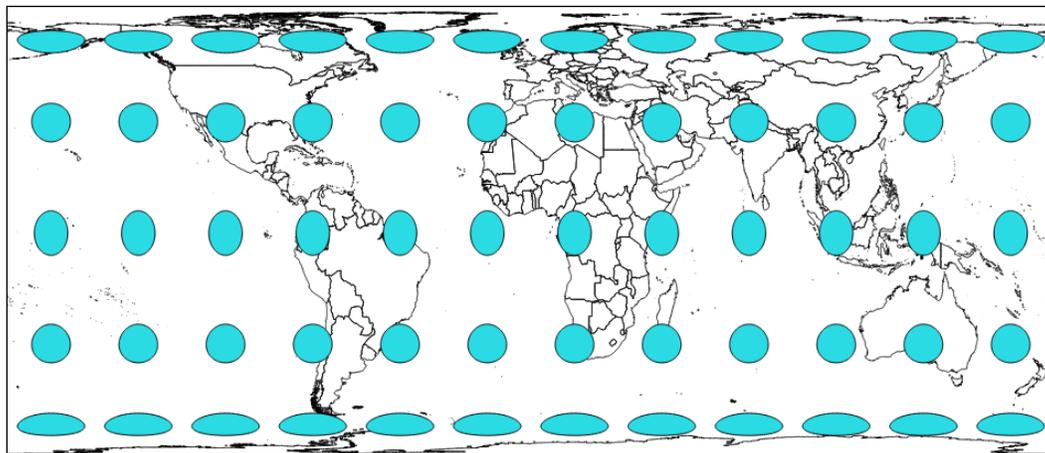
So, if there are so many different map projections, how do we decide on which one to use? Is there a best one? The answer is no. The 'best' projection to use depends on the context in which you use your map, what you're looking at, and what characteristics you wish to preserve.

Projection characteristics

As a two-dimensional representation is not without distortion, each projection makes a trade off between some characteristics. As we lose a dimension when projecting the earth onto a map, we must make some sort of trade off between the characteristics we want to preserve. There are numerous characteristics, but for now, let's focus on three of them.

Area

Area refers to the size of features on the map. Projections that preserve area are known as **equal-area projections** (also known as equiareal, equivalent, or homolographic). A projection preserves area if, for example, a meter measured at different places on the map covers the same area. Because area remains the same, angles, scales, and shapes are distorted. This is what an equal area projected map may look like:



Here, we use **Tissot indicatrix** with EPSG:3410 **NSIDC EASE-Grid Global**, where the EPSG code helps define all existing projections. We will cover EPSG in detail, later in this chapter.

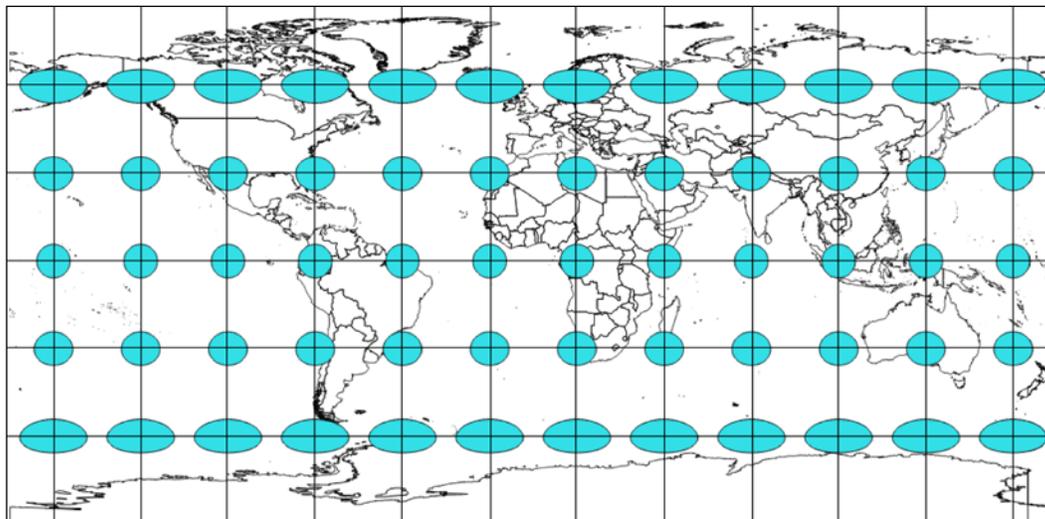
Without going into technical details, Tissot indicatrix is a way to display map projections deformation visually. In a perfect projection, we will keep area, distance, and shape, with circles with equal area and equal distance.

As you see, with this equal-area projection, we have circle and ellipse shapes but areas remain the same.

Scale

Scale is the ratio of the map's distance to the actual distance (for example, one centimeter on the map may be equal to one hundred actual meters). All map projections show scale incorrectly at some areas throughout the map; no map can show the same scale throughout the map. There are parts of the map, however, where scale remains correct—the placement of these locations mitigates scale errors elsewhere. The deformation of scale also depends on the area being mapped. Projections are referred to as **equidistant** if they contain true scale between a point and every other point on the map.

An example to illustrate can be the EPSG:32662 projection known as Plate Carree.

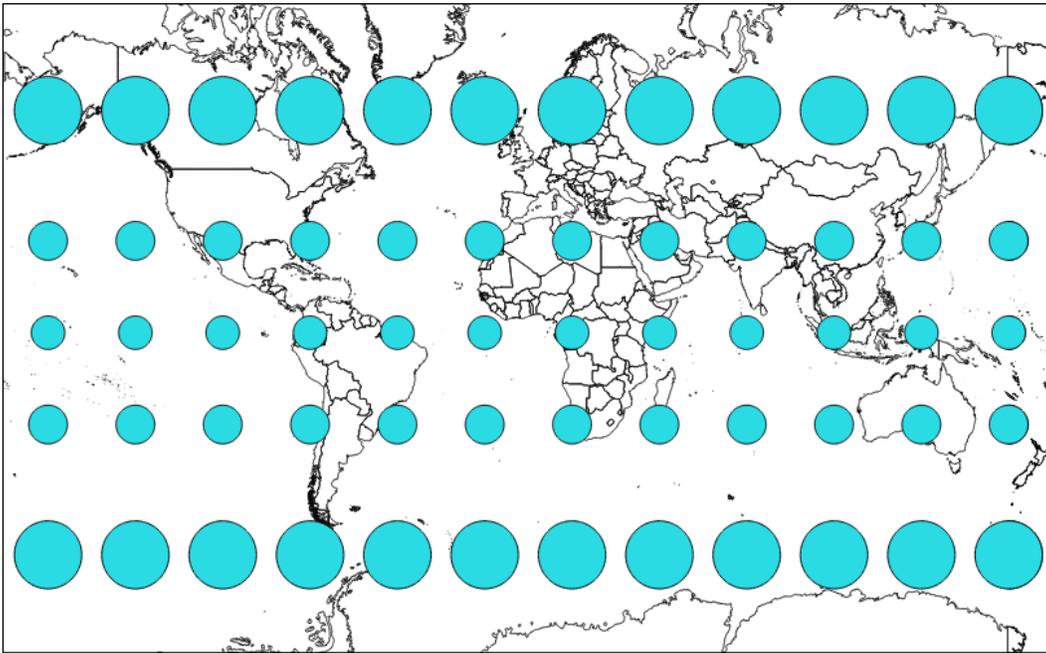


Here, we keep the distance between the center of the ellipse/circle. We overlay on top of the image of a grid so that you can better evaluate distance.

Shape

Maps that preserve shape are known as **conformal** or **orthomorphic**. Shape means that relative angles to all points on a map are correct. Most maps that show the entire earth are conformal, such as the Mercator projection (used by Google Earth and other common web maps). Depending on the specific projection, areas throughout the map are generally distorted but may be correct in certain places. Also, a map that is conformal cannot be equal-area.

To illustrate shape preservations, let's see the following example using EPSG code 3395 (WGS 84 - World Mercator), where all circles stay circles wherever they are:



Other characteristics

Projections have numerous other characteristics, such as bearing, distance, and direction. The key concept to take away here is that all projections preserve some characteristics at the expense of others. For instance, a map that preserves shape cannot completely preserve area.

There is no perfect map projection. The usefulness of a projection depends on the context the map is being used in. A particular projection may excel at a certain task, for example, navigation, but can be a poor choice for other purposes. For example, when we do thematic mapping and respect representations rules, colors are related to areas of countries. When we look at a world thematic map with a wrong projection, our eyes see a country bigger than the others, whereas because of projections, this country can, in reality, have a calculated area identical to countries represented with a smaller size.

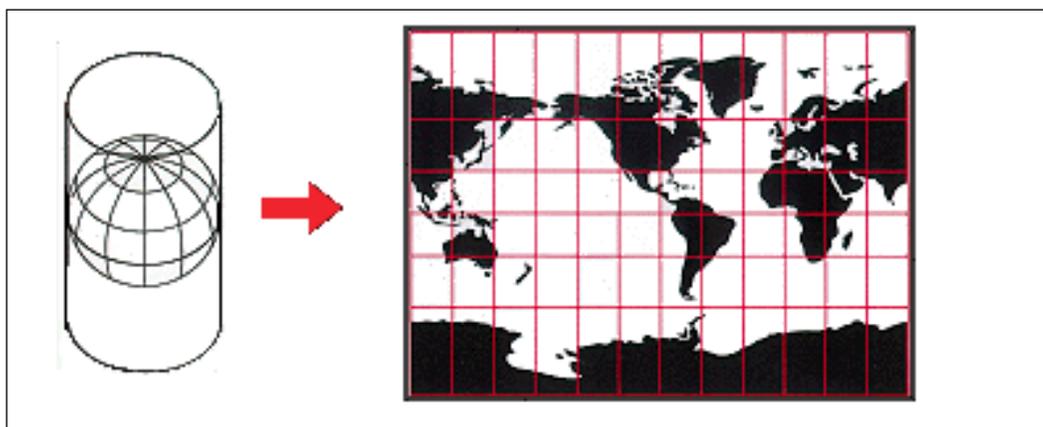
Your instructions until now are:

- ◆ To not look at the code but only the behavior of the scale line in the bottom-left corner of the map.
- ◆ In both cases, to zoom in and at the same zoom level, pan up and down looking at the scale line.
- ◆ How the scale line behaves.
- ◆ How do you explain it?

Types of projections

Projections are projected onto a geometric surface, three of the most common ones being a **plane**, **cone**, or **cylinder**.

Imagine a cylinder being wrapped around the earth, with the center of the cylinder's circumference touching the equator. Now, the earth is projected onto the surface of this cylinder, and if you cut the cylinder from top to bottom vertically and unwrap it and lay it flat, you'd have a regular cylindrical projection:



The **Mercator** projection is just one of these types of projections. If you've never worked with projections before, there is a good chance that most of the maps you've seen were in this projection.

Because of its nature, there is heavy distortion near the ends of the poles. Looking at the previous screenshot, you can see that the cells get progressively larger, the closer you get to the North and South poles. For example, Greenland looks larger than South America, but in reality, it is about the size of Mexico. For illustrating this problem visually, you can compare countries overlapping with <http://overlapmaps.com>. If area distortion is important in your map, you might consider using an equal area projection, as we mentioned earlier.



More information about projections can be found at the **USGS (US Geological Survey)** website at <http://pubs.er.usgs.gov/publication/pp1395>, where you can download the reference book *Map Projections: A Working Manual (U.S. Geological Survey Professional Paper 1395)*, John P. Snyder, 1987, 397 pages.

EPSG codes

As we mentioned, there are literally an infinite number of possible projections. So, it makes sense that there should be some universally agreed upon classification system that keeps track of projection information. There are many different classification systems, but OpenLayers uses **EPSG** codes. EPSG refers to the **European Petroleum Survey Group**, a scientific organization involved in oil exploration, which in 2005 was taken over by the **OGP (International Association of Oil and Gas Producers)**.

For the purpose of OpenLayers, EPSG codes are referred to as `EPSG:4326`.

The numbers (4326, in this case) after `EPSG:` refer to the projection identification number. It uses the familiar longitude/latitude coordinate system, with coordinates that range from -180° to 180° (longitude) and -90° to 90° (latitude).

Time for action – using different projection codes

Let's create a basic map using a different projection. Using the usual code from *Chapter 1, Getting Started with OpenLayers*, recreate your map object the following way. We'll be specifying the `projection` property, along with the `center` and `zoom` properties. The projection we will use is `EPSG:4326`, a projection used for world data. Usually, when you don't specify a projection, the default projection in OpenLayers is `EPSG:3857` (historically, called `EPSG:900913`), used by Google Maps and other third-party APIs such as Bing Maps or OpenStreetMap.

1. Declare a new layer:

```
var blueMarbleLayer = new ol.layer.Tile({
  source: new ol.source.TileWMS({
    url: 'http://maps.boundlessgeo.com/geowebcache/service/wms',
    params: {
      'TILED': true,
      'VERSION': '1.1.1',
      'LAYERS': 'bluemarble',
      'FORMAT': 'image/jpeg'
    }
  })
});
```

2. Then, declare a new view:

```
var view = new ol.view({
  projection: 'EPSG:4326',
  center: [-1.81185, 52.44314],
  zoom: 6
});
```

3. Now, declare the map object:

```
var map = new ol.Map({
  target: 'map'
});
```

4. Add the layer and the view to the map object:

```
map.addLayer(blueMarbleLayer);
map.setView(view);
```

5. Save the file into the usual sandbox folder, we'll refer to it as `chapter7_ex1.html`. You should see something like the following:



What just happened?

We just created a map with the `EPSG:4326` projection. The process to use another projection is really similar to all previous examples in the book.

One of the main differences is the backend server. It can provide a layer projected in another projection from the default one in OpenLayers 3 library. In our case, it's the source URL, `http://maps.boundlessgeo.com/geowebcache/service/wms`, from the `blueMarbleLayer` layer object that permits this.

The other difference is at the view level. In the constructor, we set a new property: `projection` that refers to wanted EPSG code and we also directly use coordinates from the projection to set the center on our map.

Apart from the code, you'll notice that the example looks quite different from the maps we've made so far. This is because of its projection.

Specifying a different projection

OpenLayers supports any projection, but if you want to use a projection other than `EPSG:3857`, you must specify this option in the view projection. The default value is `EPSG:3857`.

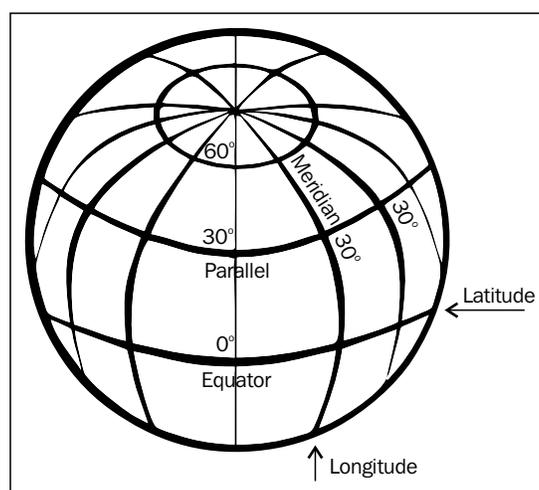
If you do not specify this option, the default value is used (most of the other maps so far, have been using the default values).

You can pass to the projection a string with `EPSG:yourcode`, but you can also give it an `ol.proj.Projection` object. You can define it manually but most of the time, you will retrieve it from a preconfigured projection setting. We will only cover how to define it when you are using `Proj4js`, a JavaScript library dedicated to manage projections. As a beginner will not need to work with use cases without EPSG codes. Be careful, as OpenLayers only supports `EPSG:4326` and `EPSG:3857` (both with a few aliases) out-of-the-box.

 In the API documentation, you will sometimes see `ol.proj.ProjectionLike:`, which means, the accepted parameters can be a string with an EPSG code or an `ol.proj.Projection` object.

Latitude/longitude

Longitude and latitude are two terms most people are familiar with, though they have limited geographic knowledge or get confused by the two. Let's take a look at the following screenshot and then go over these two terms:



Latitude

Latitude lines are imaginary lines parallel to the equator, aptly known also as *parallels of latitude*. Latitude is divided into 90 degrees, or 90 spaces (or cells), above and below the equator. -90° is the South Pole, 0° would be the Equator, and 90° is the North Pole.

Each space, or cell, (from 42° to 43° , for example) is further divided into 60 minutes and each minute is further divided into 60 seconds. The minutes and seconds terminology has little to do with time. In the context of mapping, they are just terms used for precision. The size of a degree of latitude is constant (if calculation is based on projected distance). Because they measure 'north to south', OpenLayers considers the *y* coordinate to be the latitude.

Longitude

Longitude lines are perpendicular to the lines of latitude. All lines of longitude, also known as *meridians of longitude*, intersect at the North Pole and South Pole, and unlike latitude, the length of each longitude line is the same. Longitude is divided into 360 degrees, or spaces. Similar to latitude, each space is also divided into 60 minutes, and each minute is divided into 60 seconds. For EPSG:4326, -180 to 0 measures west of the Greenwich meridian, whereas 0 to 180 measures east of Greenwich.

As the space between longitude lines gets smaller, the closer you get to the poles, the size of a degree of longitude changes (when not relying on projected distance). The closer you are to the poles, the lesser time it will take you to walk around the Earth.

With latitude, it makes sense to use the equator as 0°, but with longitude, there is no spot better than to start the 0° mark at. So, while this spot is really arbitrary, the Observatory of Greenwich, England, is today universally considered to be 0° longitude. Because longitude measures east and west, OpenLayers considers the x coordinate to be longitude.

Time for action – determining coordinates

Let's take a look at a couple of examples on coordinates from our previous maps:

1. Open up the final example from *Chapter 1, Getting Started with OpenLayers*. Pan around the map in any direction. Then, in Chrome Developer Tools, type the following:

```
map.getView().getCenter();
```

Depending on where you have panned, your output should read something like the following:

```
[9397474.0038099, 3595597.9798909]
```

2. Now, open up the example from the beginning of this chapter. Pan around, and then in Chrome Developer Tools, type:

```
map.getView().getCenter();
```

You should see something like the following:

```
[-72.8125, 19.6875]
```

3. Reuse this last array to change the representation of your degrees values. For calculation, we always use **dd (decimal degrees)** but some people such as sailors will prefer the **DMS (Degrees, Minutes, Seconds)** notation:

```
ol.coordinate.toStringHDMS([-72.8125, 19.6875]);
```

What just happened?

We just took a look at the longitude and latitude values for the center of the map in two different maps with different projections. When we call `map.getView().getCenter()`, we get back an `ol.Coordinate` object, in fact, an array of x, y values.

In the first map, the max extent of the map was between -20037508.342789244 meters and 20037508.342789244 meters for x , and between -20037508.342789244 meters and 20037508.342789244 meters for y .

These are the values used by the EPSG:3857, and it is an x and y type of Cartesian coordinate system. The values for x and y change in the second map because they are not in the same projection (they are in EPSG:4326). So, x are between -180° and 180° and y between -90° and 90° .

The x and y means longitude and latitude, respectively in EPSG:4326 and easting and northing in EPSG:3857. To understand definition of easting and northing, go to the Wikipedia dedicated page, https://en.wikipedia.org/wiki/Easting_and_northing.

OpenLayers projection class

So far, we've been talking about the abstract idea of a projection. Let's dive into OpenLayer's `ol.proj` namespace functions and the associated class `ol.proj.Projection` class, which is what we use to actually handle projections. The `ol.proj.Projection` class relies on internal code, managing the most used projection in the web mapping world: the EPSG:4326 projection (also named WGS 84) and the EPSG:3857 projection, also known as EPSG:900913 (using leetspeak, it means Google, the first company relying on this exact projection), and also, alternatively named WGS 84 Spherical Mercator. For reference, you can have the full history of the second projection at <http://wiki.openstreetmap.org/wiki/EPSC:3857>

For other use case such as custom projections, OpenLayers, for convenience, supports an external library called Proj4js, which can be found at <http://proj4js.org>. First, we'll talk about what we can do without the Proj4js library, and then talk about what we can do with it.

Creating a projection object

In truth, whenever you load your web mapping application, you have already instantiated the default projections, EPSG:4326 and EPSG:3857.

You only need to access `ol.proj.Projection` by typing the following line of code:

```
ol.proj.get('EPSG:3857')
```

In `ol.proj.get`, you can use a `projectionCode`, a string for identifying the **WKID** (**Well Known Identifier**) for the projection, such as an EPSG code in the form of `EPSG:4326`.

When creating a map and loading a particular projection, you will only require to declare Proj4js-specific definition and use OpenLayers built-in functions to use them. This string, such as `EPSG:4326`, is also known as an **SRS (Spatial Reference System)** code. When passing in a code, like we've done with all our examples so far, `ol.proj.get()` will automatically create a projection object, as long as the projection definition is known to Proj4js.

Functions

The projection class (the list is available at <http://openlayers.org/en/v3.0.0/apidoc/ol.proj.Projection.html>) has a number of methods, including the following:

Function	Description
<code>getCode()</code>	This gets the code for the projection, <code>EPSG:4326</code> for example.
<code>getExtent()</code>	This returns an <code>{ol.Extent}</code> , in truth an array with four values to define extent [<code>minx</code> , <code>miny</code> , <code>maxx</code> , <code>maxy</code>]. It uses the projection units and defines the validity extent for this projection.
<code>getMetersPerUnit()</code>	This gets the amount of meters per unit of this projection. If the projection is not configured with a units identifier, the return is undefined.
<code>getUnits()</code>	This gets the units of this projection. Units can be <code>degrees</code> , <code>ft</code> , <code>m</code> , or <code>pixels</code> .
<code>isGlobal()</code>	This returns if the projection is a global projection that spans the whole world.

Transforming coordinates

Transforming a point means you take a coordinate in one projection and turn it into a coordinate of another projection. This operation is also called **reprojection**. The term reprojection is also applied when deforming a raster image from one projection to another. Apart from transforming `EPSG:4326` to `EPSG:3857` and vice versa, OpenLayers does not provide support for transforming other projections out-of-the-box. To do transforms with other projections, you can include Proj4js (which can be found at <http://proj4js.org>) or provide your own transforms and register them with OpenLayers. You may be wondering why. The main reason is to not maintain projections in the core library when we can keep it outside, in a well-maintained library. The other goal, is to avoid increasing the overall library size. There are thousands of projections, whereas most projects only require some of them. The gain is not worth the drawback.

In most scenarios, it is the job of the backend map server to handle projection transformations. Often, it's useful or faster to do it on the client-side (such as in the case of vector layer coordinate transformations) because we don't need to call server-side again for transformation or because we don't control the server-side like for external web services. Let's take a look at how to transform EPSG:4326 to EPSG:3857 with OpenLayers.

Time for action – coordinate transforms

Proj4js is not necessary for this example, as transforming between these two projections is possible without `proj4js`. Try the following steps:

1. Open up the previous example in your browser. We won't be modifying any code, so any page that includes the OpenLayers library will be fine.

2. Open Chrome Developer Tools. In the console, create two projection objects:

```
var proj_4326 = ol.proj.get('EPSG:4326');
var proj_3857 = ol.proj.get('EPSG:3857');
```

3. Now, let's create an array with *x*, *y* coordinates, which will contain a point in EPSG:4326 coordinates:

```
var point_to_transform = [-79, 42];
```

4. And now, let's transform it. We'll take it from EPSG:4326 (our source `proj_4326` projection object) to EPSG:3857 (our destination `proj_3857` projection object):

```
var myTransformedPoint = ol.proj.transform(point_to_transform,
proj_4326, proj_3857);
```

5. Finally, we'll print the new value:

```
console.log(myTransformedPoint);
console.log(myTransformedPoint[0], myTransformedPoint[1]);
```

6. Your output should read something like:

```
[-8794239.7714444, 5160979.4433314]
-8794239.7714444 5160979.4433314
```

What just happened?

We just transformed a point in the EPSG:4326 projection to a point in the EPSG:3857 projection. Let's take a closer look at the `transform` method we called on the `point_to_transform` object:

```
ol.proj.transform(point_to_transform, 'EPSG:4326', 'EPSG:3857');
```

This will transform the original point from the EPSG:4326 projection to the EPSG:3857 projection. Notice, we are calling the function directly from an `ol.Coordinate` array. The `ol.proj.transform()` function's definition is as follows:

Function	Description	Parameters
<code>ol.proj.transform(coordinate, source, destination);</code>	This function transforms <code>ol.Coordinate</code> (an array of coordinates) without changing the original value. It returns the transformed <code>ol.Coordinate</code> .	Coordinates: an array with x, y coordinates Source: Source projection Destination: Destination projection

In this case, our source projection is in EPSG:4326, and our destination projection is in EPSG:3857. Keep in mind however, that EPSG:4326 and EPSG:3857 are the only two projections you can do transforms on with OpenLayers out-of-the-box.

When creating a map, all the raster layers (image-based layers; nearly every layer except the vector and image layer) must be in the same projection as the map. It's possible to do projection transformations with coordinates and the vector layer, but once OpenLayers gets back an image from a map server, it cannot reproject the image itself (that's something the map server has to do).

The Proj4js library

The Proj4js library allows you to transform the coordinates from one coordinate system into another coordinate system. The Proj4js website is <http://proj4js.org>. By just including the Proj4js library on your page (like you do with OpenLayers), you can do more transforms within OpenLayers. Note that Proj4js also only ships with only a few codes. Definitions need to be added for all others.

 The site <http://epsg.io> contains Proj4js definitions for most of the EPSG codes. When you are using data from foreign countries, you need to know the most common used projections. For this, go to the ProjFinder website, <http://projfinder.com>, and guess projections for unknown places.

Ideally, you should be using the same projection throughout your map, but there are times when you may want to display the coordinates in a different projection—such as with a vector layer. Let's take a look at how to set up the Proj4js library.

Time for action – setting up Proj4js.org

This step is similar to the way we set up the now usual template for OpenLayers 3.

1. Download Proj4js from <https://github.com/proj4js/proj4js/releases>. At the time of writing, the latest version was proj4js 2.3.3; so, go ahead and download it by clicking on the **proj4.js** green button for 2.3.3 (or whichever the latest version is).
2. Copy the `proj4.js` file into a new `assets/proj4js` directory at the root code directory.
3. Add the following line in the `<head>` section of your code before the OpenLayers 3 library inclusion code:

```
<script src="../../assets/proj4js/
proj4.js">
</script>
```

4. You can also use the online source, <http://cdnjs.cloudflare.com/ajax/libs/proj4js/2.3.3/proj4.js>, for production purposes. In this case, do not forget to use a fallback to the local file if the CDN fails for any reason.
5. Now, open up the page and start Chrome Developer Tools. Type and run the following code:

```
var test_proj = proj4('EPSG:4326');
console.log(test_proj);
```

6. You should see an output that looks like the following:
`Object {forward: function, inverse: function, oProj: Projection}`

What just happened?

We just included the Proj4js library and tested to see if it worked. If you received an error when you attempted to call `proj4('EPSG:4326')`, it means that the location of the `proj4.js` file was wrong. Ensure that the path in the `<script>` tag correctly references the JavaScript file.

Proj4js custom projections

Proj4js custom projections are required, particularly when you are using data at the local level and you want to use your country official projection(s) or you depend on external data sources such as web services.

Adding custom projections

Now that the Proj4js library is included, you can do transforms with more projections, the same way we did in the previous example. Except EPSG:3857, EPSG:4326, and EPSG:4269, there are no projections defined; however, you are able to define them yourself. For example, for France, the main official EPSG code is as follows:

```
proj4.defs("EPSG:2154", "+proj=lcc +lat_1=49 +lat_2=44 +lat_0=46.5  
+lon_0=3 +x_0=700000 +y_0=6600000 +ellps=GRS80 +towgs84=0,0,0,0,0,0,0  
+units=m +no_defs");
```

After this, you'd be able to use EPSG:2154 for projection transformations just like you were able to use EPSG:4326 and EPSG:3857 from the earlier examples.

A more complete list of projections (containing Proj4js definitions for nearly any EPSG code) can be found at <http://epsg.io>.

To get projection definitions, you can copy them from <http://epsg.io> or also load them from the URL. For example, adding the `proj4.js` script after the `<script src="http://epsg.io/2154.js"></script>`. The URL pattern to retrieve the definition is `http://epsg.io/xxx.js` where `xxx` is the EPSG code you want to use.

OpenLayers 3 custom projections use cases

When you are using custom projections in OpenLayers 3, you need to declare the projection, as described earlier. Use `ol.proj.get` to retrieve its definition and define the projection extent. For this, reuse the <http://epsg.io> site.

When you want to declare a custom projection, you must create an object, such as the preceding one, when you start your JavaScript code:

```
var projection = ol.proj.get('EPSG:2154');  
projection.setExtent([-378305.81, 6093283.21, 1212610.74,  
7186901.68]);
```

You will then be able to use the usual `ol.proj.transform` function with this new projection.

Sometimes, in another context for example, to provide parameters to web services it can be necessary to convert extent between projections. Let's inspect how to do this operation.

Time for action – reprojecting extent

Until now, we only see how to do reprojection using points coordinates but how can we do it for extent?

1. Head to one of the official examples at <http://openlayers.org/en/v3.0.0/examples/wms-image-custom-proj.html?mode=raw> and see that you have extent at the layer level typing:

```
console.log(extent);
```

2. Apply a built-in function to transform extent from one coordinate's projection to another one:

```
ol.proj.transformExtent(extent, 'EPSG:21781', 'EPSG:4326');
```

What just happened?

We reused the function behind the `ol.proj.transform` function without knowledge.

The `ol.proj.transformExtent` method expects an extent as a first parameter, as a second parameter, it needs the origin projection, and as a third parameter, it's the destination projection. We declared that we use as input the extent; as origin, EPSG:2181; and as destination, EPSG:4326. At the internal OpenLayers 3 library level, the function loops on the extent and transforms each coordinate.

With this function, if we need to get a bounding box in EPSG:4326 from local projections, it will really help.

Using raster layers with projections

If you remember *Chapter 4, Interacting with Raster Data Source*, we introduced you to the tiled and untiled raster. Most tiled rasters do not serve in a foreign projection, for example, a non-Spherical Mercator projection, but contrary to most cases, WMS sources can be served and consume using custom projections.

Time for action – using custom projection with WMS sources

In this part, we will see how to display the WMS image coming from the authority responsible for geology maps in France, the BRGM (equivalent to USGS to simplify):

1. Let's copy the usual template into the sandbox directory but do not forget to include, in this case, the reference to Proj4js JavaScript library before the `ol3.js` file.

2. Go within the `<script>` tag and declare the additional projection for local projection, in this case, Lambert 93, an official projection for France:

```
proj4.defs("EPSG:2154", "+proj=lcc +lat_1=49 +lat_2=44  
+lat_0=46.5 +lon_0=3 +x_0=700000 +y_0=6600000 +ellps=GRS80  
+towgs84=0,0,0,0,0,0 +units=m +no_defs");
```

3. Declare the extent and the projection reusing your knowledge about declaring custom projection:

```
var extent = [-378305.81, 6093283.21, 1212610.74, 7186901.68];  
var projection = ol.proj.get('EPSG:2154');  
projection.setExtent(extent);
```

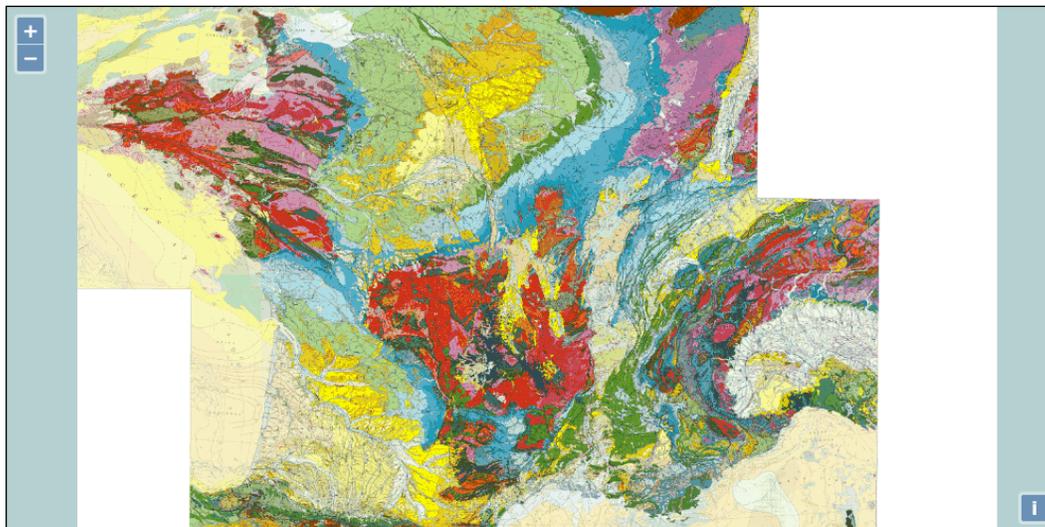
4. Declare an array with one layer using a source providing a WMS-projected web service in EPSG:2154, the EPSG code for Lambert 93:

```
var layers = [new ol.layer.Image({  
  source: new ol.source.ImageWMS({  
    url: 'http://geoservices.brgm.fr/geologie',  
    attributions: [new ol.Attribution({  
      html: '&copy; ' +  
        'BRGM (French USGS equivalent)'  
    })]  
  })  
  params: {  
    'LAYERS': 'SCAN_F_GEOL1M',  
    'VERSION': '1.1.1'  
  },  
  extent: extent  
})  
];
```

5. Declare the map and the view with its center and zoom:

```
var map = new ol.Map({  
  layers: layers,  
  target: 'map',  
  view: new ol.view({  
    projection: projection,  
    center: [495520.187986, 6587896.855407],  
    zoom: 2  
  })  
});
```

6. Open the file in the browser and you should see the following screenshot:



What just happened?

We reused the custom projection by first declaring the Proj4js projection declaration and its extent. We recommend that you visit the website <http://epsg.io> to better understand how to get the extent and the meaning of the second parameter in from the `proj4.defs` function.

Then, we used our raster WMS knowledge to create the layer. Analyzing the network can be useful to remind you about the relationship between the WMS source layer declaration and the backend web server delivering the image. You can look in particular at `getCapabilities`, to inspect the available projections and the layers name you may change, if you want to play with the sample. The most important part to understand is to set the projection in the map view projection parameter. How can we deduce this? We understood that because in all the code, we never set any projection at the layer or source level. We should mention that Proj4js is not needed for maps, as long as they do not need any client-side transforms.

Using our example, a minimal case can be achieved replacing previous projection declarations by only declaring a projection, with units and code parameters like below:

```
var projection = new ol.proj.Projection({
  code: 'EPSG:2154',
  units: 'm'
});
```

Have a go hero – applying a raster projection on your own

When someone reviews someone else job, it seems to be quite easy but reusing the same method for your own case is not the same, and will help you to really understand it.

So, we will ask you to complete a simple job:

1. Find local projections for your country by visiting your national mapping agency, if available or sort out projections using the recommended website, <http://epsg.io>.
2. Find web services that provide WMS in your local projection. Search engines or Geodata portals can help you. Do not forget to use the `getCapabilities` operation to get a layer's name or projections available for the data. If you don't find public web services using local projections for your country, to complete the assessment, explore other countries local projections web services.
3. Find the extent and the code you will need to make your map with local projections.
4. Copy the previous example to readapt it and not reinvent the wheel.

Never forget to inspect the **Network panel** to help you if you encounter web services issues. You may also need to use the DOM renderer within the map; it helps you to inspect the `url` call. With the default canvas renderer, images are assembled in the background and you can't get the WMS URL that can help you.

To find the open data portals, the main entry for America is <https://www.data.gov>. For Europe, you should visit <http://publicdata.eu>. For a worldwide overview, go at <http://datacatalogs.org>, a website for A Comprehensive List of Open Data Catalogs from Around the World. To grasp the state of OpenData in your country, you can visit Global Open Data Index at <http://global.census.okfn.org>. It's a website maintained by the community to make surveys about each country's open data initiative. The focus is mainly on the type of open data datasets available.

After inspecting how to work with custom projection using raster layers, it's time to see vector reprojection. We already reviewed how to manipulate vector but not explaining further how to manage vector projections. Let's see a bit about them.

Time for action – reprojecting geometries in vector layers

When you draw in OpenLayers, you draw in local projections' features. Then, if you need, for example, to exchange data source with a third party, sometimes you need to make *reprojections*. It's useful to know how to consume data and reproject them or on the contrary, export them. It's what we will see here:

1. Again, let's copy the previous sample into a new file in the `sandbox` directory.

2. Edit the file, and after the `var projection` declaration, add a new GeoJSON source, a vector source:

```
var countriesSource = new ol.source.GeoJSON({
  projection: 'EPSG:2154',
  url: '../assets/data/nutsv9_lea.geojson'
});
```

3. Add a listener on the source that fires once and that sends some `console.log` statements:

```
countriesSource.once('change', function(evt) {
  if (this.getState() == 'ready') {
    console.log(this.getFeatures()[0].getGeometry().
getCoordinates());
    console.log(this.getFeatures()[0].getGeometry().clone().transform('EPSG:2154', 'EPSG:4326').getCoordinates());
  }
});
```

4. Declare the vector layer within the layers existing array, reusing the `countriesSource` as the source. You will normally write something like the following:

```
var layers = [
  new ol.layer.Image({
  }),
  new ol.layer.Vector({
    source: countriesSource
  })
];
```

5. Create a new vector layer with an empty GeoJSON source and add it to the map:

```
var bbox = new ol.layer.Vector({
  source: new ol.source.GeoJSON()
})
map.addLayer(bbox);
```

6. Create a GeoJSON `featureCollection` inline. It's recommended by the GeoJSON specifications to have coordinates using EPSG:4326:

```
var geojson = {
  "type": "FeatureCollection",
  "features": [
    {
      "type": "Feature",
      "properties": {},
      "geometry": {
        "type": "Polygon",
        "coordinates": [
          [[-0.944824, 46.134170], [-0.944824, 48.312428],
          [4.438477, 48.312428], [4.438477, 46.134170],
```

```
        [-0.944824, 46.134170]
      ]
    ]
  }
}
]
```

- 7.** Create an `ol.format.GeoJSON` with `defaultDataProjection`:

```
var format = new ol.format.GeoJSON({
  defaultDataProjection: 'EPSG:4326'
})
```

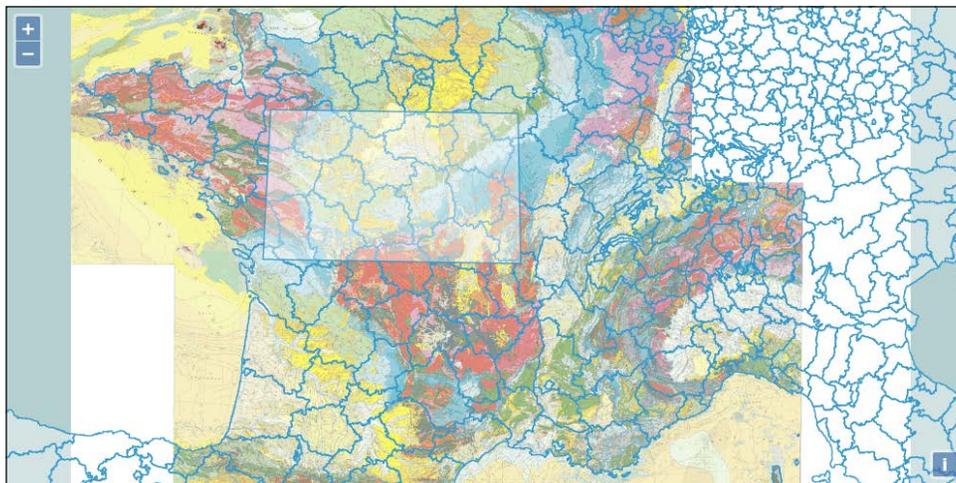
- 8.** Read the features to reproject them and add them to the source of the `bbox` layer:

```
var features = format.readFeatures(geojson, {
  dataProjection : 'EPSG:4326',
  featureProjection: 'EPSG:2154'
});
bbox.getSource().addFeatures(features);
```

- 9.** Finish with some `console.log` statements to help inspect the result, but also see how you can use `writeFeatures` and `reproject`.

```
console.log(features);
console.log(
  format.writeFeatures(features, {
    dataProjection : 'EPSG:4326',
    featureProjection: 'EPSG:2154'
  })
);
```

- 10.** Open in your browser the example and you will see a screen similar to the following:



What just happened?

We first set a source by defining its target projection. You might not remember but when you consume GeoJSON, the data default projection is supposed to be EPSG:4326, but our previous map example relies on EPSG:2154, a local projection. By setting this parameter, we are able to tell our application to make a reprojection from EPSG:4326 to EPSG:2154.

How can we be sure it works? You just need to inspect your GeoJSON file and see the coordinates. For EPSG:4326, the approximate values are mostly less than a hundred degrees, whereas with EPSG, the units are meters and expressed with thousands of meters.

For this purpose, we already set a listener with `countriesSource.once('change', function(evt) {` to inspect the features values. We checked before firing the `console.log` statements that the GeoJSON was ready to use `getState`. Then, we tried to inspect the coordinates that the layer vector source contained. As you can see, we chained methods to write a shorter code. We requested all the features with the `getFeatures` method; the `0` index is to select only the first feature in the array. By reusing this feature, we got geometry with `getGeometry`, and on this geometry, we retrieved the coordinates.

With a second `console.log`, we started like the previous statement, but we cloned the geometry. It's because we wanted to keep the values in the original feature intact. The API documentation mentions about the `ol.geom.Geometry.transform` method that *it transforms a geometry from one coordinate reference system to another, modifies the geometry in place. If you do not want the geometry modified in place, first clone() it and then use this function on the clone.*

If you extend both returned arrays in the console, you will see that the transformation to EPSG:2154 was already stored in the features, and by transforming again, we were able to get the EPSG:4326 original values.

For the rectangle box in the new layer, we choose another way to manipulate projections with vector. We choose to use an empty source within a new vector layer.

The goal was to show you that when you need to add features using the `addFeatures` method from the `ol.source.GeoJSON` vector source, you need to reproject features using an object `ol.format`. Here, we used `ol.format.GeoJSON`, but it could have been `ol.format.WKT`. As long as the type of format accepts `dataProjection` and `featureProjection` as options in the `readFeatures`, you can make reprojections.

The important part to keep in mind is the role of the `ol.format.GeoJSON` methods, `readFeatures` and `writeFeatures` and their options.

When you use `readFeatures`, you reproject from EPSG:4326 to EPSG:2154, and when you use `writeFeatures`, you reproject from EPSG:2154 to EPSG:4326.

At the code level, when you use `readFeatures`, you need to provide a string or a GeoJSON object with options and when you write them, it must be `Array.<ol.Feature>` with options. An excerpt from the document will help to understand those options (common to `readFeatures` and `writeFeatures`), as follows:

Name	Type	Description
<code>dataProjection</code>	<code>ol.proj.ProjectionLike</code> <code>undefined</code>	This is the projection of the data we are writing. If not provided, the <code>defaultDataProjection</code> value of the format is assigned (where it is set). If no <code>defaultDataProjection</code> is set for a format, the features will be returned in the <code>featureProjection</code> option.
<code>featureProjection</code>	<code>ol.proj.ProjectionLike</code>	This is the projection of the feature geometries that will be serialized by the format writer.

We also need to mention that for simplicity, we used `readFeatures` and `writeFeatures`, but for only one feature (when outside a GeoJSON `FeatureCollection`), you have to use the `readFeature` and `writeFeature` methods (note the singular in the methods' names). Refer to the complete API documentation for more at <http://openlayers.org/en/v3.0.0/apidoc/ol.format.GeoJSON.html>.

After this review, it's up to you to imagine how you can play with features from the source and also how to manage projections in other formats in various use cases, as we mainly focus for demonstration on GeoJSON.

Pop Quiz – projections

Q1. Give some reasons why you might want to use a projection other than `EPSG:3857`?

1. To have more precision.
2. To manage external WMS.
3. To manage national data.
4. To overlay OpenStreetMap tiles.

Q2. Which areas will not be best suited for displaying the `EPSG:3857` projection?

1. The North Pole.
2. The Equator.

Q3. You need to get your local country EPSG code, where do you need to go to be efficient?

1. <http://epsg.io>.
2. <http://bingmaps.com>.
3. <http://openstreetmap.org>.

Summary

In this chapter, we talked about projections. We covered what they are and the various different types of projections. Longitude, latitude, and other geographic concepts were also discussed. While we just scratched the surface of these pretty complex topics, you should have enough fundamental information to understand how to use projections.

We also talked about the `ol.proj.Projection` class and the namespace `ol.proj` associated for coordinates' manipulation, along with how to transform coordinates and use the **Proj4js** library. You'll often work with data in coordinate systems other than `EPSG:4326`, and knowing how to work with and transform data in other projections is important. Because Proj4js alone is not useful without OpenLayers 3, we also reviewed the different use cases for managing projections in a layer context, depending on the main layer type, for example, vector or raster. It can be useful to know reprojection in vector when you want to manage projections in the various `ol.format` classes we already discovered in *Chapter 5, Using Vector Layers*.

Now, after reviewing how projections work, it's time to review how interactions components work. Without even being aware, we already use them but never really highlighted them until now. When you pan the map for instance, you are already using interactions. Let's dive into the next chapter, *Interacting With Your Map*.

8

Interacting with Your Map

This chapter's goal is to review main interactions in OpenLayers 3. Interactions are components that manage relations between mouse or keyboard actions and the map. They do not rely on HTML elements like buttons.

What are the main interactions? It's the most asked function for end users, such as interactions with events on the map to retrieve map or layers information or to create new information with a drawing. You can, for example, click on a polygon representing a property and find out who owns the place and since when. All such information is called attributes. Along this chapter, we will see how to use main interaction-related components, in particular for querying, drawing, and modifying geographical features. Then, we will see the default interactions at both the functional and code levels. We will end by reviewing the remaining interactions.

In this chapter, we will cover:

- ◆ Understanding how you can make your own files for vector layers and hence to get information from your map
- ◆ Selecting features from the layers (requesting information from web services or data sources such as GeoJSON or KML)
- ◆ Discovering how to get information from the map using map features methods
- ◆ How to display content in a DOM element and also in a pop-up. How to use a pop-up with simple HTML content or using content coming from layers data
- ◆ Drawing and modifying features on the map using dedicated components

- ◆ Inspecting default interactions, implicit interactions, which we have been using since the beginning
- ◆ Reviewing the remaining interactions, in particular the ones that help in drawing rectangles and can be later used to execute any operation

Let's get started by reviewing the part related to conversion and selection of vector formats.

Selecting features with OpenLayers 3

Selection is mainly achieved through vector layers. So, a small introduction to data conversion can be useful.

Using, creating, and converting your own data

In this section, we want to introduce you to the creation of static data in a particular vector, which is required in most cases where there is a need to click on your map to get information.

Let's see how you can provide vector data to our OpenLayers 3 library. We will not explain again how to work with vectors here—just how to provide them.

If you remember, we told you in *Chapter 1, Getting Started with OpenLayers*, in the section *Anatomy of a web-mapping application*, that the OpenLayers 3 library can consume dynamic vector data or static. The main difference resides in the fact that data is dynamically provided on demand. At the end of it all, OpenLayers consumes the same formats.

As a reminder for vector layers, the main following formats are supported:

- ◆ **GeoJSON**: This is *an open standard format for encoding collections of simple geographical features along with their non-spatial attributes using JavaScript Object Notation* according to Wikipedia. It's also the most popular format nowadays for web mapping.
- ◆ **KML (KeyHole Markup Language)**: This is a standard XML-based format created by **Keyhole**, a company acquired by Google. Its popularity comes mainly from the default support of Google Maps and Google Earth.
- ◆ **GPX**: This is the most common format produced by GPS devices, and it's XML-based, too.
- ◆ **TopoJSON**: *It is an extension of GeoJSON that encodes topology*, as stated in Wikipedia. It enables you to get lighter files for lines and polygons.

- ◆ **WKT:** Wikipedia defines **WKT (Well-known text)** as *a text markup language for representing vector geometry objects*. It's one of the most common formats to encode geometry.
- ◆ **GML:** This is *the GML (Geography Markup Language) is the XML grammar defined by the Open Geospatial Consortium (OGC) to express geographical features*. It's the default format when using OGC Web Services for features (vector).

You can go further by reviewing the content from *Chapter 5, Using Vector Layers*, and inspecting all `ol.format.*` available following the API documentation at <http://openlayers.org/en/v3.0.0/apidoc/ol.format.html>. You should not forget some formats can be abstract classes for other formats.

We have chosen to focus only on GeoJSON and KML: they are the most used formats for static files. As long as your applications do not use large amount of data, it's one of the most practical solutions. But most of the time, we don't have data directly available in those formats: a large percentage of geographic data production and manipulation is done using desktop mapping software that does not use those formats as a primary storage solution.

To understand why, let's see a context where you start to make your own examples. In this case, you have three main choices to have data:

- ◆ Drawing your data with the dedicated drawing component
- ◆ Consuming external sources through third-party APIs as a service
- ◆ Consuming files directly or after data format conversion that the OpenLayers 3 library supports
- ◆ The first way requires time to get the data you want to produce. The second method is good for large datasets, but you might be limited by the selection of content in the data provided or by restrictive terms of service.
- ◆ The last way used to be restricted to local authorities or private companies. They were the only ones who could afford both data producing and software costs for GIS.



From a programmer's point of view, **GIS (Geographical Information System)** is software to manage geographical datasets and make maps. We really chose to restrict the definition to keep it simple. That's why we encourage you to learn further by starting with the GIS Wikipedia page http://en.wikipedia.org/wiki/Geographic_information_system and also try out searches through search engines on the topic.

GIS was first used for desktop applications. With the growth of the Web, the GIS world extended to the Internet. The main problems to fill the gap between desktop-oriented geographic data and web geographic data were:

- ◆ Availability of geographic data for non-specialists
- ◆ Data conversion to break the barrier between the two worlds; the first barrier was partly broken with the OpenData movement, defined by Wikipedia as *the idea that certain data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control*

The second is also partly broken with open data, but lots of open data datasets always use GIS Desktop formats like the shapefile. We will not explain this format but demonstrate by an example of how you can do some data conversion.



To find open data portals, the main entry for America is

<https://www.data.gov>.

For Europe, you should visit <http://publicdata.eu>.

For a worldwide overview, go at <http://datacatalogs.org>, a website for *A Comprehensive List of Open Data Catalogs from Around the World*.

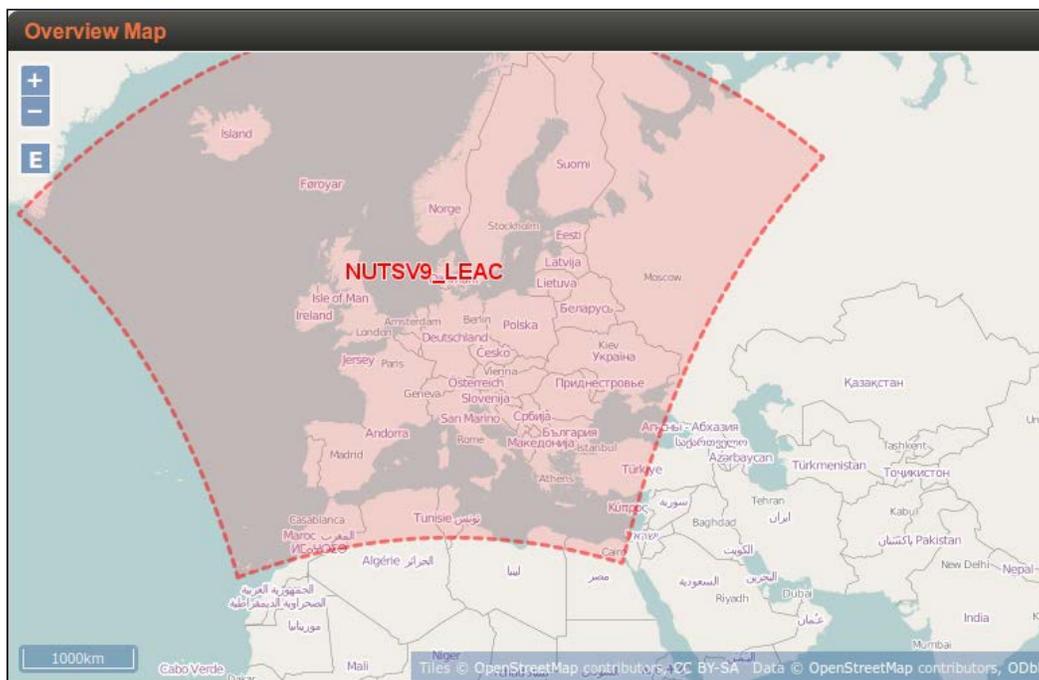
To grasp the state of OpenData in your country, you can visit the **Global Open Data Index** at <http://global.census.okfn.org>. It's a website maintained by the community to make surveys about each country's open data initiative. The focus is mainly about the type of open data datasets available.

Time for action – converting your local or national authorities data into web mapping formats

For illustration purposes, we will use data coming from the **Geographical Information System at the Commission (GISCO)**, a Eurostat (an European commission organism) service which promotes and stimulates the use of GIS within the European Statistical System and the Commission. We chose to use the **Nomenclature of Units for Territorial Statistics (NUTS)**, the main administrative units within Europe. Perform these steps to achieve the objective outlined in this paragraph:

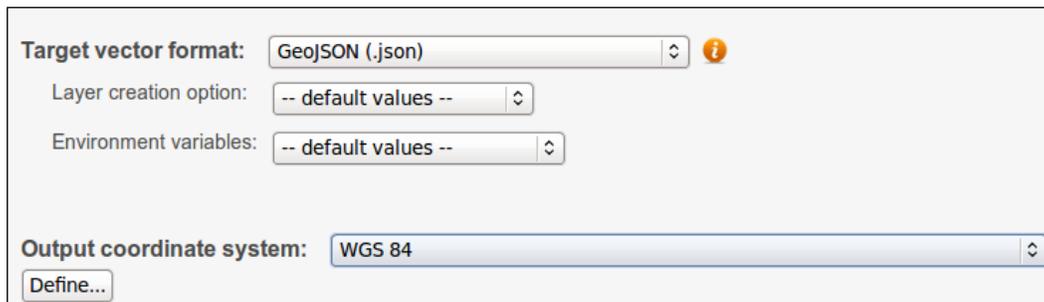
1. Go to the URL <http://www.eea.europa.eu/data-and-maps/data/administrative-land-accounting-units>, and click on **Download file** within the **GIS DATA** block.

- Go to <http://converter.mygeodata.eu>, a website to make online conversion of spatial data files, vector, and raster. On the left-hand side part, in the block **Upload your data files**, click on **Browse** to select the downloaded ZIP file. After that, click on the **Submit** button. The following screenshot is the result of these two steps:



- After this operation, you should see in the block **My GeoData** on the left-hand side part, below the previous block, a date of upload and the `shp` file name `NUTSV9_LEAC.shp`. You will also see in the page center an **Overview Map**.
- Scroll down to change **Target vector format:** to `GeoJSON` and **Output coordinate system:** to `WGS84`. It should be like the following image.
- Before clicking on the button **Convert now!**, continue to scroll down to inspect dataset information like the layer name, the input format, the geometry type (polygon, line, or point), the number of elements, the extension, the projection and its associated SRID (read again if you need to *Chapter 7, Wrapping Our Heads around Projections*) and the column names with their type.

- Now, click for real on the button **Convert now!**, wait to see a new page appear with a button **Download result**, and click on it. You will have to wait to see an ad before getting a ZIP file `mygeodata.json`. Here's how the screen will look upon performing these steps:



Target vector format: GeoJSON (.json) ⓘ

Layer creation option: -- default values --

Environment variables: -- default values --

Output coordinate system: WGS 84

Define...

- Unzip the file to get a GeoJSON file named `NUTSV9_LEAC.json`. Rename it now to `nutsv9_lea.geojson`. Our application will use it later.

What just happened?

We saw how we can use an external online website to have a first approach of geographical data conversion without installing specific software on your machine. You also saw that you only review a small part of the possibilities of the online tool to make conversion.

After this small conclusion, let's work more on the topic of data.

Have a go hero – find out more about GIS files

Remember that we introduced open data portals during the chapter and GIS files formats in particular in *Chapter 5, Using Vector Layers*. To revise and go a bit further, perform the following tasks:

- ◆ Find out your local and national open data portals, places dedicated to sharing open data and retrieve some GIS datasets
- ◆ From the first step, use the raw or converted GIS data to add it to a vector layer in your map example. It can be either GeoJSON or KML.
- ◆ Discover the documentation about shapefile, the most common GIS format. If you start to play more with cartography, you will have to know it.
- ◆ Try to discover web services such as **Web Feature Service (WFS)** instead of using a file; they serve content remotely. Use them instead of files, reusing your knowledge from *Chapter 5, Using Vector Layers*.

- ◆ Simplify the returned GeoJSON resulting from the previous conversion: it is too large. Use MapShaper for this (see the following tip to learn about this tool):



Data conversion tips

We chose to introduce you to an on-line application to make GIS data conversion. Imagine that you need to filter a large dataset and the upload size is big; you may need to use a local application for this. We advise you to do it with QGIS at <http://qgis.org>, an open source desktop software where you can view the geographical dataset itself in a GUI. If you prefer the command line, you'd better use **GDAL (Geospatial Data Abstraction Library)**, a tool to make GIS data conversion, available at <http://gdal.org>.

You should also visit the website <http://www.mapshaper.org>. Contrary to the reviewed use case, the goal of MapShaper is to simplify the data in order to get a lighter dataset, in particular to gain time when loading. Do not hesitate because most of the time, you don't need a high level of precision!

Diving into the OpenLayers 3 select component

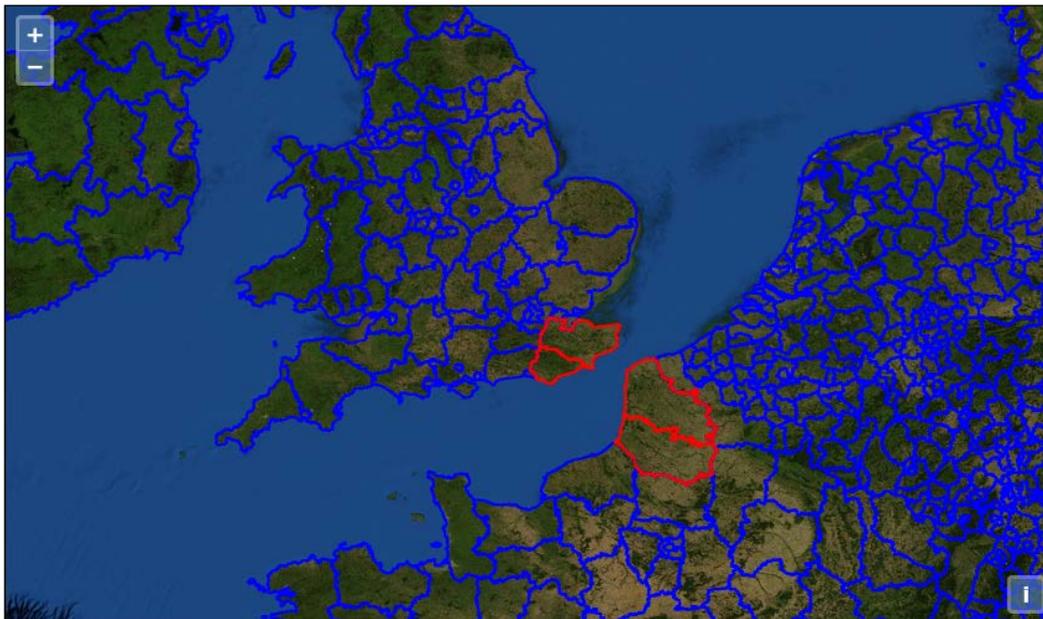
Until now, you only learned some useful skills to transform data. It was good way to reintroduce the vector layer topic. Now, let's review how you can start selecting some geographic objects on your map.

Time for action – testing the use cases for ol.interaction.Select

With this example, you will also be able to learn some useful things that you will learn more deeply in *Chapter 6, Styling Vector Layers*. Perform the following steps to do just that:

1. From the support files available with this book (<https://www.packtpub.com/web-development/openlayers-3-beginner's-guide>), download the file `2360_08_01_simple_select.html` and put it in the `sandbox` directory.
2. Create a data directory in the `assets` folder, and put the file `nutsv9_lea.geojson` there, or download it also from the support site.
3. Put the file into a webserver directory, or use the Python-included server with `python -m SimpleHTTPServer` because of Ajax's same-origin policy requirements.

4. Next, open your browser and navigate to the page hosted by your web server (for example, http://localhost:8000/2360_08_01_simple_select.html if you use the Python server) to click on the blue features. Use the *Shift* key, and select more than one feature to get a result that might look like the following screenshot:



What just happened?

Let's have a look at the code used in this task.

First, we declared the usual raster layer as the background with the following code:

```
var raster = new ol.layer.Tile({
  source: new ol.source.MapQuest({layer: 'sat'})
});
```

Then, we started to declare the style that is applied when we select one or more features. It's exactly like the usual styling.

Later, when selecting with the `ol.interaction.Select`, we will reuse this style. Here's how we declare the style:

```
var selectEuropa = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: '#ff0000',
    width: 2
  })
});
```

This part is dedicated to preparing styling for the vector layer when there is no selection; it's the blue stroke you see in the preceding screenshot:

```
var defaultEuropa = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: '#0000ff',
    width: 2
  })
});
```

Next, we started to declare the vector layer and its source `ol.source.GeoJSON`, where we mentioned the projection of the map and the GeoJSON file we produced in the previous part of the chapter. We lowered the GeoJSON file and renamed the extension `nutsv9_lea.geojson`. We added into the style property in `ol.layer.Vector` an `ol.style.Style` class that uses your previous `defaultEuropa`, as follows:

```
var vectorEuropa = new ol.layer.Vector({
  id: 'europa',
  source: new ol.source.GeoJSON({
    projection: 'EPSG:3857',
    url: '../assets/data/nutsv9_lea.geojson'
  }),
  style: defaultEuropa
});
```

We also needed to declare the interaction constructor to make the selection, or our style for selection will never work.

The way to do it is to instantiate it with:

```
var selectInteraction = new ol.interaction.Select({
  condition: ol.events.condition.singleClick,
  toggleCondition: ol.interaction.condition.shiftKeyOnly,
  layers: function (layer) {
    return layer.get('id') == 'europa';
  }
});
```

When you are in a complex map, you have more than one layer. Using the option `layers` is the way to say the click will only query information from layers that match the condition. You use a function to do this filtering. You can also use an array of layers, but it's less powerful. So, if you click in a place where a feature with layer `id` is `'europa'`, it will apply the right style. The `condition` variable is a static variable you can choose when you want to change behavior for `select`. By default, it's the single click that triggers the selection, but it can also be, for example, the `Alt` + click that can do it if you wish. It's also the same for `toggleCondition`. The purpose of this property is to set the condition when you want to toggle selection. In this case, we just use the default condition for learning purposes.

Then, we do the usual operations: declare the center, the view, and the map, then add to the map the layers, and set the view for the map, as follows:

```
var london = ol.proj.transform([-0.12755, 51.507222], 'EPSG:4326',
  'EPSG:3857');
var view = new ol.View({
  center: london,
  zoom: 6
});
var map = new ol.Map({
  target: 'map'
});
map.addLayer(raster);
map.addLayer(vectorEuropa);
map.setView(view);
```

At the end of it all, we finished by adding the `ol.interaction.Select` object, as follows:

```
map.getInteractions().extend([selectInteraction]);
```

An alternative syntax to get the same result can be done by adding it in the `interactions` property of the `ol.Map` constructor, as follows:

```
var map = new ol.Map({
  interactions: ol.interaction.defaults().extend([selectInteraction]),
  target: 'map'
});
```

After this first introduction, let's do another useful example to learn how to manage multi-selection or make a selection with points instead of polygons.

Time for action – more options with `ol.interaction.Select`

Now, let's reuse the previous example and discover more.

1. Start by copying `2360_08_01_simple_select.html` in a new file called `2360_08_02_select_options.html`.
2. After the `vectorEuropa` declaration, add the following JavaScript code to create the vector layer for points. A new dataset, a GeoJSON file `france_4326.geojson`, is available on the book's webpage:

```
var defaultFrancePoints = new ol.style.Style({
  image: new ol.style.Circle({
    fill: new ol.style.Fill({
      color: 'blue'
    }),
    stroke: new ol.style.Stroke({
      color: '#ffcc00'
    }),
    radius: 8
  })
});
var selectFrancePoints = new ol.style.Style({
  image: new ol.style.Circle({
    fill: new ol.style.Fill({
      color: '#ff0000'
    }),
    stroke: new ol.style.Stroke({
      color: '#ffccff'
    }),
    radius: 16
  })
});
var vectorFrancePoints = new ol.layer.Vector({
  id: 'france',
  source: new ol.source.GeoJSON({
    projection: 'EPSG:3857',
    url: '../assets/data/france_4326.geojson'
  }),
  style: defaultFrancePoints
});
```

3. Change a little bit the `selectInteraction` declaration, as follows:

```
var selectInteraction = new ol.interaction.Select({
  layers: function(layer) {
    return layer.get('selectable') == true;
  }
});
```

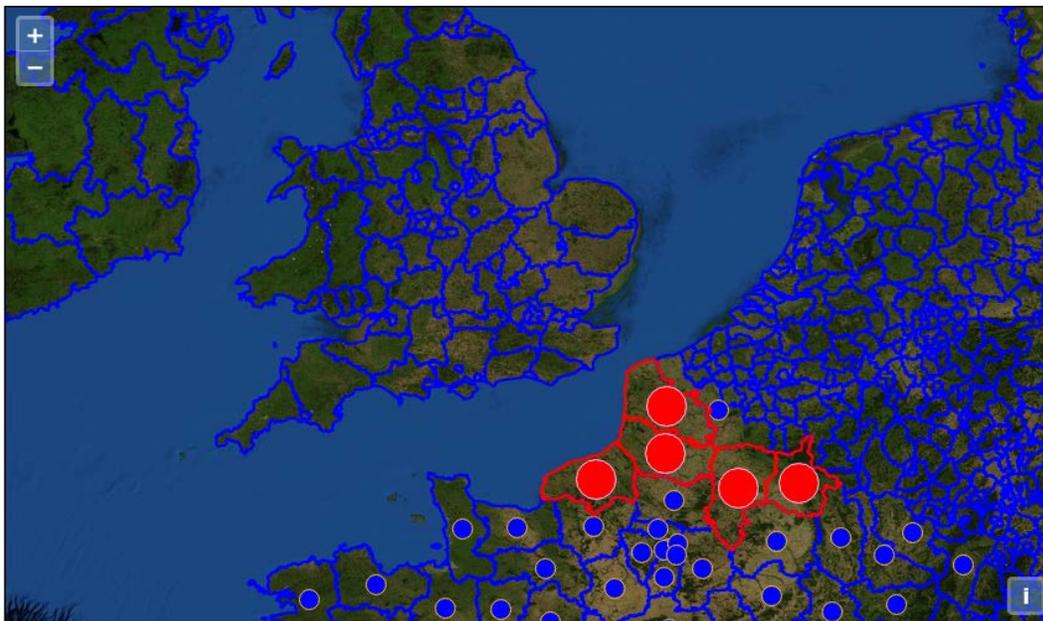
4. At the end of the preceding steps , after you added the `vectorEuropa`, add the new vector layer, as follows:

```
map.addLayer(vectorFrancePoints);
```

5. Then, set a property for both layers; arbitrarily, we use `selectable` to be more meaningful, as follows:

```
vectorEuropa.set('selectable', true);  
vectorFrancePoints.set('selectable', true);
```

6. Open your browser and play with the selection with the *Shift* key to make multi-selection over the different layers.
7. You should see a result like the following screenshot:



What just happened?

We will not review all the code, but focus only on important points.

In the new block that declares the `vectorFrancePoints` layer, we just reviewed the vector point styling. Using the `ol.style.Circle` component, we set in style with the key `image`.

We kept the logic of the styles in order to keep the behavior for the selection: rules as reminders are applied if conditions they contain are met, whereas the style in `ol.layer.Vector` is the default style for the vector layers.

In the `selectInteraction` declaration, we changed the property that helps match our layers. Previously, we were matching using `id` with the value `europa`, and now, we are matching if a property `selectable` is `true`. But, as we do not declare initially in the layers some properties, we set them by adding a `selectable` property to both layers.

Have a go hero – try to make your own example

After you've seen everything you have to know about the `ol.interaction.Select` component, it's time to try to go further to really acquire knowledge by yourself about this part of the library.

For this, reuse the previous example and improve it using the following instructions:

- ◆ Find a dataset using `linestrings`. It can be SHP, KML, or GeoJSON. If required, transform the format to be able to consume it with the OpenLayers 3 library.
- ◆ Add a third layer using the retrieved dataset.
- ◆ Find out what `styles` you have to use to style the `linestrings` layer.
- ◆ Instead of adding options hardcoded in the code, use `ol.dom.Input` to be able to play on selectability.

Until now, we have only focused on the `ol.interaction.Select` component. Its main goals are to be able to highlight information by making a symbolization change and get information from the geographic features, for example.

But how can you also return information from the layers on your map and show them? That what we will see in the next part.

Introducing methods to get information from your map

If you remember the description of layers, two main layers types are vector and raster. Some layers with specific `ol.source` accept methods to access geographic features in your map. The map queries each of the specified layers for this information, but not all layers support this. Only layers that support querying for geographic features will return results.

Without going deep into explanation, think that for the vector, you are querying the features near the point where you've done the click. Whereas for raster, you ask a remote resource to get a position on the image and extrapolate from this position the features of the image.

We will first review how to work with a vector source and then with raster sources. Do not worry if you don't already understand everything: we will review some concepts in the chapters dedicated to layers in particular.

So, we will see first how to get features from vectors, then explore how to do it from the method associated with raster, and try to discover where they differ.

Getting features information from your map vector layers

To understand the way they work, we will need to reuse some knowledge and code from our previous examples.

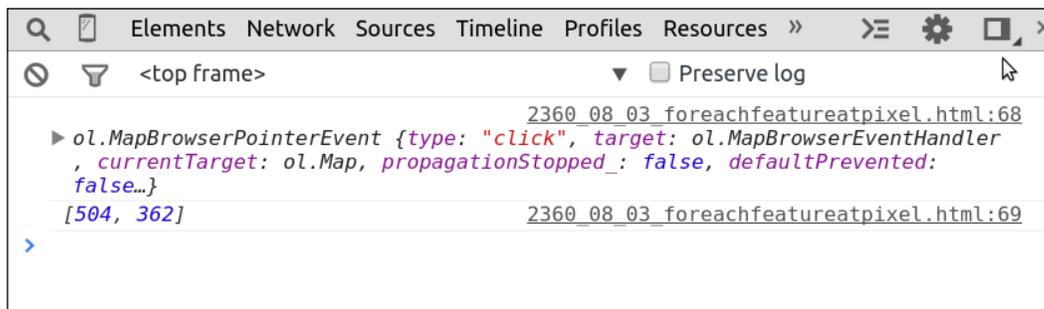
Time for action – understanding the `forEachFeatureAtPixel` method

Let's try with another example to discover more about the `forEachFeatureAtPixel` method. It should remind you about the last sample from *Chapter 5, Using Vector Layers*. To complete the task, check the following steps:

1. First, copy and paste the code from *Time for action – converting your local or national authorities data into web mapping formats*, that is, the file `2360_08_01_simple_select.html` in a new HTML file `2360_08_03_foreachfeatureatpixel.html`.
2. Then change the `ol.js` JavaScript file reference with `ol-debug.js`.
3. After that, add at the end of the JavaScript section of the new HTML file the following:

```
map.on('click' , function(evt) {  
    var pixel = evt.pixel;  
    console.log(evt);  
    console.log(pixel);});
```

4. Open your browser with the console, and click where you have blue features to get a result like the following screenshot:

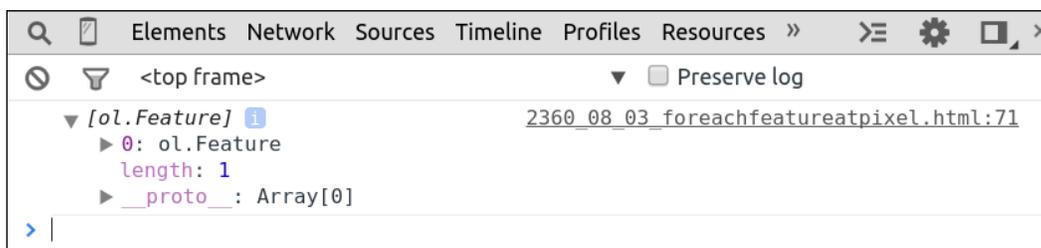


5. Next, remove both `console.log` statements, and add the following code just after the line `var pixel = evt.pixel; displayFeatureInfo(pixel);`.

6. Add the function `displayFeatureInfo` before the `map.on()` code:

```
var displayFeatureInfo = function(pixel) {
  var features = [];
  map.forEachFeatureAtPixel(pixel, function(feature, layer) {
    features.push(feature);
  });
  console.log(features);};
```

7. Again, open your browser and try to click not only on features, but also on the sea, where you don't have features to understand the behavior. Here's the resultant screenshot:



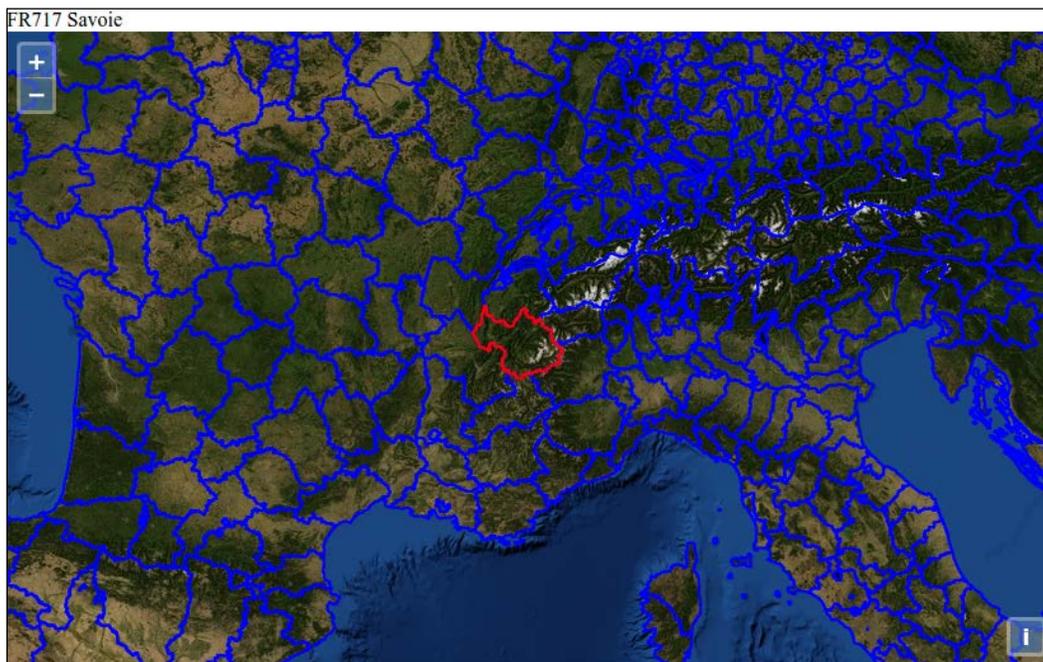
8. Replace `console.log` with this code:

```
var container = document.getElementById('information');
if (features.length > 0) {
  var info = [];
  for (var i = 0, ii = features.length; i < ii; ++i) {
    info.push(features[i].get('N3NM'));
  }
  container.innerHTML = info.join(', ') || '(unknown)';
} else {
  container.innerHTML = '&nbsp;';
}
```

9. Add just before the HTML div the class `map`, as follows:

```
<div id="information"></div>
```

- 10.** Now, for the last time, open or reload your example, and click on features on the map to see something like the following screenshot:



What just happened?

First, with `console.log`, we tried to see the event content and also get the pixel position with an array of `x, y`, where we click. Next, we made a call to the function that relies on a `map.forEachFeatureAtPixel` function. Its purpose is to get back every feature under the click using the pixel position from the event where we want to see the return you get from the callback in success property and also restrict the action on the `vectorEuropa` layer.

We also saw that the return contained the `ol.Feature` object, and because of this, we chose to play to try if the return was empty or not. As a click can send back more than one feature, we used a loop to push the features property `N3NM` information in an array. Depending on this, we have the choice to display or not the name of the NUTS region with the attribute `N3NM` in a DOM element in the screenshot **FR717 Savoie**.

After this review, we know how to retrieve and manipulate information from vector layers. You understand that the method `map.forEachFeatureAtPixel` within `displayFeatureInfo` sends back `ol.Feature`. You can manipulate to retrieve geometry or attributes from the layers you click on.

There is another way to retrieve information when clicking, and it's with the WMS `getFeatureInfoUrl` method. In which circumstances should we use it, and why does it exist?

The `getFeatureInfoUrl` method – an alternative way of getting information from a map

The title can be unclear if you don't already have some basics.

For this, we will start by reviewing the **Open Geospatial Consortium (OGC) Web Map Services (WMS)** standard.

Let's begin with the basics of WMS, and later, we will come back to the main topic.

Basics of the WMS standard

For this, we will reuse two excerpts from the Geoserver documentation (a server-side component that can work with the OpenLayers 3 library).

The first one summarizes what WMS is:

"The OGC Web Map Service (WMS) specification defines an HTTP interface for requesting georeferenced map images from a server."

The second one, a table, gives you the type of requests the WMS standard can perform:

Operation	Description
<code>DescriptionExceptions</code>	This is displayed when an exception occurs.
<code>GetCapabilities</code>	This retrieves metadata about the service, including supported operations and parameters and a list of the available layers.
<code>GetMap</code>	This retrieves a map image for a specified area and content.
<code>GetFeatureInfo</code> (optional)	This retrieves the underlying data, including geometry and attribute values, for a pixel location on a map.
<code>DescribeLayer</code> (optional)	This indicates the Web Feature Service (WFS) or Web Coverage Service (WCS) to retrieve additional information about the layer.
<code>GetLegendGraphic</code> (optional)	This retrieves a generated legend for a map.

In this list of possible operations, the most common operation is `GetMap`, an operation that send back an image to display in a client, JavaScript or desktop.

But you also see `GetFeatureInfo`, an optional operation for WMS.

Here, when you read, the point is that it's not the client side that manages returned features, but the server side. The purpose here is to have less load on the client side: managing a lot of features in the client side is mainly a pain, in particular if you use DOM.

The idea is to send the information to a server and retrieve the minimum and really light result. The result can be an HTML, a GML, raw text or depending on your server, also a GeoJSON. To illustrate, type into your browser the following URL:

```
http://demo.opengeo.org/geoserver/  
wms?SERVICE=WMS&VERSION=1.3.0&REQUEST=GetFeatureInfo&FORMAT=image/png  
&TRANSPARENT=true&WIDTH=256&HEIGHT=256&LAYERS=ne:ne&QUERY_LAYERS=ne:n  
e&STYLES=&CRS=EPSG:3857&BBOX=-10018754.171394622,5009377.085697312,-  
5009377.085697311,10018754.171394624&INFO_FORMAT=text/html&I=94&J=182
```

You will see an HTML table with information from the point where we clicked on:
INFO_FORMAT= text/html. It is the way to say we want an HTML format return.

As a conclusion, just retain at the moment that when you choose to use the OpenLayers
getFeatureInfoUrl method, you are supposed to use it with WMS layers.

Now, you have enough knowledge, let's go back to the main topic.

Using the getFeatureInfoUrl method to get information from your map

After, this quick review of WMS, let's try to work with another example using
getFeatureInfoUrl.

Time for action – understanding the getFeatureInfoUrl method

Let's start with a new example:

- 1.** To begin with, copy and paste the now usual HTML page 2360_08_01_simple_select.html to reuse it as a model in 2360_08_04_getgetfeatureinfofourl.html.
- 2.** Add just after the script referencing the ol.js file the HTML content that follows:
<script src="http://code.jquery.com/jquery-1.11.0.min.js"></script>
- 3.** Remove all the JavaScript block content between <script> </script>. Next, add the following code into the same block:

```
var wms_layer = new ol.layer.Tile({  
  source: new ol.source.TileWMS({  
    url: 'http://demo.opengeo.org/geoserver/wms',  
    params: {'LAYERS': 'ne:ne'}  
  })  
})
```

```
});

var view = new ol.View({
  center: [0, 0],
  zoom: 1
});

var map = new ol.Map({
  layers: [wms_layer],
  target: 'map',
  view: view
});

var viewProjection = view.getProjection();
var viewResolution = view.getResolution();

map.on('click', function(evt) {
  var container = document.getElementById('information');
  var url = wms_layer.getSource().getGetFeatureInfoUrl(
    evt.coordinate, viewResolution, viewProjection,
    {'INFO_FORMAT': 'text/javascript',
     'propertyName': 'formal_en'});
  if (url) {
    var parser = new ol.format.GeoJSON();
    $.ajax({
      url: url,
      dataType: 'jsonp',
      jsonpCallback: 'parseResponse'
    }).then(function(response) {
      var result = parser.readFeatures(response);
      if (result.length) {
        var info = [];
        for (var i = 0, ii = result.length; i < ii; ++i) {
          info.push(result[i].get('formal_en'));
        }
        container.innerHTML = info.join(', ');
      } else {
        container.innerHTML = '&nbsp;';
      }
    });
  }
});
```

4. Open your browser, and click wherever you want. You will see a result that looks like the following screenshot:



What just happened?

We started by creating a tiled WMS layer, a raster type layer. Next, we created the view and the map. Then we got parameters from the view required later in the code—the resolution and the projection—and we got the DOM element `information` reference where we will display our click result. The most important part happens in the declaration `map.on('click', function(evt) {`, means wherever you click in the map, the code within the block is executed.

In this block, we declared an `url` variable to call the WMS web service. Its result was provided by a function generated from a WMS source using also the coordinates of the click, the resolution, the projection, and the query parameters.

The coordinates were provided by the click. The query parameters defined the returned type expected from the web service. In this case, we wanted the JSONP return encapsulating GeoJSON (JSONP) using `'INFO_FORMAT': 'text/javascript'`. They also help to select only the properties we want from the web service (`'propertyName': 'formal_en'`).

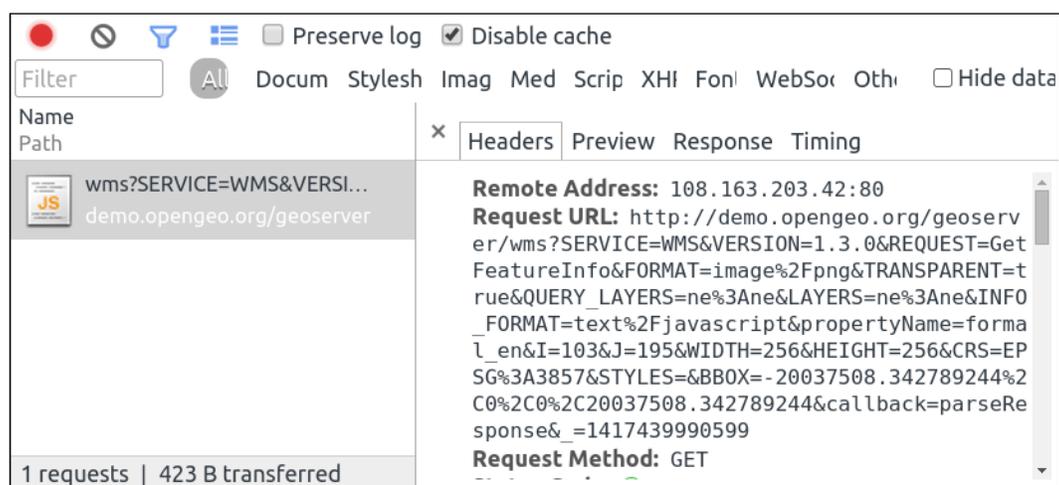
You can discover more by setting a breakpoint, and when clicking on the map, copying the URL string, and then, opening it in a new browser window to inspect.

Then, we declared an `ol.format.GeoJSON` object called `parser`, a component designed to understand the returned GeoJSON content from the Ajax call just after.

The Ajax call was done using a jQuery function `$.ajax({...}).then(function (response) {`, hence the jQuery script addition previously. The `url` parameter is not enough to manage JSONP. We need to custom the Ajax call to manage JSONP. JSONP allows remote calls to resources external to your website without encountering any issues with *Ajax same origin policy* (see the Wikipedia web page about the subject https://en.wikipedia.org/wiki/Same-origin_policy).

The code in the block reuses the received content and adds it as a JavaScript object in the result variable. This new object, an `array`, is manipulated to retrieve the text data **United States of America** and displays it in the `container` DOM element.

It's recommended also that you see in the network panel what happens every time you click on the map. The following screenshot is a depiction of the network panel:



The important thing here is you rely on a web service able to provide a raster map based on a standard, and you are also able to get remotely the features below the place where you click. The main advantage here is to have less coupling between your server code and your JavaScript code. However, on the other side, you can suffer from latency (time to receive the response from the URL call). Up until now, every piece of information returned was always displayed in a DOM element outside of the map. How can we display it on the top of the map as a pop-up?

That's what we will see in the next part mainly based on `ol.Overlay`, a component we already use in the *Chapter 2, Key Concepts in OpenLayers*.

Adding a pop-up on your map

To add a pop-up, you can rely exclusively on HTML and CSS, but the OpenLayers 3 library bundles a component to help you to display information in a pop-up.

You will find below the reference for this component called `ol.Overlay`. Only a light review will be done here because some examples will follow to illustrate.

The `ol.Overlay` reference

The object is instantiated with a constructor such as:

```
var yourOverlay = new ol.Overlay({
  element: document.getElementById('yourOverlayElement')
})
```

Because `ol.Overlay` inherits from `ol.Object`, we only describe here the methods related to the object itself.

Method	Parameters	Description
<code>getElement()</code>	None.	This gets the DOM element of the overlay.
<code>getMap()</code>	None.	This gets the map associated with the overlay.
<code>getOffset()</code>	None.	This gets the offset of the overlay.
<code>getPosition()</code>	None.	This gets the current position of the overlay in map projection.
<code>getPositioning()</code>	None.	This gets the current positioning of the overlay. It's the position of the overlay relative to the click.
<code>setElement(element)</code>	Need a DOM Element or undefined.	This sets the DOM element to be associated with the overlay.
<code>setOffset(offset)</code>	<code>Array.<number></code>	This sets the offset for the overlay. Offsets are in pixels used when positioning the overlay. The first element in the array is the horizontal offset. A positive value shifts the overlay to the right-hand side. The second element in the array is the vertical offset. A positive value shifts the overlay down. Default is <code>[0, 0]</code> .
<code>setPosition(position)</code>	Need an object <code>ol.Coordinate</code> or undefined.	This sets the position for the overlay in map projection.

Method	Parameters	Description
setPositioning (positioning)	ol.Overlay Positioning	This sets the positioning for the overlay, for example, how the overlay is positioned relative to its point on the map. Possible values are bottom-left, bottom-center, bottom-right, center-left, center-center, center-right, top-left, top-center or top-right.
setMap (map)	Need an object ol.Map or undefined.	This sets the map to be associated with the overlay.

You can check out the complete `ol.Overlay` API documentation at <http://openlayers.org/en/v3.0.0/apidoc/ol.Overlay.html>.

After this small component review, we will first see the simplest case for using `ol.Overlay` with a static example where the information is not coming from any query but only from a DOM element.

Time for action – introducing ol.Overlay with a static example

To illustrate the simplest use case for `ol.Overlay`, let's perform the following steps:

1. Copy the HTML model `2360_08_01_simple_select.html`, we always used in the chapter, in a new file `2360_08_05_simple_overlay.html`. You can also check the code at the Packt code book URL.
2. Add into `assets/css/samples.css` this code:

```
#popup {
  background: red;
}
```
3. In the HTML code, replace `<div id="map" class="map"></div>` with `<div id="map" class="map">`, as follows:

```
<div id="popup"><b>OpenLayers 3 Code Sprint</b> <i>Humanities A3</i></div>
</div>
```
4. Replace all the JavaScript part with the following code:

```
var popup = new ol.Overlay({
  element: document.getElementById('popup')
});

var osmLayer = new ol.layer.Tile({
```

Interacting with Your Map

```
    source: new ol.source.OSM()
  });

  var ol3_sprint_location = ol.proj.transform([-1.20472, 52.93646],
  'EPSG:4326', 'EPSG:3857');

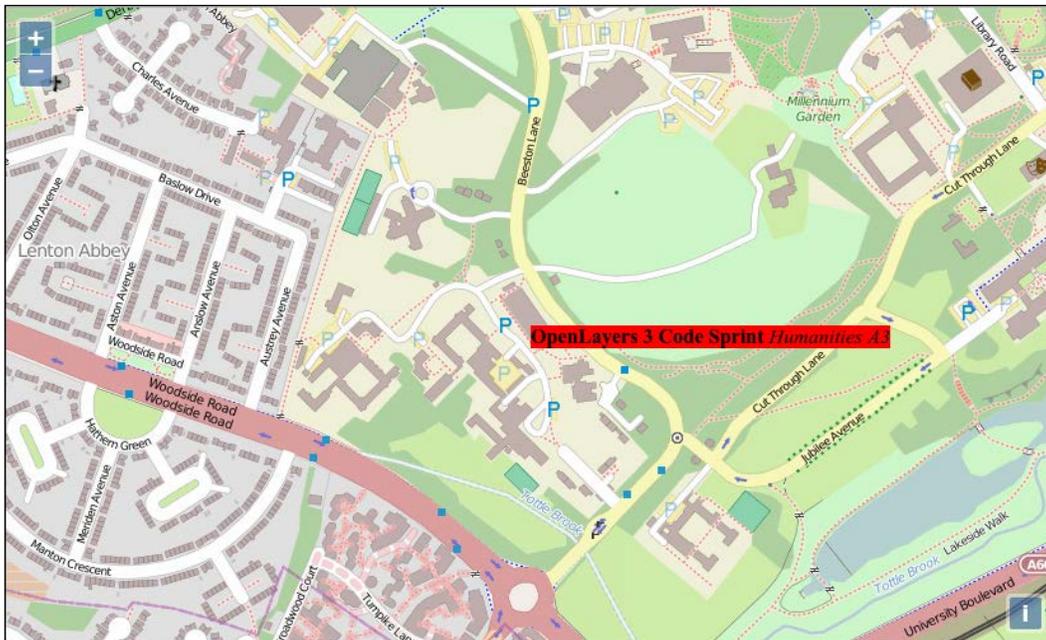
  var view = new ol.View({
    center: ol3_sprint_location,
    zoom: 16
  });

  var map = new ol.Map({
    target: 'map'
  });

  map.addLayer(osmLayer);
  map.setView(view);

  map.addOverlay(popup);
  popup.setPosition(ol3_sprint_location);
```

5. Open your browser and you will see this is how it looks:



What just happened?

Let's review the code to understand the way `ol.Overlay` works.

First, we defined a new `ol.Overlay` with the following:

```
var popup = new ol.Overlay({
  element: document.getElementById('popup')
});
```

The `element` property in the object literal option of the constructor has to reference an HTML element.

Here, we reference the HTML text `OpenLayers 3 Code Sprint<i>Humanities A3</i>` located in a `<div>` tag with an `id` value of `popup`.

Next, we performed the usual steps, such as creating layers, creating map, adding the layers, and setting the view, as follows:

```
var osmLayer = new ol.layer.Tile({
  ...
  ...
  map.setView(view);
```

Just after this block, we added the `ol.Overlay` object to the map in order to declare that we are using an overlay:

```
map.addOverlay(popup);
```

Instead of adding overlays after the preceding map, you can also use the option in the `ol.Map` constructor, as shown in the following sample:

```
var map = new ol.Map({
  target: 'map',
  overlays: [popup]
});
```

The following line was to set the position of the DOM element by matching coordinates and image position:

```
popup.setPosition(ol3_sprint_location);
```

The name overlay implies also that there is something at the top of something else. To understand, just see the screenshot of the Chrome Developers Tools **Elements** panel, as follows:

```
<!DOCTYPE html>
<html>
  #shadow-root
  <script>...</script>
  <head>...</head>
  <body>
    <div id="map" class="map">
      <div class="ol-viewport" style="position: relative; overflow: hidden;
width: 100%; height: 100%;">
        <canvas class="ol-unselectable" width="808" height="500" style=
"width: 100%; height: 100%;">
          <div class="ol-overlaycontainer"></div>
          <div class="ol-overlaycontainer-stopevent">
            <div style="position: absolute; left: 404px; top: 250px;">
              <div id="popup">
                <b>OpenLayers 3 Code Sprint</b>
                <i>Humanities A3</i>
            </div>
          </div>
        </div>
      </div>
    </div>
  </body>
</html>
```

As you see, the pop-up is included in a `div` tag, also contained in a `div` tag with class `ol-overlaycontainer` situated after the `canvas` element (where the map is drawn).

Now, let's assemble our knowledge with overlay and map feature methods.

Combining `ol.Overlay` with `ol.Map` features methods

The goal is simple: we are able to display content at the top of the map image but without getting information from the map itself. Let's discover how we can achieve this by again using an example.

Time for action – using `ol.Overlay` dynamically with layers information

In this case, we will reuse just the previous example as a model.

1. So, copy the previous example's code in a new HTML page named `2360_08_06_layer_overlay.html`.
2. Remove the string `OpenLayers 3 Code Sprint <i>Humanities A3</i>` from the HTML.
3. Then, just after the `osmLayer` declaration, add the following code, where we are reusing again the `vectorEuropa` layer with the styles:

```
var selectEuropa = new ol.style.Style({
  stroke: new ol.style.Stroke({
```

```

        color: '#ff0000',
        width: 2
    })
  });

var defaultEuropa = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: '#0000ff',
    width: 2
  })
});

var vectorEuropa = new ol.layer.Vector({
  id: 'europa',
  source: new ol.source.GeoJSON({
    projection: 'EPSG:3857',
    url: '../assets/data/nutsv9_lea.geojson'
  }),
  style: defaultEuropa
});

```

- 4.** Add an `ol.interaction.Select` component, as shown in the following code.

```

var selectInteraction = new ol.interaction.Select({
  layers: function (layer) {
    return layer.get('id') == 'europa';
  }
});

```

- 5.** After `map.addLayer(osmLayer);`, add to the map the following new layer:
`map.addLayer(vectorEuropa);`

- 6.** At the end of the JavaScript block, just after `map.addOverlay(popup);`, add the code that follows:

```

function pickRandomProperty() {
  var prefix = ['bottom', 'center', 'top'];
  var randPrefix = prefix[Math.floor(Math.random() * prefix.
length)];
  var suffix = ['left', 'center', 'right'];
  var randSuffix = suffix[Math.floor(Math.random() * suffix.
length)];
  return randPrefix + '-' + randSuffix;
}

var container = document.getElementById('popup');
var displayFeatureInfo = function(pixel, coordinate) {
  var features = [];

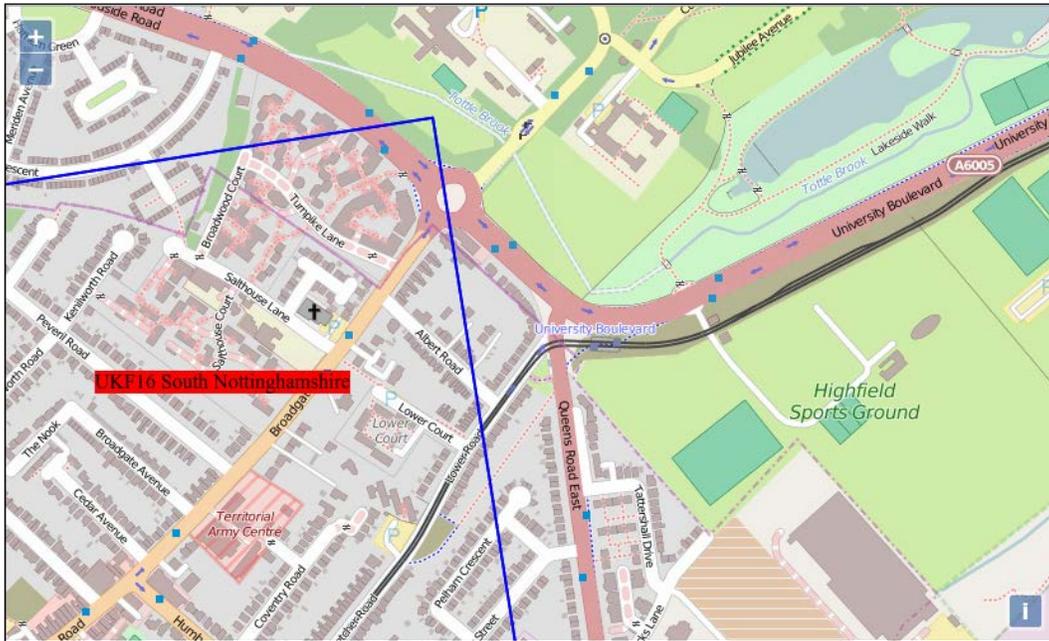
```

Interacting with Your Map

```
map.forEachFeatureAtPixel(pixel, function(feature, layer) {
    features.push(feature);
});
if (features.length > 0) {
    var info = [];
    for (var i = 0, ii = features.length; i < ii; ++i) {
        info.push(features[i].get('N3NM'));
    }
    container.innerHTML = info.join(', ') || '(unknown)';
    var randomPositioning = pickRandomProperty();
    popup.setPositioning(randomPositioning);
    popup.setPosition(coordinate);
} else {
    container.innerHTML = '&nbsp;';
}
};

map.on('click', function(evt) {
    var coordinate = evt.coordinate;
    displayFeatureInfo(evt.pixel, coordinate);
});
```

7. Now, open your browser, pan, and click, and you will see a result like the following screenshot:



What just happened?

First, we added to the previous example the vector `EuropaLayer` in order to have areas easier to click on. It's because areas cover the entire map contrary to points where you need accurate clicking.

Next, we declared a function `pickRandomProperty` in order to generate a random string, fitting positioning parameters expected by the `ol.Overlay` component for a small demonstration purpose.

Then, we declared a modified `displayFeatureInfo` function reusing most of the code from `2360_08_03_foreachfeatureatpixel.html`, where we set the positioning and the position. The position requires coordinates, so we added a second argument to `displayFeatureInfo`.

For positioning, we chose to display the content by changing the pop-up position randomly. This position is relative to the click event; to get this result, we reused the function `pickRandomProperty`, as follows:

```
var randomPositioning = pickRandomProperty();
popup.setPositioning(randomPositioning);
```

We also used the setter on the pop-up element in order to change its position according to the retrieved click coordinates, as follows:

```
popup.setPosition(coordinate);
```

We finished with the now quite usual block to add a click event to the map `map.on('click', function(evt),` but we retrieved the coordinates also and not only the pixel position to reuse the function `displayFeatureInfo`.

Now, you will learn to make dynamic use of `ol.Overlay`. You are also able to put a pop-up on your map using your geographic features.

You can try by yourself some experiments by following instructions given in the next section.

Have a go hero – customizing your pop-up

In order to go further, we advise you to do some exercises with `ol.Overlay`.

Your new assignment can be the following:

- ◆ Style the pop-up better, and try to add a tiny cross in particular to be able to close the pop-up. You should use the debugger for the styling part.

- ◆ Use the JavaScript `setTimeout()` function to stop displaying the pop-up after some time. You can see a reference about `setTimeout` at <https://developer.mozilla.org/en-US/docs/Web/API/WindowTimers.setTimeout>. A short article at <http://davidwalsh.name/javascript-debounce-function> will also help you to understand why it can be useful.
- ◆ Review the official vector examples to find some examples relying on an external library such as Bootstrap.

Creating or updating content on your map

Interactions can happen not only with selecting and displaying information from your map. It's also possible, for example, to create new features by drawing points, lines, or polygons. You can also update features. We will mainly focus on geometric representations because the built-in functionalities in OpenLayers 3 are mainly dedicated for this.

Drawing features on map

Let's start with the drawing component.

Time for action – using ol.interaction.Draw to share new information on the Web

To be able to do a basic save, we have developed a server-side script based on **Node.js**, a software platform for scalable server-side and networking applications. For the client side, the code will be more classical.

1. Install Node and NPM, an executable to manage Node.js library dependencies if you don't already have it, using <https://github.com/joyent/node/wiki/installation#installing-without-building>.
2. Next, retrieve the `index.js` and `package.json` files from the code from `upcoming_url` and put them in the `ol3_samples` directory.
3. Install the dependencies from the command line firing from the `ol3_samples` folder path, as follows:

```
npm install
```

4. Download also the file `features.geojson` into `ol3_samples/assets/data/`.
5. Try if the server side works by firing the `node index.js` and opening <http://localhost:3000/features.geojson>. You should see something like the following:

```
{type: "FeatureCollection", features: [ ]}
```

6. Create a new file `2360_08_07_create_new_content.html` in the usual sandbox folder by copying `2360_08_01_simple_select.html`.
7. Empty the HTML body to replace the HTML content to create a `<div>` tag for the map and a form to enable you to choose future drawing types (point, line string, and polygon) with the following code:

```
<div id="map" class="map">
</div>
<form class="form-inline">
  <label>Geometry type &nbsp;  </label>
  <select id="type">
    <option value="Point">Point</option>
    <option value="LineString">LineString</option>
    <option value="Polygon">Polygon</option>
  </select>
</form>
<script src="../assets/ol3/ol.js"></script>
<script src="http://code.jquery.com/jquery-1.11.0.min.js"></script>
```

8. Start `<script>` without forgetting to close it at the end, and copy the following code into it:

```
var raster = new ol.layer.Tile({
  source: new ol.source.MapQuest({layer: 'sat'})
});

var source = new ol.source.GeoJSON({
  url: '/features.geojson'
});

var vector = new ol.layer.Vector({
  id: 'vector',
  source: source,
  style: new ol.style.Style({
    fill: new ol.style.Fill({
      color: 'rgba(255, 255, 255, 0.2)'
    }),
    stroke: new ol.style.Stroke({
      color: '#ffcc33',
      width: 2
    }),
    image: new ol.style.Circle({
      radius: 7,
      fill: new ol.style.Fill({
```

```
        color: '#ffcc33'
      })
    })
  })
});

var map = new ol.Map({
  layers: [raster, vector],
  target: 'map',
  view: new ol.View({
    center: [-11000000, 4600000],
    zoom: 4
  })
});
```

- 9.** You can already open your browser at http://localhost:3000/sandbox/2360_08_07_create_new_content.html to see the definitive sample look.

- 10.** After the previous added code, add the following content:

```
var typeSelect = document.getElementById('type');
function addInteraction() {
  draw = new ol.interaction.Draw({
    source: source,
    type: typeSelect.value
  });
  map.addInteraction(draw);
}

typeSelect.onchange = function(e) {
  map.removeInteraction(draw);
  addInteraction();
};

addInteraction();
```

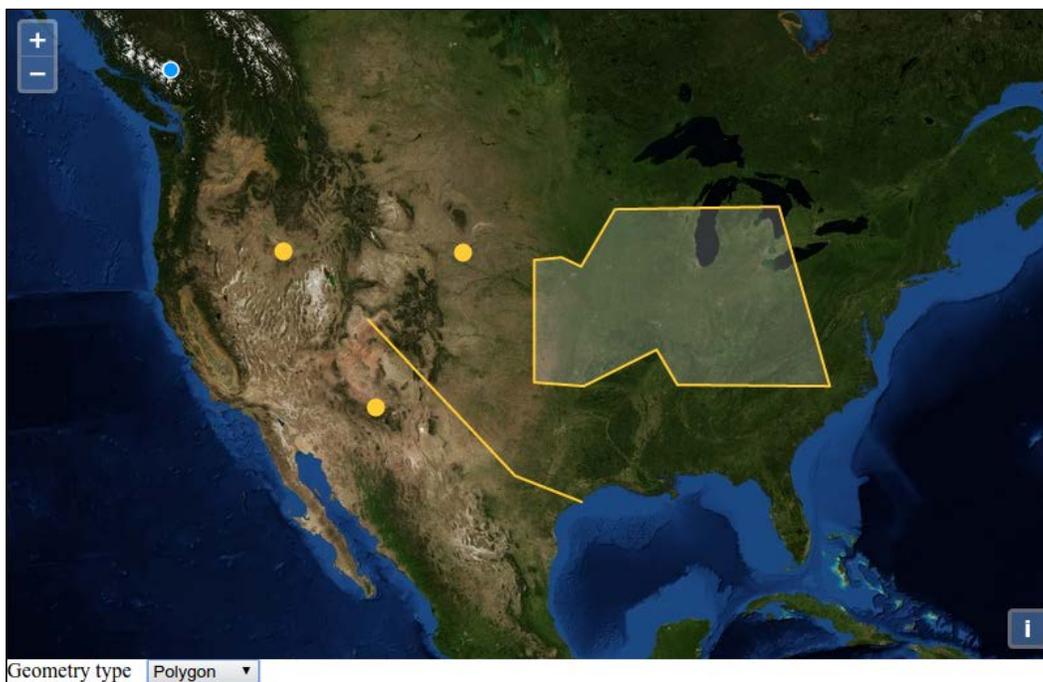
- 11.** Reload the sample, choose the type you want to draw, and click on the map to try out `componentReload` on the page to see that you can draw but there is no persistency.

- 12.** At the end of the `addInteraction` function, copy the following code:

```
draw.on('drawend',
function(evt) {
  console.log(evt.feature);
  var parser = new ol.format.GeoJSON();
```

```
var features = source.getFeatures();
var featuresGeoJSON = parser.writeFeatures(features);
$.ajax({
  url: '/features.geojson',
  type: 'POST',
  data: featuresGeoJSON
}).then(function(response) {
  console.log(response);
});
},
this);
```

13. Reload the sample, and try to draw and reload to see persistency working:



What just happened?

We created a map that uses a drawing component.

Each time you choose a Geometry type, it removes the `ol.interaction.Draw` component and adds again a new one using the code in `typeSelect.onChange`.

In the called function, the key feature is the `drawend` event bound to the `draw` component. Each time the user finishes drawing, it fires an event that send a feature.

In our case, we chose to get features from the source as GeoJSON using `ol.format.GeoJSON` and send them via an Ajax post call.

Depending on your backend, or for client storage, you can change what you want to send. The sample sends all features using a GeoJSON format, but you can customize the URL call, change the format to let's say GML, or only send the added feature and not all the features.

For this last case, you can see the log returned from `console.log(evt.feature)` ;

Modifying features on the map

After feature creation, another requirement is to make modification on geometries to existing content.

Time for action – using `ol.interaction.Modify` to update drawing

The assignment will be quite simple because the component at the time of writing needs some refining. It's possible to edit content but there are no events to catch at the end of modification: we will be unable to save the modified features. We will cover the client as is.

- 1.** Copy the first sample `2360_08_01_simple_select.html` as `2360_08_08_modify.html`.
- 2.** Before `var london`, add the following code:

```
var modify = new ol.interaction.Modify({
  features: selectInteraction.getFeatures()
});
```
- 3.** Replace `map.getInteractions().extend([selectInteraction])` ; with the following code:

```
map.getInteractions().extend([selectInteraction, modify]);
```
- 4.** Add the following code to manage features change:

```
var selected_features = selectInteraction.getFeatures();
selected_features.on('add', function(event) {
  var feature = event.element;
  feature.on('change', function(event) {
    event.target.getGeometry().getCoordinates();
  });
});
```

5. Open the new sample, select a feature, hover over some features, and click and drag to see the behavior, which is as follows:



What just happened?

We saw in this sample how to use `ol.interaction.Modify` here using the `modify` component. We also saw that it requires `ol.interaction.Select`. To be able to listen to change, there is no available method on `ol.interaction.Modify` to directly know the modification to the features. You have to listen to changes on features with `selected_features.on('add', function(event) {`.

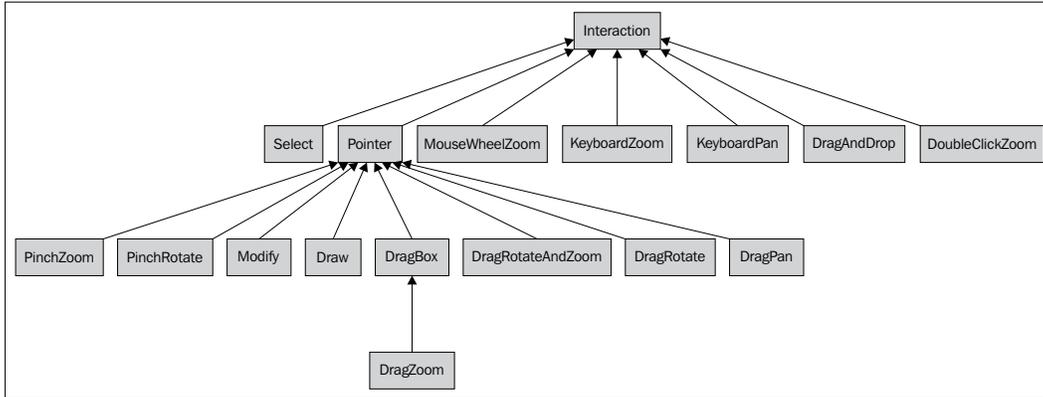
To make this behavior really more obvious, we also used a `console.log` statement, so when using the browser console debugger, you are able to follow the call when a feature is modified.

After reviewing, drawing, and modifying features, it's time to deepen our interactions knowledge: preferring a practical approach, we only scratched the surface (their definitions) until now.

Understanding interactions and their architecture

Until now, we never inspected relations between interactions. So, it's time to examine `ol.interaction.*` classes. All the classes inherit from `ol.interaction.Interaction`, but compared to controls, it's less simple; you also have subclasses.

See the following diagram to grasp the relationships between the different interaction classes:



An inspection of the above schema shows that every `ol.interaction` component inherits from `ol.interaction.Interaction`. In some cases, when an interaction uses a mouse, pen, or touchscreen, it will need to inherit from `ol.interaction.Pointer`, which deals with this use case.

You can also note with the schema that interactions are tied to touch events for mobile, mouse events like click or drag, mouse events with the mouse wheel, and the keyboard. You can combine them depending on the expected behaviors. Luckily, by default, you can deal with them with ease. Let's see how. After this, we will explore different ways to make more customizations.

The short story of interactions

Most of the time, you don't really need to deal with interaction behaviors, but sometimes knowing how to manage them is a requirement.

You have two choices for simple cases:

- ◆ To consider that you don't need interactions at all on the map. You are using the OpenLayers 3 library's abilities just to access particular information, but you don't want people interact with the map. In this case, you just have to do in a map something like the following:

```
var map = new ol.Map({
```

```

...
controls: [],
interactions: [],
...
});

```

Consider that you need most default behaviors, but you don't need all of them. In this case, you will have to use the `ol.interaction.defaults` function.

- ◆ Let's jump to this second topic.

Inspecting the `ol.interaction.defaults` function

As mentioned previously, the best and simplest way to handle interactions is by reusing the `ol.interaction.defaults` function, as follows.

Let's review the properties you can set in the options:

Name	Type	Description
<code>altShiftDragRotate</code>	<code>boolean undefined</code>	This enables /disables <code>ol.interaction.DragRotate</code> . The default value is set to <code>true</code> .
<code>doubleClickZoom</code>	<code>boolean undefined</code>	This enables /disables <code>ol.interaction.DoubleClickZoom</code> . The default value is set to <code>true</code> .
<code>keyboard</code>	<code>boolean undefined</code>	This enables /disables <code>ol.interaction.KeyboardZoom</code> and the <code>ol.interaction.KeyboardPan</code> . The default value is set to <code>true</code> .
<code>mouseWheelZoom</code>	<code>boolean undefined</code>	This enables /disables <code>ol.interaction.MouseWheelZoom</code> . The default value is set to <code>true</code> .
<code>shiftDragZoom</code>	<code>boolean undefined</code>	This enables /disables <code>ol.interaction.DragZoom</code> . The default value is set to <code>true</code> .
<code>dragPan</code>	<code>boolean undefined</code>	This enables /disables <code>ol.interaction.DragPan</code> . Default is value is set to <code>true</code> .
<code>pinchRotate</code>	<code>boolean undefined</code>	This enables /disables <code>ol.interaction.PinchRotate</code> . The default value is set to <code>true</code> .
<code>pinchZoom</code>	<code>boolean undefined</code>	This enables /disables <code>ol.interaction.PinchZoom</code> . The default value is set to <code>true</code> .

Name	Type	Description
zoomDelta	number undefined	This is the delta. It has the same meaning as the one in <code>ol.interaction.Zoom</code> . This applies to both <code>ol.interaction.KeyboardZoom</code> and <code>ol.interaction.DoubleClickZoom</code> behaviors if interactions are activated.
zoomDuration	number undefined	This is the zoom duration in milliseconds. This applies to the <code>ol.interaction.DoubleClickZoom</code> , <code>ol.interaction.KeyboardZoom</code> , <code>ol.interaction.PinchZoom</code> , and <code>ol.interaction.MouseWheelZoom</code> behaviours if interactions are activated.

Time for action – configuring default interactions

Let's deactivate zoom and pan with the keyboard and also the rotate when doing *Alt + Shift* + mouse drag.

For this, do the following:

1. Copy the usual HTML file.
2. Add in the block `<div id="map" class="map"></div>` the attribute `tabIndex` with a value `0` to make it focusable.
3. Change the `keyboard` option to `false` in the `interactions` property of the `ol.Map` object.
4. Do all this with the `altShiftDragRotate` option. Try different actions with the *left*, *right*, *up*, and *down* arrows or with the *plus* and *minus* keys.
5. Do all this by trying to use *Alt + Shift* + mouse drag.

What just happened?

Here you just saw an example to deactivate some default behaviors.

By changing keyboard options to `false`, we make the application unable to respond to keyboard interaction with pan and zoom.

After reviewing the `ol.interaction.defaults` function itself, you also learn that each map already embedded nine `ol.interaction` by default, and for keyboard, the switch works for all keyboard interactions.

A functional view for the nine default interactions

Let's see exactly what each of those interactions does at the functional level more than at the code level. We already introduced them in *Chapter 2, Key Concepts in OpenLayers*, so you should not be lost.

- ◆ `ol.interaction.DoubleClickZoom`: This interaction allows users to zoom by double-clicking. You can set the duration to change animation time and delta when you want to change the zoom delta.
- ◆ `ol.interaction.DragPan`: It allows to you to pan by dragging the map. You can set panning behavior by setting the kinetic property.
- ◆ `ol.interaction.DragRotate`: This interaction makes the map rotate when you combine both the *Alt* and *Shift* keys together to rotate the map image. You can change it by changing the condition property.
- ◆ `ol.interaction.DragZoom`: It enables you to draw a temporary rectangle when pressing the *Shift* key with the keyboard. Then, this rectangle is used to zoom on the selected region of the rectangle. You can change the condition for the behavior with a condition, but you can also choose a style when drawing. The most interesting part in this component, other than its behavior, is that it inherits from `ol.interaction.DragBox`. It means that we will be able to reuse the drawing rectangle behavior for other purposes and not only for zooming like here. Later in the chapter, we shall see how.
- ◆ `ol.interaction.PinchRotate`: On mobile devices, one of the main interactions is the pinch. In the OpenLayers 3 library's case, it is supported by default. The name itself is enough to understand that this component has a behavior similar to `DragZoom`, but when pinching. You can set the `threshold` property if your application requires to change sensitivity for rotating the map.
- ◆ `ol.interaction.PinchZoom`: As the previous component, it relies on the pinch but in order to zoom. It's like when you are browsing on mobile, but instead of getting only a lens effect, you really make a zoom in your map. You change the animation duration, setting the same duration property in the component.
- ◆ `ol.interaction.KeyboardPan`: Its role is to manage map browsing using only the keyboard. It needs to make the map focusable by adding a `tabIndex` attribute at your map `div` level. To get the focus for the map, you need to use the `tab` key. Then, panning can be controlled using the *up*, *down*, *left*, and *right* keys. The option `pixelDelta` enables you to set the translation in pixels when pushing on the keys. By default, it value is 128 pixels. It is also possible to set the now usual `condition` property.



An alternative way to make the map reactive to keyboard interaction without giving to the map the focus is to set the `ol.Map` property `keyboardEventTarget` to `document`.

- ◆ `ol.interaction.KeyboardZoom`: Its goal is similar to the previous component except that it applies when you use the keys *plus* and *minus* instead. This interaction can be set just as for `DoubleClickZoom` with the `delta` property and also the `condition` too.
- ◆ `ol.interaction.MouseWheelZoom`: As its name implies, this interaction is related to the use of the mouse wheel to zoom in or zoom out. The only custom behavior you can set for this interaction is the `duration` of the animation by default to 250 milliseconds.

After this more verbose part, it's time to see the missing interactions.

Discovering the other interactions

We will first look at `ol.interaction.DragRotateAndZoom`, and then we will move on to the others.

These other interactions were sometimes used along the book chapters, but we did not always explain them completely; it was impossible with all the other concepts that required explanation at the time.

`ol.interaction.DragRotateAndZoom`

This interaction does both actions together: rotate and zoom. By default, you need to use the *Shift* key when you drag to use it. Let's review it with an example.

Time for action – using `ol.interaction.DragRotateAndZoom`

Let's follow the component's self-explaining name to try out its behaviour :

1. First, duplicate the code from the previous `ol.interaction.defaults` sample.
2. Then, make changes in the `interactions` block in the `ol.Map` object as follows:

```
var map = new ol.Map({
  ...
  interactions: ol.interaction.defaults({
    shiftDragZoom: false
  }).extend([new ol.interaction.DragRotateAndZoom()]),
  ...
});
```
3. Finally, open your browser and drag while maintaining the keyboard on the *Shift* key.

What just happened?

First, as it can conflict with `ol.interaction.DragRotateAndZoom`, we deactivated the `shiftDragZoom` interaction by setting it to `false`. We chose this option, but it was also possible to change the key to activate the function using the `condition` property.

You also saw the now-common pattern to add interactions to existing default interaction using an array within the `extend` block. Practically, you also learned how to use the `behavior`.

Now, let's jump to the next interaction.

`ol.interaction.DragAndDrop`

This interaction, according to the official documentation API, is for handling input of vector data by drag and drop. We already saw an example of using this in *Chapter 5, Using Vector Layers*.

The only additional thing that you can add is that when you drop the file after dragging it, when the event is triggered, you can get not only the features or their projection (experimental), but you can also get the filename. It can be useful, for example, to give a name to the layer, imagining we use the component together with a layer tree.

How did we deduce that it was also possible to retrieve this information? We did this simply by inspecting the API at <http://openlayers.org/en/v3.0.0/apidoc/ol.interaction.DragAndDrop.html>. It mentions the function signature when an event is fired, as follows:

```
addfeatures(ol.interaction.DragAndDropEvent) .You can see that
ol.interaction.DragAndDropEvent is involved. If you inspect its API definition, you
will see and not be really surprised to discover members are features, files, and projections.
```

Just as a quick reminder, here are the `DragAndDrop` options (experimental):

Name	Type	Description
<code>formatConstructors</code>	<code>Array.<function(new:ol.format.Feature)> undefined</code>	These are the format constructors.
<code>reprojectTo</code>	<code>ol.proj.ProjectionLike</code>	This is the target projection. By default, the map's view's projection is used.

Now, let's continue with another interaction implying always a drag-related event.

ol.interaction.DragBox

The official documentation describes this interaction as:

"Allowing the user to zoom the map by clicking and dragging on the map, normally combined with an `ol.events.condition` that limits it to when the Shift key is held down."

When reviewing `ol.interaction.DragBox` and seeing that it's the base class for `ol.interaction.DragZoom`, we already give you some hints for other use cases based on the same logic. It can be to select features based on a rectangular selection, to draw a rectangle, or to use it as a bounding box to generate and draw other shapes, such as ellipsoids and circles.

Let's look at how you can, for example, get the drawn rectangle as a GeoJSON string, where you've done a selection. Here, we suppose you are working on your desktop as mouse interaction is not available with mobile devices.

Time for action – making rectangle export to GeoJSON with `ol.interaction.DragBox`

After introducing the goal, we should do the following:

1. Reuse the usual sample for the chapter that include the `osm_default` and `map` variables.
2. Between the two variables, declare `ol.interaction.DragBox`, as follows:

```
var dragBoxInteraction = new ol.interaction.DragBox({
  condition: ol.events.condition.shiftKeyOnly,
  style: new ol.style.Style({
    stroke: new ol.style.Stroke({
      color: 'red',
      width: 2
    })
  })
});
```
3. Like for `DragRotateAndZoom`, deactivate `DragZoom`, and add the new interaction in the `interactions` parameter within `ol.Map`, as follows:

```
interactions: ol.interaction.defaults({
  shiftDragZoom: false
}).extend([dragBoxInteraction]),
```
4. Then, open your browser and try to draw a rectangle by holding down the *Shift* key while dragging with the mouse.

5. Now, add the following code between the `dragBoxInteraction` and `map` declarations:

```
dragBoxInteraction.on('boxend', function(e) {
  var format = new ol.format.GeoJSON();
  var geom = e.target.getGeometry();
  geom.transform('EPSG:3857', 'EPSG:4326');
  var feature = new ol.Feature({
    geometry: geom
  });
  var obj = format.writeFeatures([feature]);
  console.log(JSON.stringify(obj));
});
```

6. Open again the sample in the browser with the debugger activated, and repeat the same rectangle selection operation.

What just happened?

In the first part, you should be able to draw the rectangle, but no events fired then like with the `DragZoom` for example. We chose to play with all the available options.

We set the condition to be able to activate the behavior only with the *Shift* key using `ol.events.condition.shiftKeyOnly` and changed the style to make a red border with 1 pixel's width.

We added the new interaction but disabled the other, which also uses `ol.events.condition.shiftKeyOnly`.

Finally, we reused the event listener to catch when the rectangle drawing ends with `boxend`.

Within this event, we manipulated the returned geometry `ol.geometry.Polygon` to change it projection and reuse it into `ol.Feature`. By providing this feature with the `writeFeatures` method of a new `ol.format.GeoJSON`, we were able to make the `GeoJSON` object and converted it into a string.

As a reminder, in the following table, you will find the expected optional parameters (and experimental) for the interaction:

Name	Type	Description
<code>condition</code>	<code>ol.events.ConditionType</code> <code>undefined</code>	This is a function that takes <code>ol.MapBrowserEvent</code> and returns a <code>Boolean</code> to indicate whether that event should be handled. The default is <code>ol.events.condition.always..</code>
<code>style</code>	<code>ol.style.Style</code>	This is a style for the box.

After this last assignment for the book, it's time for revision.

Pop quiz

Let's look at a few questions to see what we understood during the chapter:

Q1. In a context where we want to query a WMS, what components and methods would be required for this?

1. `ol.Map`.
2. `ol.layer.Tile`.
3. `ol.source.ImageWMS`.
4. `ol.layer.Vector`.
5. `ol.source.TileWMS`.

Q2. What will happen if we use the `addCondition` property value `ol.interaction.condition.onlyAltKey` to build `ol.interaction.Select`?

1. The cumulating selection will react when a click on the *Shift* key is done.
2. The cumulating selection will react only with the *Alt* key.
3. An error will occur: the value does not exist.

Q3. We want to make a style change. When selecting, what type is required in the option style of `ol.layer.Vector`?

1. `ol.style.Style`.
2. `ol.style.Stroke`.
3. `ol.style.Fill`.
4. an array of `ol.style.Style`.

Q4. What is(are) the condition(s) not present by default in the available conditions when using interactions :

1. `ol.events.condition.neverShift`.
2. `ol.events.condition.never`.
3. `ol.events.condition.shiftAlways`.
4. `ol.events.condition.noModifierKey`.
5. `ol.events.condition.shiftKeyOnly`.

Summary

In this chapter, we discovered more about the way to query information from your map. Compared to a paper map, interactive feedback from a map is one of the most powerful features you can expect. We hope following our guidance was not too tough.

Starting with data manipulation, you learned more about the complex world of GIS. Next, we discovered about the dedicated components to select and query maps. Afterwards, with a pop-up, we inspected how to nearly reproduce the *Push Pins map* (*you can always reproduce it as an additional task*).

We created and modified our own geographical data instead of consuming existing data.

Inspecting the default interactions, we helped to explain some hidden interactions, requiring key and mouse combinations. We didn't restrict our inspection to default interactions: we saw all interactions except the one concerning mobile devices like `PinchZoom` or `PinchRotate` as we will review them in *Chapter 10, OpenLayers Goes Mobile*.

Now, we will dive into controls. Controls are quite similar to interactions, but they depend on the DOM element. We will look at all the available controls in the coming chapter. This chapter will also help you to understand not only the purpose, but also the ways of creating custom controls.

9

Taking Control of Controls

So far, we've taken for granted that we will zoom in/out when clicking on plus or minus buttons. We haven't discussed much about what actually is behind the map interaction when you use buttons. The `ol.control` namespace contains numerous classes that make our maps interactive, in particular to configure behavior on your map. There are many built-in controls, each with their own unique functions. You can easily customize them with a CSS style or other parameters. Contrary to interactions, controls depend on DOM elements and not keyboard and mouse input only.

In this chapter, we'll cover the following topics:

- ◆ What controls are
- ◆ Adding controls to a map
- ◆ Presenting all `ol.control` classes and their organization
- ◆ Inspect how to make your own control

Introducing controls

Controls allow us to interact with our map. They also allow us to display extra information, such as displaying a scale bar with the `ol.control.ScaleLine` control. Before, in the previous generation of OpenLayers, version 2.x, some controls did not have a visual appearance. Nowadays, those elements, which do not rely on a DOM element, are called interactions like for example, touch interactions on mobiles. You can have as many controls on your map as you'd like. There are even some cases where you may not want any controls—such as embedding an unmovable map in a page, or showing a static map for printing.

Using controls in OpenLayers

Most controls are added directly to the map, such as the `ol.control.Zoom` control. By default, you can now attach a control to other elements such as the `<div>` tag outside the map.

Adding controls to your map

There are two methods for adding controls to a map:

- ◆ You can pass in a JavaScript array of `ol.control.*` objects when you instantiate the map object.
- ◆ You can add controls to the map object after it has been created by calling the map function's `addControl()`, method passing in a single control object. If you need to pass more than one control, just loop using an array of control objects, using the same `addControl()`.

When you create your map, three control objects are added automatically. These three controls are as follows:

- ◆ `ol.control.Attribution`: This is responsible for displaying credits for producers of map data sources or tiles providers like for OpenStreetMap. By default, the control is located in the bottom-right corner.
- ◆ `ol.control.Zoom`: This is responsible for showing the plus and minus buttons in the top-left corner. Those buttons when clicking help to do a zoom in for plus and a zoom out for minus.
- ◆ `ol.control.Rotate`: This is responsible for resetting the map rotation to 0.

Since these controls are added without us explicitly adding them, how do we choose to not include them? The simplest way is to pass an empty array or `null` to the control's property when instantiating the map. Another way to change default controls is to explicitly set the options for each of them to `true` or `false` when you call the `ol.controls.defaults` function in the `controls` property of the `ol.Map` object.

Let's review this use case before going further.

Time for action – starting with the default controls

Follow these steps to start manipulating the default controls:

1. Create an HTML page using the usual template referring to the OpenLayers 3 JavaScript library and its default CSS, as shown here:

```
<!doctype html>
<html>
  <head>
    <title>Default controls</title>
    <link rel="stylesheet" href="../assets/ol3/css/ol.css"
type="text/css">
    <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
  </head>
  <body>
    <div id="map" class="map"></div>
    <script src="../assets/ol3/ol.js"></script>
    <script>
    </script>
  </body>
</html>
```

2. Now, between the empty `<script>` `</script>` add the declaration to the map:

```
var osm_default = new ol.layer.Tile({
  source: new ol.source.OSM()
});
var map = new ol.Map({
  layers: [osm_default],
  target: 'map',
  view: new ol.View({
    center: ol.proj.transform([-1.81185, 52.443141], 'EPSG:4326',
'EPSG:3857'),
    zoom: 6  })
});
```

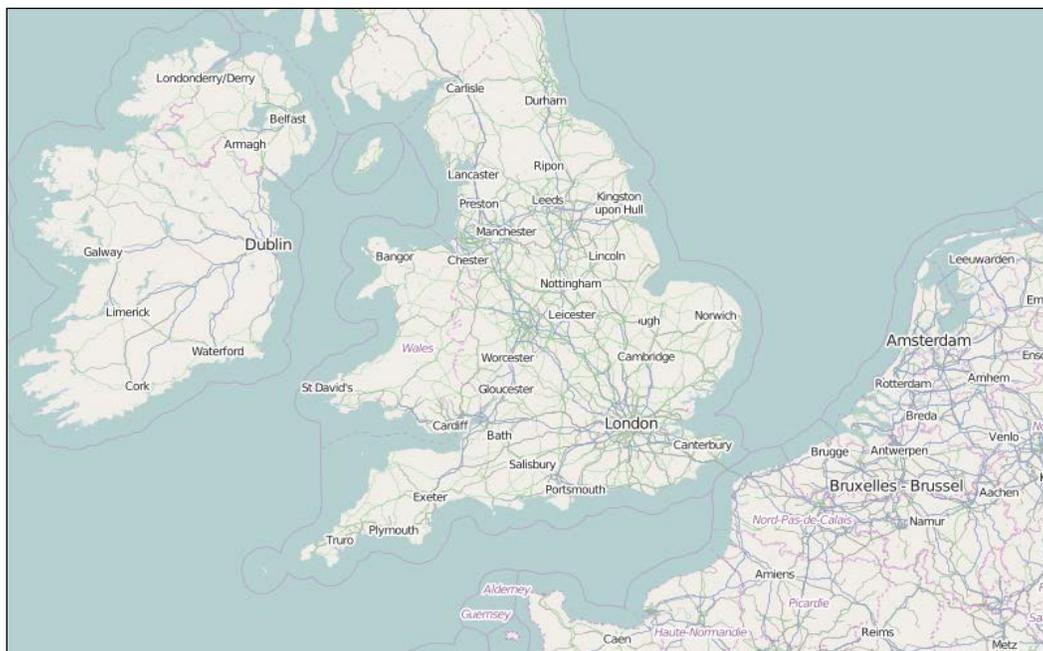
3. Try to open your HTML page. Don't forget to keep the good practice to put your page on a server or by using `python -m SimpleHTTPServer` or `node index.js` (if you are using the code from the book samples) because some sources are sensitive to the URL context (or you will get a blank map).



4. Now, change the previous page by adding the required options to `ol.control.defaults` to cancel all default controls parameters in the map constructor. See the following code to understand this:

```
var map = new ol.Map({ layers: [osm_default],
  controls: ol.control.defaults({
    zoom: false,
    attribution: false,
    rotate: false
  })
});
```

5. Reload your HTML page in the browser and you will see a result like the following:



What's just happened?

Let's examine the interesting part of the code:

```
controls: ol.control.defaults({
  zoom: false,
  attribution: false,
  rotate: false
})
```

To manage default controls, we must use a parameter in the `ol.control.defaults` function. This first parameter is an object that contains a key referring to the default controls. You can set their value to `false` to disable the corresponding control.

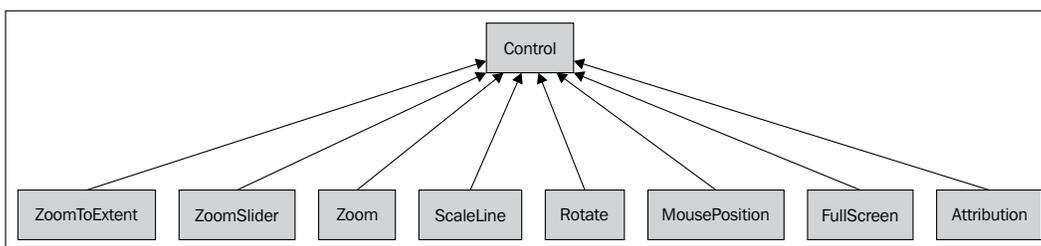
This object also supports other keys to set options for each default controls. These keys are `attributionOptions`, `rotateOptions`, and `zoomControlOptions`. We mentioned them here but we will see them later when reviewing each control individually.

The following table, an excerpt from the API documentation of `ol.control.defaults`, summarizes these properties:

Name	Type	Description
<code>attribution</code>	<code>boolean</code> <code>undefined</code>	With this property, you can set whether or not the attribution control should be displayed, with the values <code>true</code> or <code>false</code> .
<code>attributionOptions</code>	<code>olx.control.AttributionOptions</code> <code>undefined</code>	If the attribution control is used, you can pass these attribution options for the control.
<code>rotate</code>	<code>boolean</code> <code>undefined</code>	This property sets the rotate controls if you want to display the rotate control with <code>true</code> or <code>false</code> .
<code>rotateOptions</code>	<code>olx.control.RotateOptions</code> <code>undefined</code>	If the rotate control is used, you can pass these rotate options for the control.
<code>zoom</code>	<code>boolean</code> <code>undefined</code>	This property sets the zoom if you want to display the zoom control with <code>true</code> or <code>false</code> .
<code>zoomOptions</code>	<code>olx.control.ZoomOptions</code> <code>undefined</code>	If the zoom control is used, you can pass these zoom options for the the control.

Controls overview

After this long introduction to manipulation of controls, let's review all of them step by step. You can refer to the following diagram for a quick overview of the class hierarchy:



As you can see, all `ol.control.*` classes inherit from `ol.control.Control`.

So, first let's see this `ol.control.Control`.

The `ol.control.Control` class

The `ol.control.Control` is the parent class of all the available controls. It inherits from `ol.Object`, an abstract class that also inherits from `ol.Observable`, a convenient class to provide and manage listeners.

Control options

This object is responsible for the common options that all controls contain. All controls inherit from `ol.control.Control`, and it's exactly the same for the options. To understand its properties, just review how a control can be described.

"A control is a DOM element related to the map and that can be attached to an existing DOM element."

If you refer to the following table. The DOM element is the `element` property, the place that contains the look for the control. The `target` property is the place where you add the element into the DOM.

Name	Type	Description
<code>element</code>	<code>Element</code> <code>undefined</code>	This element is the control's container element. This only needs to be specified if you're developing a custom control.
<code>target</code>	<code>Element</code> <code>string</code> <code>undefined</code>	Specify a target if you want the control to be rendered outside of the map's viewport.

Never forget that it is useful to know `ol.control.Control` to understand its subclasses, but you never directly use it. You reuse this class only if you need to create your own control but it's not the time for this. First, we need to study controls provided by the Openlayers 3 library, which will be explained in the following sections.

The `ol.control.Attribution` control

The `ol.control.Attribution` control is not very new. We are already using it implicitly since we used the `ol.layer.OSM` class in *Chapter 1, Getting Started with OpenLayers*.

Attribution options

These are the options concerning the `ol.control.Attribution` control.

You can see all properties you can set for the control. You should be aware that those properties are considered as experimental in the OpenLayers 3 release.

Name	Type	Description
className	string undefined	This property sets the CSS class name for the control. The default value is <code>ol-attribution</code> .
target	Element undefined	This option sets the target to the DOM element where you want to display your control.
collapsible	boolean undefined	This specifies whether attributions can be collapsed. If you use an OSM source, this should be set to <code>false</code> —see OSM Copyright. The default value is <code>true</code> .
collapsed	boolean undefined	This specifies whether attributions should be collapsed at startup. The default value is <code>true</code> .
tipLabel	string undefined	This is the text label to use for the button tip. The default value is <code>Attributions</code> .
label	string undefined	This is the text label to use for the collapsed attributions button. The default value is <code>i</code> .
collapseLabel	string undefined	This is the text label to use for the expanded attributions button. The default value is <code>»</code> .

We will discover the way to customize it in the following section.

Time for action – changing the default attribution styles

Attributions, as a reminder, are the way to mention credits for layers sources that reference source of the tiles and/or data. The `ol.control.Attribution` control is dedicated for this.

1. First, copy the example dedicated to the defaults controls in a new file.
2. Next, change the `ol.control.defaults` options in the `controls` property of the map, and also set `logo` options to `false` at the `ol.Map` level:

```
logo: false
controls: ol.control.defaults({
  attributionOptions: {
  },
}),
```

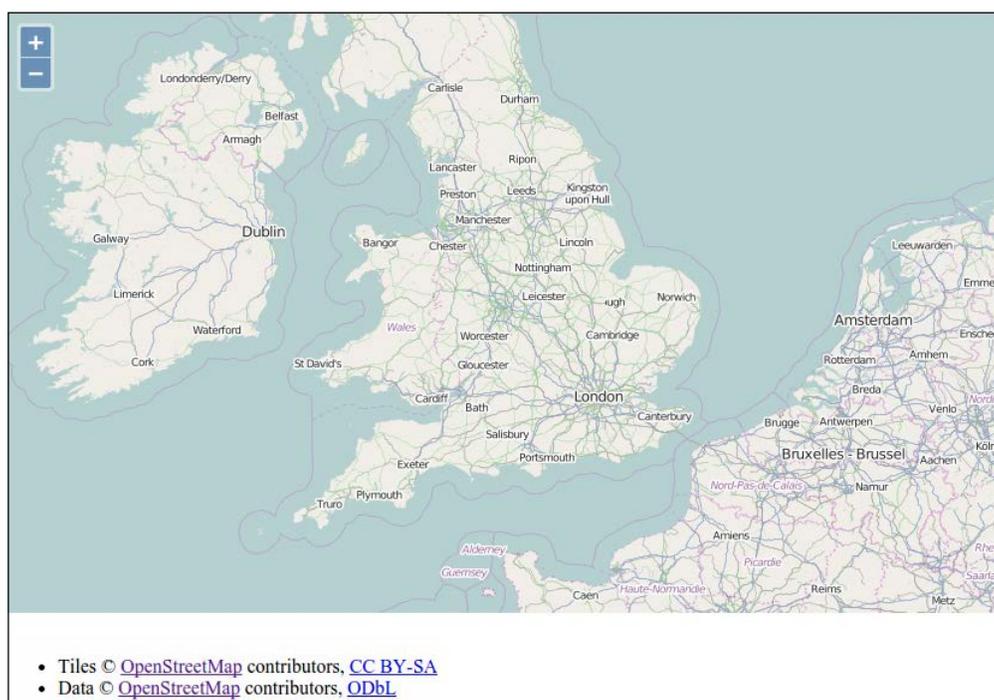
3. Open your browser (we suppose you are using Google Chrome).
4. Now, add in `attributionOptions` to the following content and reload the page:

```
attributionOptions: {
  className: 'myCustomClass'
},
```

5. Use the Chrome Developers tools to find the element with `myCustomClass` to try to understand the effect of the `className` option in `attributionOptions`.
6. Now, again add a new property in `attributionOptions`:


```
attributionOptions: {
  className: 'myCustomClass',
  target: document.getElementById('myattribution'),
},
```
7. Add also in the HTML after the `<div id="map" class="map"></div>` the following content:


```
<br/>
<div id="myattribution"></div>
```
8. Reload the HTML page and you will see an image like the one that follows:



What just happened?

We first introduced you to the `className` property. This enables you to change the default class name for the control. Then, you can customize your control with CSS according to this new class name. You may have noticed that, in the first case, you were unable to see the content in the browser, but only in the debugger because the element was always attached to the map element with its child, the `<div class="ol-viewport" ...>` tag.

With the second case, we showed you the purpose of the `target` property: you can tell the control where you want to attach the control. So, you need to use a DOM selector such as `document.getElementById('myattribution')`.

With this action, you might have seen that the control is now well separated from the `<div id="map" class="map"></div>` HTML.

It is now easy to customize as per your wish and you can display credits outside of the map: it can be useful when you use a lot of layers and don't want to display too much information.

The `ol.control.Zoom` control

The `ol.control.Zoom` control displays a plus and minus element to zoom in and zoom out. It is one of the default controls.

Zoom options

The zoom options are similar to both previous controls but we also have some other properties such as a `delta` property. The other specific properties are only to change text for the control or when the mouse hovers them.

We will not cover those options as they are quite straightforward to understand but advise you to play with it within the context of OpenStreetMap. If you remember, OpenStreetMap behavior for tiles in *Chapter 1, Getting Started with OpenLayers* (each zoom multiply zoom by 2), you will also remember how to play with the `delta` property. For each click on the control, your `delta` is 1. Change this property to a value, either 2 or 4, and try to click on the plus (+) and minus (-) buttons and see the change.

You can find the properties list for the control as follows:

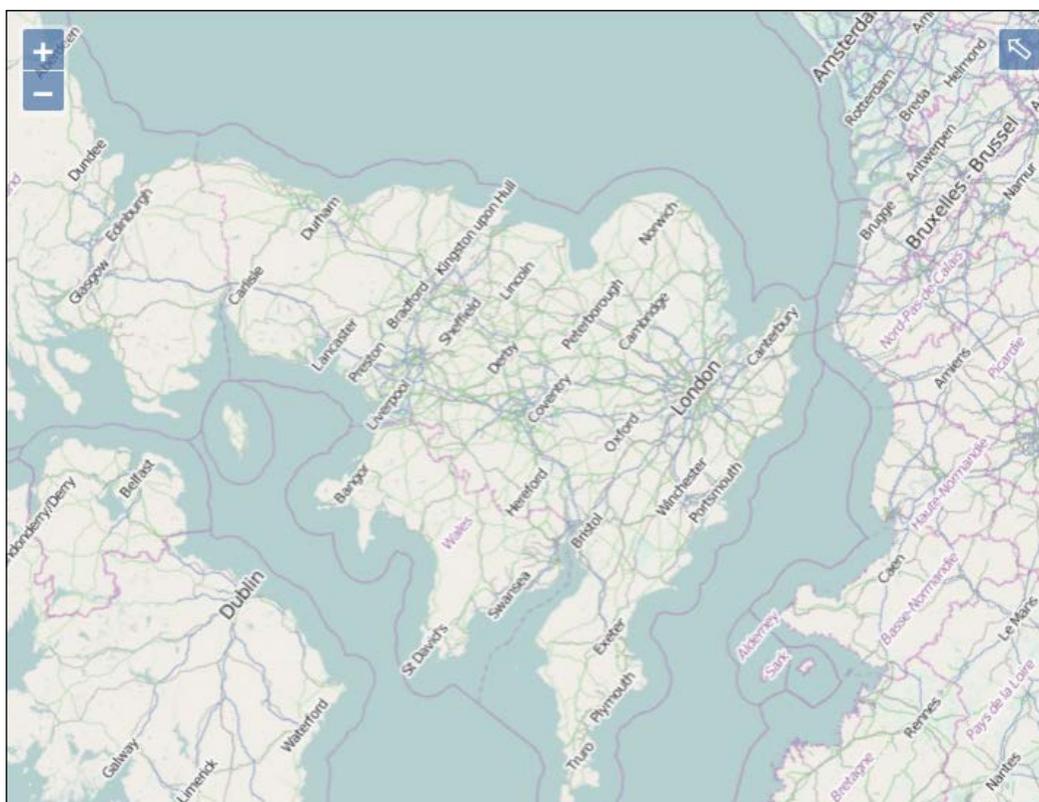
Name	Type	Description
<code>duration</code>	<code>number</code> <code>undefined</code>	This property sets the animation duration in milliseconds. The default value is 250.
<code>className</code>	<code>string</code> <code>undefined</code>	This property sets the CSS class name for the control. The default value is <code>ol-zoom</code> .
<code>zoomInLabel</code>	<code>string</code> <code>undefined</code>	This is the text label to use for the zoom in button. The default value is <code>+</code> .
<code>zoomOutLabel</code>	<code>string</code> <code>undefined</code>	This is the text label to use for the zoom out button. The default value is <code>-</code> .
<code>zoomInTipLabel</code>	<code>string</code> <code>undefined</code>	This is the text label to use for the button tip. The default value is <code>Zoom in</code> .
<code>zoomOutTipLabel</code>	<code>string</code> <code>undefined</code>	This is the text label to use for the button tip. The default value is <code>Zoom out</code> .

Name	Type	Description
delta	number undefined	The zoom delta is applied on each click.
target	Element undefined	This option sets the target, to the DOM element where you want to display your control.

The ol.control.Rotate control

The `ol.control.Rotate` control is not really obvious to understand. As OpenLayers 3 targets mobile browsers or applications, it can be useful to reset the rotation when you choose to make an interactive map that relies on the compass from your device. Sometimes, you want to reset the north direction for readability for end users. In fact, this control is a default one.

You can make it appear by reopening the previous example, then click and drag while pressing down both *Shift* and *Alt* keys. You will see a result like the following:



Rotate options

Let me remind you that you will find the options available to customize the `Rotate` control:

Name	Type	Description
<code>className</code>	<code>string</code> <code>undefined</code>	This property sets the CSS class name. The default value is <code>ol-rotate</code> .
<code>label</code>	<code>string</code> <code>undefined</code>	This property sets the text label to use for the rotate button. The default is <i>Upper arrow</i> key, as seen in the upper-right corner in the previous screenshot.
<code>tipLabel</code>	<code>string</code> <code>undefined</code>	This property sets the text label to use for the rotate tip. The default value is <code>Reset rotation</code> .
<code>duration</code>	<code>number</code> <code>undefined</code>	This property sets the animation duration in milliseconds. The default value is <code>250</code> .
<code>autoHide</code>	<code>boolean</code> <code>undefined</code>	With this, you can hide the control when rotation is <code>0</code> . The default value is <code>true</code> .
<code>target</code>	<code>Element</code> <code>undefined</code>	This property sets the target for the control.

You can play around with these options; for example, you can always display North with an arrow like for paper maps with `autoHide`. It's also possible, if your application is not targeting English-speaking users, to change the `tipLabel`.

The `ol.control.FullScreen` control

With this control, you can easily switch to the fullscreen mode that relies on HTML5. Also, for this reason, it will work better with a modern browser that supports this feature, such as Google Chrome, Firefox, and so on. Typing `ESC` will take you out from this mode.

This is the first control we've reviewed that is not a default one. If you need it, you can use the `ol.Collection` returned by the `ol.control.defaults` method and with it the `ol.Collection.extend` method, add the control using an array to the collection, when instantiating `ol.Map` with the bare minimum (no options):

```
controls: ol.control.defaults().extend([new ol.control.FullScreen()]),
```

As a reminder, supposing `map` is the `ol.Map` object name, you can also add the control with the following line:

```
map.addControl(new ol.control.FullScreen());
```

FullScreen options

These FullScreen are options for the FullScreen control. Except for the `keys` property that depends on latest support in browsers and `tipLabel` to set the tip text on the button, the properties are the usual ones, the ones inherited from `ol.control.Control`. All are considered as experimental.

Name	Type	Description
<code>className</code>	<code>string undefined</code>	This property sets the CSS class name for the control. The default value is <code>ol-full-screen</code> .
<code>tipLabel</code>	<code>string undefined</code>	This property sets the next label to use for the button tip. The default value is <code>Toggle full-screen</code> .
<code>keys</code>	<code>boolean undefined</code>	This property grants full keyboard access.
<code>target</code>	<code>Element undefined</code>	This option sets the target, to the DOM element where you want to display your control.

The `ol.control.MousePosition` control

The `ol.control.MousePosition` control helps you to determine the coordinates where your mouse is pointing on the map.

One way to do this is by instantiating the element with the syntax that follows:

```
controls: ol.control.defaults().extend( [
  new ol.control.MousePosition({
    key: value,
    ...
  })
]),
```

The object into the control constructor is optional.

MousePosition options

The MousePosition options are the available properties you pass to the control `ol.control.MousePosition`. They help customize the behavior of the control such as coordinates formatting or units.

Name	Type	Description
<code>className</code>	<code>string undefined</code>	This property sets the CSS class name for the control. The default value is <code>ol-mouse-position</code> .

Name	Type	Description
coordinateFormat	ol.CoordinateFormatType undefined	This property sets the coordinate format.
projection	ol.ProjectionLike	This property sets the projection and the library uses it for displaying units.
target	Element undefined	This option sets the target, to the DOM element where you want to display your control.
undefinedHTML	string undefined	This property sets the markup for undefined coordinates. The default value is an empty string.

We will review these options with an example.

Time for action – finding your mouse position

Follow these steps to get started with the mouse position behavior:

1. Reuse the usual HTML for the chapter by copying it in a new file.
2. Now, edit the file to be sure that you create an HTML element with an ID myposition such as `<div id="myposition"></div>`.
3. Declare a JavaScript variable that references the control:

```
var mousePosition = new ol.control.MousePosition({
  coordinateFormat: ol.coordinate.createStringXY(2),
  projection: 'EPSG:4326',
  target: document.getElementById('myposition'),
  undefinedHTML: '&nbsp;';
});
```
4. Add the control to the map without forgetting that this operation is only available after you create the map:

```
map.addControl(mousePosition);
```
5. See the result in your browser and hover with your mouse the map.
6. Go back in your HTML code and add the following code in your CSS file, `assets/css/samples.css`:

```
#myposition > .ol-mouse-position {
  position: relative;
  margin-left: 20px;
  font-size: 30px;
}
```

7. Reload your page and you will see a screenshot like the following:



What just happened?

Here, we choose to use most of the options of the controls.

The first one, `coordinateFormat`, accepts an `ol.CoordinateFormatType`. It simply means that when you retrieve the coordinates, you may want to change them to **Degrees Minutes Seconds** notation or you may want to change the precision you display in the HTML file.

The two relevant options to set here are:

- ◆ `ol.coordinate.createStringXY(2)`: This is where 2 is the precision you expect
- ◆ `ol.coordinate.toStringHDMS`: This is useful only if you use degrees units and the result will look like **51° 30' 33" N "8° 49' 22" E"**

Be careful to not set `ol.coordinate.toStringHDMS()` instead; it's a bit surprising, but you need to use the class itself.

The projection option helps you choose the coordinates you want. You may have forgotten but each projection has a defined unit system (and subunits). For example, the EPSG:4326 projection returns units in a decimal degree. It's what you see in the bottom of the previous image. The `undefinedHTML` option just sets what you want to display when you are not hovering over the map. You can confirm ` ` availability by searching in the Chrome debugger **Elements** panel, the string in precedent example.

The `target` option and the CSS part were only to remind you of previous use cases.

We've never really insist until now, but you can also set the parameters after controls creation. In fact, for each property, you always have a setter and a getter.

Just open your browser with the example, type in the console the following line, and hover over the map to understand:

```
mousePosition.setProjection(ol.proj.get('EPSG:3857'))
```

As you see, you can really explore the methods available in the `ol.control.MousePosition` control. We really encourage you to play in the console using auto completion: you will see that you can really find useful things that may remind you of other examples. You should also focus on the **Fires**: part of the API documentation at <http://openlayers.org/en/v3.0.0/apidoc/ol.control.MousePosition.html> because it will help you to apply your events knowledge in the context of controls and here, the `mousePosition` control.

The `ol.control.ScaleLine` control

If you remember, we already introduced you to this control in the *Chapter 7, Wrapping Our Heads Around Projections* at a functional level.

The purpose of `ol.control.ScaleLine` is to show a scale line bar to give people an overview of scale and distance. Be aware that it is only useful for projection that keeps distances.

You just need to add it to the map with something such as `map.addControl(new ol.control.ScaleLine())` if you don't use the options.

ScaleLine options

The following is the options list you can set for the scale line control:

Name	Type	Description
<code>className</code>	<code>string</code> <code>undefined</code>	This property sets the CSS class name for the control. The default value is <code>ol-scale-line</code> .
<code>minWidth</code>	<code>number</code> <code>undefined</code>	This option sets the minimum width in pixels.

Name	Type	Description
target	Element undefined	This option sets the target, to the DOM element where you want to display your control.
units	ol.control.ScaleLineUnits undefined	This property sets the units you want to use in your scale line. The supported values are degrees, imperial, nautical, metric, and US.

Have a go hero – discovering ol.control.ScaleLine specific parameters

Although this book is about introducing the OpenLayers 3 library, we suppose that if you are reading this, it also means you want to understand what you are doing. So, let's give you some tasks to do by yourself:

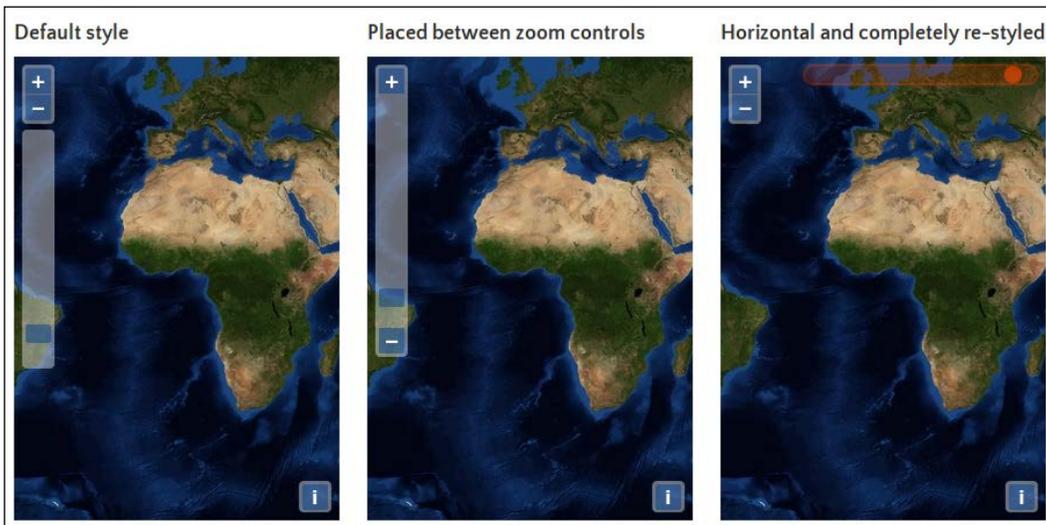
- ◆ Reuse the usual chapter code.
- ◆ Set the `minWidth` property to a value you want in pixels.
- ◆ Zoom in, zoom out, and pan to see the control behavior.
- ◆ Change units in the scale line (the `ol.control.ScaleLineUnits` description is available in the following content). When you want to display your map legend using others units, you need to know the available units. You can find them using the table that follows, extracted from the `ol.control.ScaleLineUnits` type definitions in the OpenLayers 3 API:

Name	Type	Default
degrees	string	This property returns the the string degrees required for internal library units changes. Check out Wikipedia to learn more on this unit (decimal degree) at http://en.wikipedia.org/wiki/Decimal_degrees .
imperial	string	This property is similar to previous property but returns the string imperial. Check out Wikipedia to learn more about the unit at http://en.wikipedia.org/wiki/Imperial_units .
nautical	string	This property is similar to the previous property but returns the string nautical. It refers to nautical miles. Check out Wikipedia for more information at http://en.wikipedia.org/wiki/Nautical_mile .
metric	string	This property is similar to the previous property, but returns the string metric that refers to metre or meter. Check out Wikipedia for an history at http://en.wikipedia.org/wiki/Metre .
us	string	This property is similar to the previous property but returns the string US. It refers to US units. Check out Wikipedia for more information at http://en.wikipedia.org/wiki/United_States_customary_units .

- ◆ Inspect the HTML element using the debugger
- ◆ What CSS rules apply to the elements within the DOM element control
- ◆ Tweak the control color
- ◆ Change the scale line position with CSS, the `target` property or both of them

The `ol.control.ZoomSlider` control

The `ol.control.ZoomSlider` control helps you to see your zoom levels using a slider. We advise you to go to the official example at <http://openlayers.org/en/v3.0.0/examples/zoomslider.html> because it's well illustrated for CSS styling. You can display the slider horizontally or vertically for the example illustrated in the following screenshot:



ZoomSlider options

The following content presents the available options/properties in `ol.control.ZoomSlider`.

Name	Type	Description
<code>className</code>	<code>string</code> <code>undefined</code>	This property sets the class name for the control.
<code>maxResolution</code>	<code>number</code> <code>undefined</code>	This option defines the maximum resolution.
<code>minResolution</code>	<code>number</code> <code>undefined</code>	This option sets the minimum resolution.

You can manage and try to better understand resolutions by using the `getResolution()` function at the view level (with `map.getView()`).

The `ol.control.ZoomToExtent` control

The `ol.control.ZoomToExtent` control permits you to create a button to go to a particular extent.

In a real context, it may help you to get a map with a zoom on a country, and using this control, you will be able to zoom directly on a particular city. In another case, you may want to go back to the initial extent of your map, and this control is also a way to address this requirement.

Time for action – configuring `ZoomToExtent` and manipulate controls

In order to learn better, let's try another example:

1. Copy the HTML code from other examples.
2. Set the center and zoom of the map at loading to different values from the usual one. You can get values reusing the view with `map.getView().getZoom()` and `map.getView().getCenter()`.

3. Create a control named `zoomToExtentControl`:

```
var zoomToExtentControl = new ol.control.ZoomToExtent({
    extent: [-11243808.051695308, 4406397.202710291,
            -4561377.290892059, 6852382.107835932]
});
```

4. Reuse it with the code that follows, after your `map` instantiation:

```
addControl(zoomToExtentControl);
```

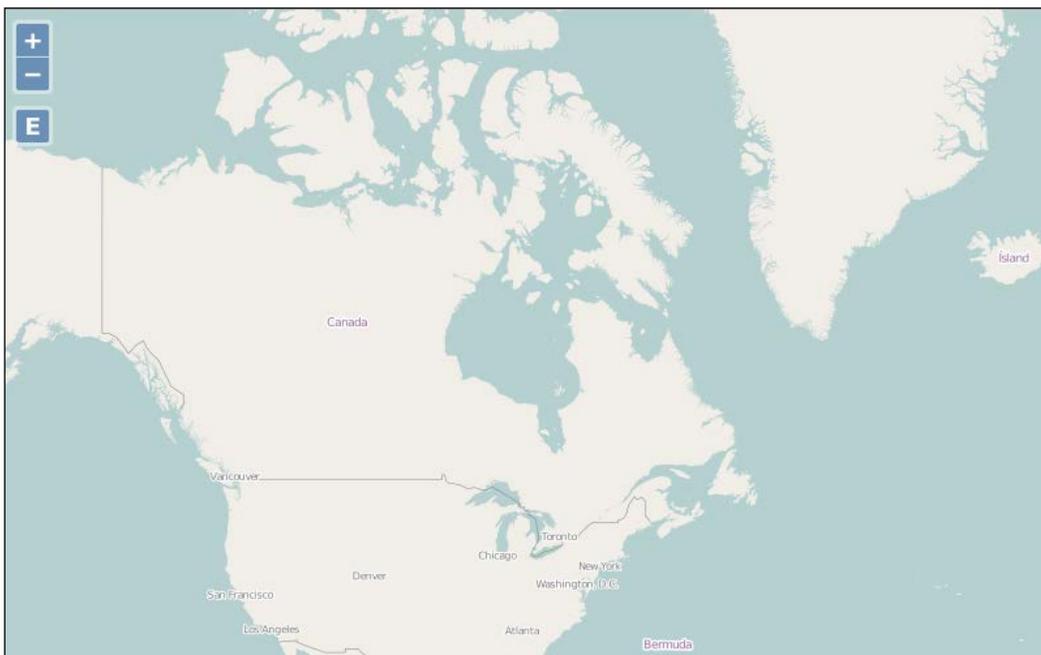
5. Find the control within the controls attached to the map:

```
var controls = map.getControls();
var attributionControl;
controls.forEach(function (el) {
    if (el instanceof ol.control.Attribution) {
        attributionControl = el;
    }
})
```

6. Remove the `ol.control.Attribution` control using the reference you retrieve and supposing map reference the `ol.Map` instance.

```
map.removeControl(attributionControl);
```

7. Just see the result centered on **Canada**:



What just happened?

Here, we've just seen an example to learn how to manage the `ol.control.ZoomToExtent` control. The most interesting part is related to the code that enables you to find your control reference without having an object control reference. For this, we use the `instanceof` JavaScript function.

Now, we also know how to list controls for a map using the `map.getControls()` function, and also loop through it using the `forEach` method from `ol.Collection`.

Finally, we discovered how to remove a control when for any reason, we needed to delete it afterward with the `map.removeControl()` function. You also have to understand that for learning purposes we don't check everything. For example, imagine there were more than one `ol.control.Attribution` control. A good exercise can be to change code to manage this case.

ZoomToExtent options

These properties set the options for the `ol.control.ZoomToExtent` control.

Name	Type	Description
<code>className</code>	<code>string</code> <code>undefined</code>	This property sets the class name for the control.
<code>target</code>	<code>Element</code> <code>undefined</code>	This option sets the target to the DOM element where you want to display your control.
<code>tipLabel</code>	<code>string</code> <code>undefined</code>	This is the text label to be used for the button tip. The default value is <code>Zoom to extent</code> .
<code>extent</code>	<code>ol.Extent</code> <code>undefined</code>	This defines the extent you can zoom. If <code>undefined</code> , the validity extent of the view projection is used.

Now, we got an overview of controls, let's see how to make our own ones, for specific purposes.

Creating a custom control

You may wonder "why do we need to learn that?"

Some points to explain this requirement are:

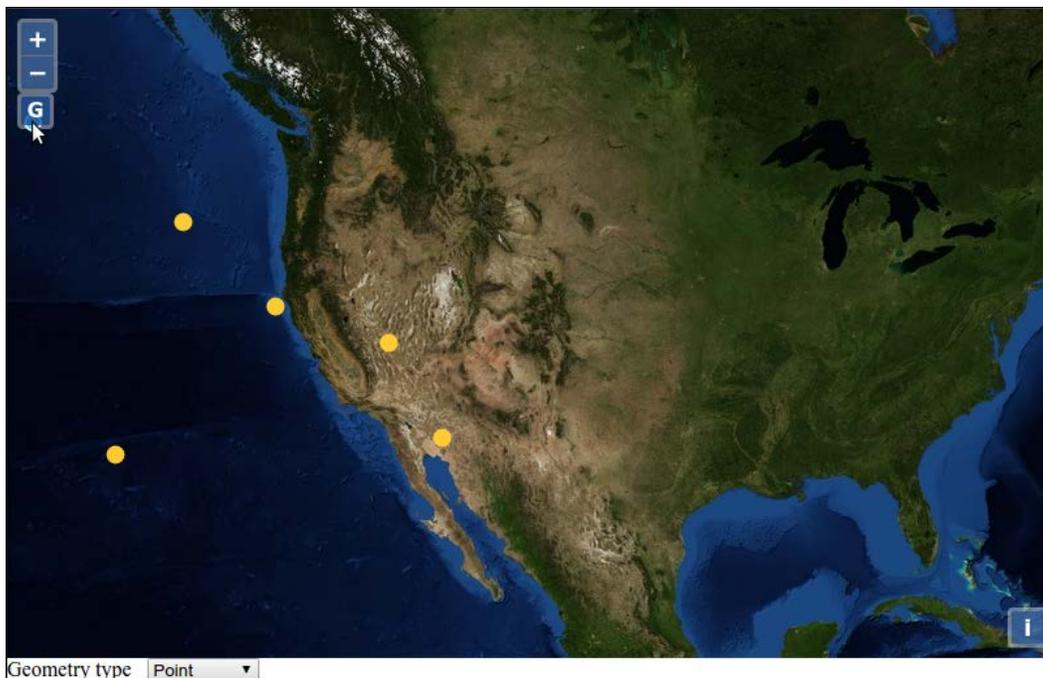
- ◆ Reusing components instead of using a boilerplate each time
- ◆ Correctly overlaying UI buttons on the top of the map, particularly for a full screen case
- ◆ Unifying UI manipulation because based on the same parent class, for example, adding a control using the various Map class methods is more easy than managing OpenLayers 3 and non-OpenLayers 3 objects separately

Let's see how we can do it.

Time for action – extending ol.control.Control to make your own control

Let's get started. Contrary to most examples, it will need more code than usual. So, to keep things simple, we will explain how to build the sample by retrieving the various code files instead of inlining it. After these operations, we will focus on the important parts of the code to understand them:

1. Go to the samples directory and retrieve all the `css` class with the `export-geojson` string from `assets/css/samples.css` and copy paste them in your own `samples.css` file. Next, retrieve a new JavaScript file from <https://github.com/eligrey/FileSaver.js/blob/master/FileSaver.js> into a new subdirectory, `assets/js`.
2. If you don't already have it from *Chapter 8, Interacting with Your Map*, go to download the `features.geojson` file from `assets/data/features.geojson`, within the book samples.
3. Then, retrieve the code from `chapter09/23600S_09_06_custom_control.html`.
4. Finally, run `node index.js`, open your browser, and draw something. Push on the new button named **G** just below the minus plus buttons and you can download a file.
5. You should see an example similar to the following screenshot:



What just happened?

We will just highlight the most important parts.

At a functional level, we reused `ol.interaction.Draw` with the possibility to switch between drawing points, lines, and polygons. We removed the server-side dependency for saving the efforts for the same.

Instead we introduced a new component, `app.generateGeoJSONControl`, with the following snippet:

```
controls: ol.control.defaults().extend(
  new app.generateGeoJSONControl({source: source})
]),
```

This component reuses the declared `ol.source.GeoJSON` vector source used to get a GeoJSON content with the `source: source` option.

This new control is created by declaring a namespace with:

```
window.app = {};
var app = window.app;
```

Then, we declared the function with `app.generateGeoJSONControl = function(opt_options) {` and directly prepared to get `opt_options` with the following line of code:

```
var options = opt_options || {};
```

We made an anchor DOM element, then a temporary variable with `var this_ = this;` to be able to keep the scope for the `getGeoJSON` function.

Within this named function, we stopped a default behavior to not get the URL changed and started to manipulate the features from the source to transform them to a GeoJSON string. With a new `download` function, we made it possible to save the text content in a file.

This declaration is not the call; so, we needed to bind the function to event `click` and `touchstart` for desktop and mobiles experiences on the anchor DOM element with:

```
anchor.addEventListener('click', getGeoJSON, false);
anchor.addEventListener('touchstart', getGeoJSON, false);
```

Near the end, we added a new `<div>` tag and appended `anchor` as a child.

We made an interesting statement by using a call function from `ol.control.Control`:

```
ol.control.Control.call(this, {
  element: element,
  target: options.target
});
```

It enables us to reuse the option from the parent control and to set them, for example, target and element, the newly created `<div>` tag.

Making a `call` was just to call the function of the parent class; so, after the end of the `app.generateGeoJSONControl` function, we explicitly used a special declaration `ol.inherits` to apply the `ol.control.Control` parent methods and properties to our custom class:

```
ol.inherits(app.generateGeoJSONControl, ol.control.Control);
```

Pop quiz

Q1. You need to stop the zoom in / zoom out behavior on the map. In the `ol.Map` object, what do you need to change in the options and why?

1. The interactions property.
2. The controls property.
3. Both controls and interactions properties.

Q2. If you want to use panning on your map, what do you need to change in `ol.Map`?

1. The interactions property.
2. The controls property.
3. Both controls and interactions properties.

Q3. Assuming I have made my own control named `mycustomControl` and I declare the following within `ol.Map`:

```
controls: ol.control.defaults().extend([
  mycustomControl({source: source})
])
```

What will happen and why?

1. It will work.
2. It will fail.

Summary

In this chapter, we discovered more about the controls. Up until now, we've used it without really understanding their purpose—what can they do for us?

Firstly, we organized our thoughts using inheritance schema. In fact, it's more complicated, but for a beginner book, it was quite enough. We didn't go too deep; we used and reviewed existing components but didn't focus a lot on creating new ones. You don't really need to use augmented controls in most cases. When you need to make a new control, don't hesitate to review the behavior from the various interaction: it's simple to combine them with buttons.

After this review of how to use controls with your map using the available components from API, it's time to dive into OpenLayers support for mobile. You will learn how OpenLayers touch events work but also how to reuse device geolocation and orientation. Using the mobile context, we will review some HTML 5 features that can help with improving application experiences. This overview will cover web mapping sites such as native applications for mobiles.

10

OpenLayers Goes Mobile

The rise in popularity of mobile devices—smart phones and tablets—has changed the landscape of web development. Now, users expect our websites and applications to work on their mobile devices' smaller screens, respond to touchscreen interfaces and know where they are via integrated GPS. OpenLayers 3 provides some great features targeting mobile platforms, and we will highlight those in this chapter. But, developing mobile-friendly web applications has its challenges too, so we'll look at how to debug web applications on mobile devices and at some strategies to use when mobile devices lose their network connections.

In this chapter, we will cover the following topics:

- ◆ Touch support in OpenLayers
- ◆ Using `ol.Geolocation` to get the location of a mobile device
- ◆ Using `ol.DeviceOrientation` to track orientation of a mobile device
- ◆ Debugging mobile web applications on Android and iOS
- ◆ Using HTML5 `ApplicationCache` to run web applications offline
- ◆ Using HTML5 `Storage` to save data for offline use
- ◆ Going native with HTML5 apps

Touch support in OpenLayers

One of the biggest differences between desktop and mobile web applications is how we interact with an application. On a desktop or laptop computer, we have a keyboard and a mouse or trackpad, and we *point and click* or *click and drag* things. On mobile devices though, there is no keyboard and no mouse pointer. Instead, we use our fingers, and we do things like touch, drag, and tap. We can also do more complicated things, such as pinching two fingers together or rotating two fingers, and we usually expect this to do something in an application. In mapping applications on touch devices, for instance, we might expect that dragging a finger will pan the map and pinching two fingers will zoom in or out.

OpenLayers provides touch support for us in the form of interactions—recall that we talked about interactions in *Chapter 8, Interacting with Your Map*. The touch-specific interactions are as follows:

- ◆ `ol.interaction.DragPan`: This pans the map in response to one or more fingers being dragged across the screen
- ◆ `ol.interaction.PinchRotate`: This rotates the map in response to two fingers twisting in a circular motion on the screen
- ◆ `ol.interaction.PinchZoom`: This zooms the map in or out in response to two fingers pinching in or out on the screen

These interactions are created by default and enabled on devices that support touch events. Let's see them in action!

Using a web server

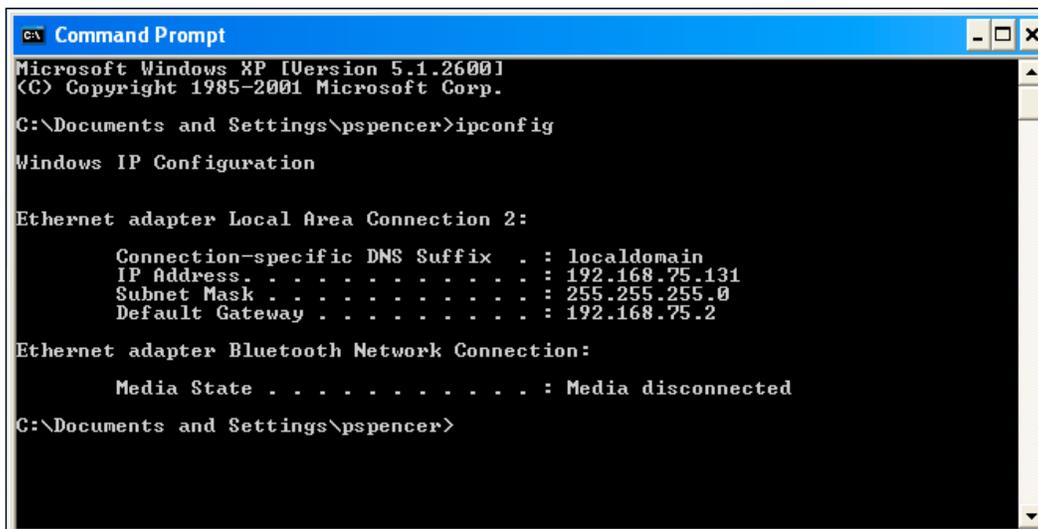
Because we'll view the examples in this chapter on a mobile device with a browser that does not have direct access to your development machine, we'll need to serve them through a web server and access them using the HTTP protocol. Your computer also needs to be connected to the same **Local Area Network (LAN)** as your mobile device.

We've already been using a web server with the samples using the URL `http://localhost/`. This URL uses the name `localhost`, a special name that tells the web browser to connect to the local machine. This is great for your desktop browser, but it isn't going to work for our mobile device. You'll need to find the IP address of your computer on the LAN.

Finding your IP address on Windows

On Windows, open a command prompt (`cmd.exe`) and type `ipconfig`.

You should see something like the following screenshot:



```
Command Prompt
Microsoft Windows XP [Version 5.1.2600]
(C) Copyright 1985-2001 Microsoft Corp.

C:\Documents and Settings\spencer>ipconfig

Windows IP Configuration

Ethernet adapter Local Area Connection 2:

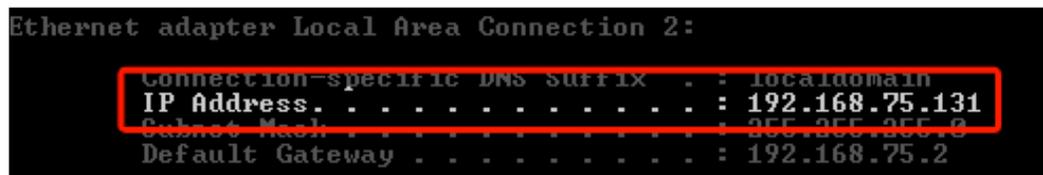
    Connection-specific DNS Suffix  . : localdomain
    IP Address. . . . .                : 192.168.75.131
    Subnet Mask . . . . .              : 255.255.255.0
    Default Gateway . . . . .          : 192.168.75.2

Ethernet adapter Bluetooth Network Connection:

    Media State . . . . .              : Media disconnected

C:\Documents and Settings\spencer>
```

The `ipconfig` command will output some information about your network connections; the actual output will be different depending on your setup and how you are connected to the network, but you are looking for the marked line in the following screenshot:



```
Ethernet adapter Local Area Connection 2:

    Connection-specific DNS Suffix  . : localdomain
    IP Address. . . . .                : 192.168.75.131
    Subnet Mask . . . . .              : 255.255.255.0
    Default Gateway . . . . .          : 192.168.75.2
```

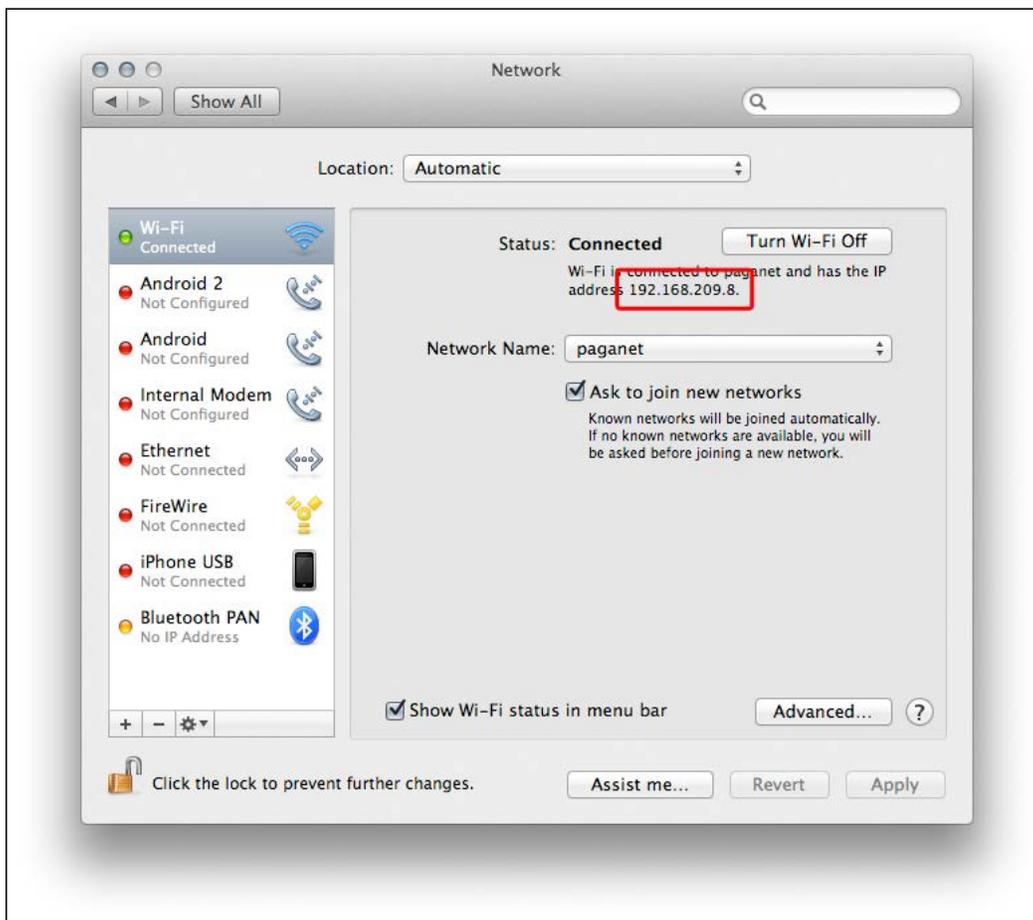
Write down the IP address for future reference.

Finding your IP address on OSX

On OSX, you can find your IP address from **System Preferences**. Perform the following steps to find your IP address:

1. From the Apple menu, pull down **System Preferences**
2. Click on the **Network** preference pane

3. Your IP address will be visible on the right-hand side, as indicated in the following screenshot:



Finding your IP address on Linux

On Linux, open a terminal window and use the `ifconfig` command to get your IP address. If you are connecting using WIFI, type:

```
ifconfig wlan0
```

If you are connecting using Ethernet (cable), type:

```
ifconfig eth0
```

You will see output like the following screenshot:

```
thomas@thomas-ThinkPad-T430:~$ ifconfig wlan0
wlan0      Link encap:Ethernet  HWaddr 8c:70:5a:ae:ba:80
           inet addr:10.192.2.200  Bcast:10.192.255.255  Mask:255.255.0.0
           inet6 addr: fe80::8e70:5aff:feae:ba80/64  Scope:Link
           UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
           RX packets:101615 errors:0 dropped:0 overruns:0 frame:0
           TX packets:72640 errors:0 dropped:0 overruns:0 carrier:0
           collisions:0 txqueuelen:1000
           RX bytes:107302639 (107.3 MB)  TX bytes:11046712 (11.0 MB)
```

You should see the IP address between **inet addr** and **Bcast**.

Testing your IP address

Before we continue, let's make sure that the IP address is correct. Replace `localhost` in your browser address bar with your IP address, and make sure that the page loads the same way. For instance, if you determined that your IP address is `192.168.0.1`, then the URL would start with `http://192.168.0.1/`. Next, open the web browser on your mobile device and enter the same test URL. You should see that page opens in your mobile device's web browser.

If you are having problems with this step, make sure that WIFI is enabled on your mobile device and that it is connecting to the same network as your development machine.

Time for action – go mobile!

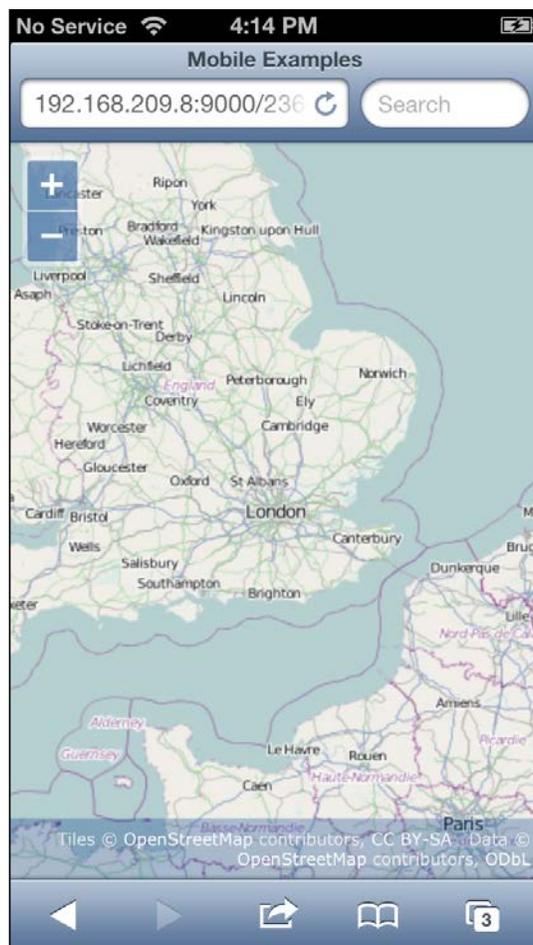
Now, we are ready to test our new setup with a fully mobile-capable OpenLayers application. As you'll see in the following steps, there's nothing special you need to do with OpenLayers itself to work in a mobile environment:

1. First, let's create a new web page for this chapter as there are some differences needed to support mobile devices that we haven't seen before. Add the following to a new file in your text editor, and save it as `mobile.html`:

```
<!doctype html>
<html>
  <head>
    <title>Mobile Example</title>
    <meta name="viewport" content="width=device-width, initial-
scale=1.0, maximum-scale=1.0, user-scalable=no">
```

```
<link rel="stylesheet" href="../assets/ol3/ol.css" type="text/
css" />
<link rel="stylesheet" href="../assets/css/samples.css"
type="text/css" />
</head>
<body>
<div id="map" class="full-map"></div>
<script src="../assets/ol3/ol.js"></script>
<script>
  var layer = new ol.layer.Tile({
    source: new ol.source.OSM()
  });
  var london = ol.proj.transform([-0.12755, 51.507222],
'EPSG:4326', 'EPSG:3857');
  var view = new ol.View({
    center: london,
    zoom: 6,
  });
  var map = new ol.Map({
    target: 'map',
    layers: [layer],
    view: view
  });
</script>
</body>
</html>
```

- 2.** Open this page in a web browser on your mobile device. You should see something like the following screenshot:



3. Try out the touch interactions by dragging, pinching, and twisting your fingers on the screen.

What just happened?

We created an example very similar to the ones we've been using in previous chapters and, just by loading it on a mobile device, we get new capabilities from OpenLayers' default touch interactions. We can now pinch to zoom in and out, move two fingers in a circular motion to rotate the map, and touch drag the map to pan around.

We made a couple of small changes to the example we used in previous chapters though, so let's highlight the differences. In the `<head>` section, we've added a `<meta>` tag. The `<meta>` tag provides information to the web browser rendering the page, its name indicates the type of information it is providing, and its content is the information or data we want to inform the browser about. In this case, we've used the `viewport` `<meta>` tag to provide some information that mobile web browsers can use to modify how a user interacts with the web page in a mobile browser. Let's break down the content and explain what it's doing, as follows:

```
<meta name="viewport" content="width=device-width, initial-scale=1.0,
maximum-scale=1.0, user-scalable=no">
```

The content is a series of comma-separated key-value pairs formatted as `key=value`. The `width` key indicates how wide the browser's viewport should be. It can be set to a specific number of pixels or to a predefined value `device-width`, which indicates that the viewport should be 100 percent wide. The `initial-scale` and `maximum-scale` keys constrain the mobile browser viewport scale factor, which would allow rendering a page more zoomed-in than its default. Setting the `user-scalable` key to `no` disables zooming the web page in response to the user performing a pinch gesture. We want the pinch gesture to zoom the map, not the whole page. We've also changed the class name used on the HTML element that contains the map from `map` to `full-map`. This changes the map element to take up 100 percent of the width and the height of the browser viewport.

The remainder of the example is exactly the same as in previous chapters. In fact, you can load this example in your normal web browser, and it should function in exactly the same way as many of the other examples, the only difference being that the map will fill your browser window.

So, we get touch support in our web mapping application without really having to do anything at all. But just supporting touch events isn't that exciting. Let's explore what else OpenLayers has to offer on mobile devices, starting with finding our location.

The Geolocation class

OpenLayers provides us with the `ol.Geolocation` class, which can be used to find the current location of the user and to track changes in location over time. This class accesses information provided by web browsers through the HTML 5 Geolocation API.

Limitations of the Geolocation class

Before we go any further, it's important to discuss the technology behind the Geolocation API a little bit to understand its limitations. The location of a device can be determined by several methods. Typically, we think of the location as being determined by a **Global Positioning System (GPS)**, but in practice, the location of a device can be determined by several means, including the following:

- ◆ **Public IP address:** Every device that can access the Internet has a public IP address. Public IP addresses are allocated to various Internet providers in specific blocks, and so an approximate location for any device can be guessed from its public IP address. The accuracy of this guess can vary widely and might even identify the location as being in the wrong city.
- ◆ **Cellular network towers:** Every mobile device that connects to the Internet does so through a wireless cellular network. The device knows which network towers it is connected to, and since these towers have known locations, the location of the device can be estimated.
- ◆ **GPS:** A series of geostationary satellites can be used to determine the location of a device with a high degree of accuracy.

A mobile device can use any of these techniques to determine its location, and the owner of the device can choose to turn any or all of these methods off, perhaps for privacy reasons or to conserve battery power.

Using the Geolocation class

Now that we know there are limitations, let's create an example using `ol.Geolocation`, and then we'll provide some more details about what can be done with it. Our new example will place a marker on the map at the location reported by the Geolocation API.

Time for action – location, location, location

Let's add another resource to our page, so that we can access some nice icons. In the past, we might have done this by creating images for each of the icons we wanted and then adding `` tags. We are going to try a different approach this time using an iconic font called **Font Awesome**. We'll discuss why after the example; for now, just follow these steps:

1. Add the following `<link>` tag to the `<head>` tag of your HTML document, just after the link to `ol.css`:

```
<link href="//netdna.bootstrapcdn.com/font-awesome/3.2.1/css/font-awesome.css" rel="stylesheet">
```

2. Now, add a new `<style>` section inside the `<head>` tag:

```
<style>
.marker {
  position: absolute;
  width: 24px;
  height: 24px;
  font-size: 24px;
}
</style>
```

3. Next, we need to add an HTML element for our marker. Add the following new `<div>` tag just after the `<div>` tag:

```
<div class="map"></div>
<div id="location" class="marker icon-flag"></div>
```

4. Finally, add the following code at the end of the `<script>` tag, after all the other code:

```
var marker = new ol.Overlay({
  element: document.getElementById('location')
});
map.addOverlay(marker);
var geolocation = new ol.Geolocation({
  tracking: true
});
geolocation.bindTo('projection', view);
geolocation.bindTo('position', marker);
```

5. Reload the page in your mobile web browser, and you should see a flag on the map at your current location. If you don't live near London, England, then you might need to zoom out and pan to see the marker on the map.

What just happened?

Step 1 adds a link to a stylesheet that defines an **iconic font**, which we'll discuss in more detail in just a moment. In step 2, we created a new CSS class called `marker` that we can add to the HTML elements we want to be displayed as markers on the map. This class sets the width and height of the element to be 24 pixels and also the font size, as we are using an iconic font for our marker images. In step 3, we added the HTML element we want to use as our marker. We gave it an ID of location, so that we could refer to it later and added both `marker` and `icon-flag` to the class. The `marker` class makes the element a specific size, and the `icon-flag` class indicates which icon to use from our iconic font. In step 4, the new code we added creates a new `ol.Overlay` attached to our marker element and adds it to the map. Then, we create an instance of `ol.Geolocation` and tell it we want to track location updates. Then, we bind the projection property of the `geolocation` object to the view's `projection` and `position` properties to the marker. The `geolocation` object will now automatically convert location updates into the correct projection for our view and move our marker overlay to our current location.

More about iconic fonts

Iconic fonts are just like any other font, except that the characters in the font are designed as pictures instead of letters. Like text in a web page, the icons in a font are easily resizable and adapt to different resolution displays automatically. Mobile devices such as the iPhone 4 and later sport retina displays have a high pixel density. Normal images on retina devices end up looking blocky. Icon fonts are automatically rendered at a higher resolution on retina devices and are crisp and clear.

FontAwesome (<http://fontawesome.github.io/Font-Awesome/>) is a popular iconic font (at the time of writing this) and is easy to use in any web application, just by including a single `<link>` tag and then using icon-specific class names. We'll use a couple more Font Awesome icons in later examples, but if you are interested in what icons are available, visit their site and take a look around.

Font Awesome isn't the only choice for an icon font, and there are many tools on the Web to help you make your own icon fonts from existing vector art.

The Geolocation class in detail

Now that we've seen `ol.Geolocation` in action, let's take a look at its full capabilities.

Geolocation constructor options

When creating an instance of `ol.Geolocation`, you can provide the following optional properties to control its initial behavior:

Option	Type	Description
<code>tracking</code>	Boolean	When tracking is turned on (<code>true</code>), the Geolocation API reports changes in location automatically. The default value is <code>false</code> .
<code>trackingOptions</code>	Object	The tracking options support three properties: <ul style="list-style-type: none"> ◆ <code>enableHighAccuracy</code>: This is a Boolean value, default value of which is <code>false</code>. If <code>true</code>, it asks the mobile device to provide the highest-accuracy results. This can result in slower response times and increased power consumption. However, for many devices, it is necessary to enable this option to get any results at all. ◆ <code>timeout</code>: This is a number value, with the default value of 0. This is the number of milliseconds to wait for a new position. If 0, there is no timeout. If set to a value greater than 0 and a position is not obtained within this time frame, then an error of the type <code>TIMEOUT</code> is emitted. ◆ <code>maximumAge</code>: This is a number value, with the default value of 0. This option allows the device to return a cached location whose age is no more than the specified time in milliseconds. A value of 0 means that the device must get a new position.
<code>projection</code>	String	The projection in which the coordinates of location updates are reported defaults to <code>EPSG:4326</code> (latitude and longitude). Typically, you will need to provide the same projection as the map's view or transform the location using <code>ol.proj.transform</code> yourself.

Geolocation KVO properties

The Geolocation class inherits from `ol.Object` and has the following key-value observing (KVO) properties (recall that we discussed KVO in *Chapter 2, Key Concepts in OpenLayers*):

Name	Type	Description
<code>accuracy</code>	number	This is a read-only property. It is the accuracy of the position returned by the device in meters.

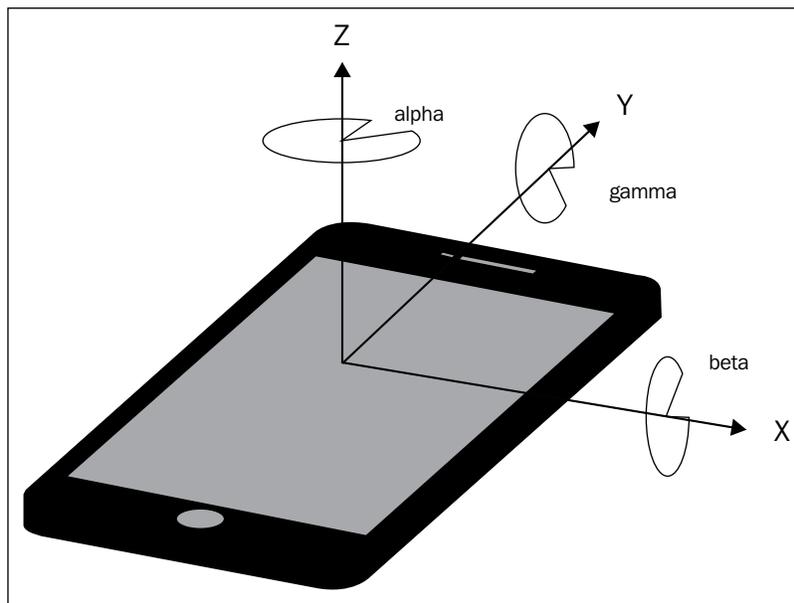
Name	Type	Description
accuracyGeometry	ol.geom. Geometry	This is a read-only property. It is a geometry that can be used to represent the accuracy of the geometry measurement, basically a circle around the location with a radius equivalent to the <code>accuracy</code> property. This geometry can be added to a vector layer and styled to visualize the current accuracy of the location.
altitude	number	This is a read-only property. It is the altitude of the position in meters above mean sea level.
altitudeAccuracy	number	This is a read-only property. It is the accuracy of the altitude in meters.
heading	number	This is a read-only property. It is the heading of the device in radians clockwise from north.
position	ol.Coordinate	This is a read-only property. It is an <code>ol.Coordinate</code> array representing the position of the device. If a projection has been set on the Geolocation instance, the coordinate will already have been transformed into this projection.
projection	ol.proj. Projection	This is the projection in which the coordinates of location updates are reported.
speed	number	This is a read-only property. It is the instantaneous speed in meters per second.
tracking	boolean	When tracking is turned on (<code>true</code>), the Geolocation API reports changes in location automatically. When off (<code>false</code>), the position is not updated in response to moving the device.
trackingOptions	Object	These are the tracking options; see the <i>Constructor options</i> for details.

The DeviceOrientation class

Many new computers, and especially mobile phones and tablets, provide hardware support to track their orientation. The HTML 5 specification defines the `DeviceOrientation` API to expose this information. Just as with the Geolocation API, OpenLayers provides the `ol.DeviceOrientation` class to make it easier to work with this API in a stable, cross-browser compatible way.

Device orientation refers to the orientation of the mobile device relative to a common starting point. A device's orientation is then reported as angles of rotation from this common reference orientation. For mobile devices, the reference orientation is defined as the phone lying face up on a table with the top of the phone pointing north. For computers, it is the same, except the screen is open at 90 degrees. This represents the zero state, and all angles are reported relative to this state.

Device orientation is reported as three angles—*alpha*, *beta*, and *gamma*—relative to the starting orientation along the three planar axes *X*, *Y*, and *Z*. The *X* axis runs from the left edge to the right edge through the middle of the device. Similarly, the *Y* axis runs from the bottom to the top of the device through the middle. The *Z* axis runs from the back to the front through the middle. In the starting position, the *X* axis points to the right, the *Y* axis points away from you, and the *Z* axis points straight up from the device lying flat, as shown in the following screenshot:



In practice, this allows us to respond to the user turning and tilting the device. The most useful property is the value of *alpha*, which lets us figure out where the compass heading the device is pointing at. Let's see this in action!

Time for action – a sense of direction

In this example, we'll display an icon at the user's location, use values from the DeviceOrientation API to create a simple compass, and by rotating it, show which way is north. Perform the following steps to achieve what's been set out in this paragraph:

1. Open the previous example in your text editor, and change the icon we are using from a flag to an arrow. We'll use an arrow pointing up for north. Here's the code to accomplish this:

```
<div id="location" class="marker icon-arrow-up"></div>
```

2. Now, add the following code at the end of the script tag, right after our Geolocation code:

```
var deviceOrientation = new ol.DeviceOrientation({
  tracking: true
});
deviceOrientation.on('change:heading', onChangeHeading);
function onChangeHeading(event) {
  var heading = event.target.getHeading();
  var el = document.getElementById('location');
  el.style['-webkit-transform'] = 'rotate('+heading+'rad)';
  el.style['transform'] = 'rotate('+heading+'rad)';
};
```

3. Reload the page in your mobile device's web browser and try turning. The arrow should rotate as you do, showing the direction you are pointing relative to the map.

What just happened?

Let's walk through the code and see what it does. First, we create a new instance of OpenLayers' helper class `ol.DeviceOrientation` and indicate we would like to receive orientation updates, as follows.

```
var deviceOrientation = new ol.DeviceOrientation({
  tracking: true
});
```

Next, we register a function to receive updates to the `heading` property, and it will be passed an event object that has the information we need, as follows.

```
deviceOrientation.on('change:heading', onChangeHeading);
```

The function that receives the orientation update event does several things. First, we get the value of the `heading` property (in radians) from the event target.

```
var heading = event.target.getHeading();
```



We mentioned before that the value of `alpha` is used to figure out the compass heading. Not all devices support reporting of the device orientation in the same way. In particular, WebKit on iOS reports an `alpha` value that is computed from where the device is pointing when tracking is turned on instead of from north. OpenLayers provides a special property, `heading`, which reports the true angle from north and standardizes this across different devices behind the scenes.

Next, we obtain a reference to the HTML element that contains our arrow. We gave it an ID to make this easier, as follows.

```
var el = document.getElementById('location');
```

Finally, we use CSS to rotate the arrow relative to north so that it's pointing in the direction our phone is pointing. The CSS3 `transform` property can apply a number of transformation functions to an element (see <https://developer.mozilla.org/en-US/docs/Web/CSS/transform>); in this case, we've selected the `rotate` function. We set the angle we want to rotate and specify that the value is in radians, since that is the unit that OpenLayers reports angles in. The following is the code to accomplish this:

```
el.style['-webkit-transform'] = 'rotate('+heading+'rad)';  
el.style['transform'] = 'rotate('+heading+'rad)';
```

We set this property twice to accommodate Safari and Chrome, which still only support the vendor-specific prefixed version of the property name.

Here is the complete API for the `DeviceOrientation` class.

DeviceOrientation constructor options

When creating an instance of `ol.DeviceOrientation`, there is only one option currently available, which is as follows:

Option	Type	Description
<code>tracking</code>	Boolean	When tracking is turned on (<code>true</code>), the <code>DeviceOrientation</code> API reports changes in orientation automatically. The default value is <code>false</code> .

DeviceOrientation KVO property methods

The `DeviceOrientation` class inherits from `ol.Object` and has the following KVO properties.

Name	Type	Description
<code>alpha</code>	<code>number</code>	This is a read-only property. It is the value of <code>alpha</code> in radians. This might not be relative to north depending on the device.
<code>beta</code>	<code>number</code>	This is a read-only property. It is the value of <code>beta</code> in radians.
<code>gamma</code>	<code>number</code>	This is a read-only property. It is the value of <code>gamma</code> in radians.
<code>heading</code>	<code>number</code>	This is a read-only property. It is the heading of the device in radians clockwise from north, normalized for browser differences.
<code>tracking</code>	<code>Boolean</code>	This is a Boolean value indicating whether tracking is enabled or not.

Debugging mobile web applications

Mobile web browsers offer some exciting capabilities for our web applications, especially for map applications! But they offer some challenges too. We've seen in *Chapter 2, Key Concepts in OpenLayers*, that web developers have powerful tools like Chrome Developer Tools at their disposal for debugging web applications. But it's not that easy on mobile devices, where these tools don't exist. Fortunately, there is an answer! In this section, we'll cover techniques for debugging web applications on each of iOS and Android, as well as another tool that isn't device-specific.

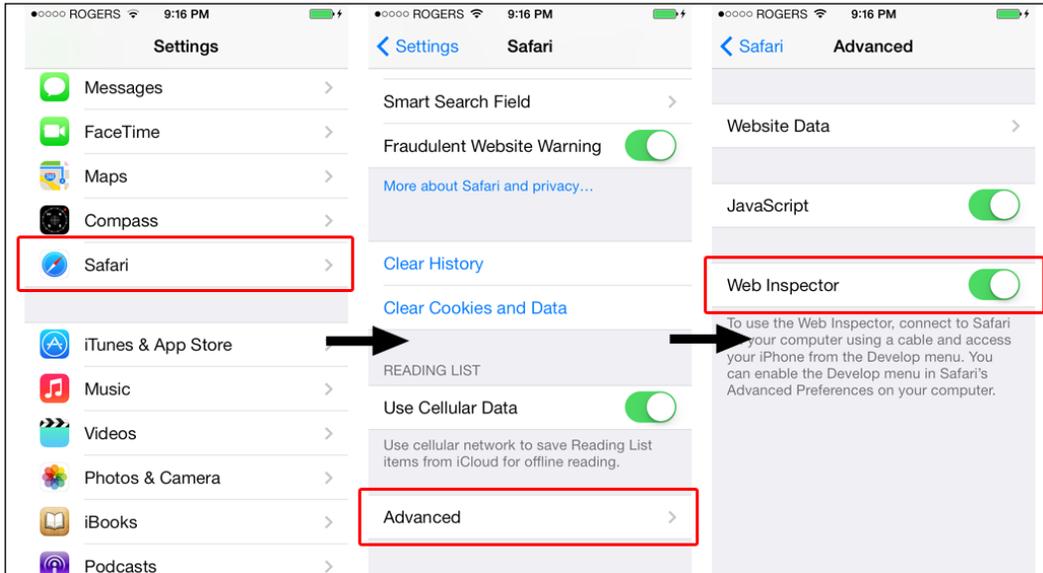
Debugging on iOS

The simplest way to debug web applications on iOS is to enable remote debugging with Safari on your Mac. If you don't have a Mac, skip ahead to the *Debugging on Anything* section.

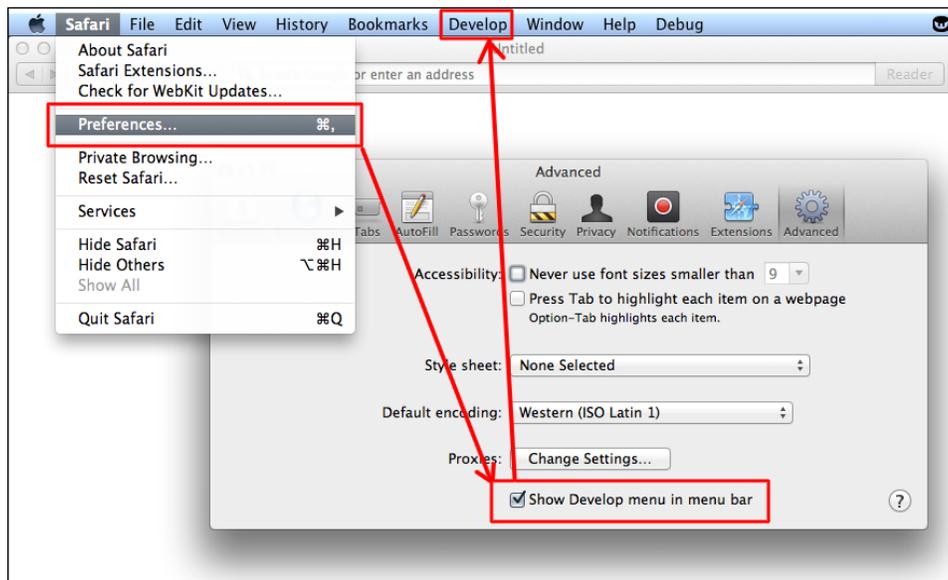


You need a Mac, iOS version 6 or later and Safari version 6.0 or later to enable this feature.

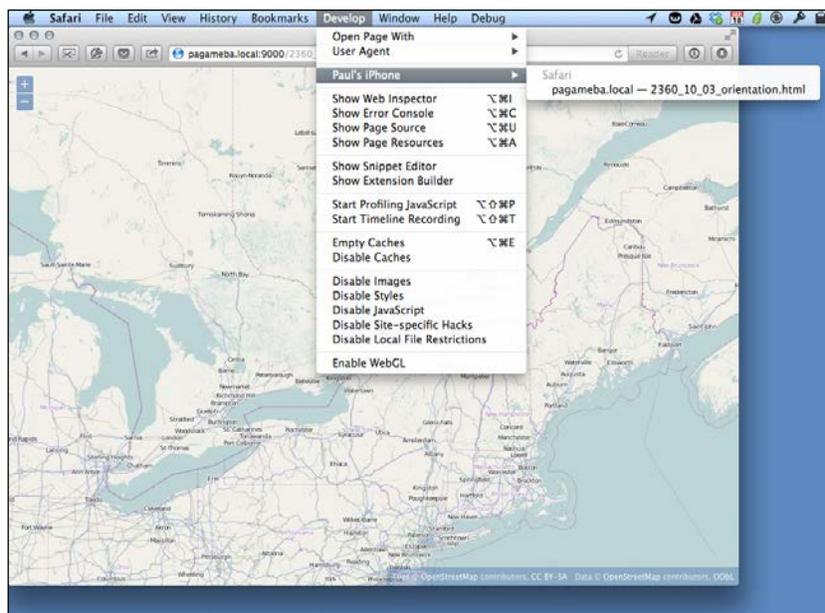
1. First, on your iOS device, head over to **Settings | Safari | Advanced** and toggle **Web Inspector** on. These actions are depicted in the following screenshot:



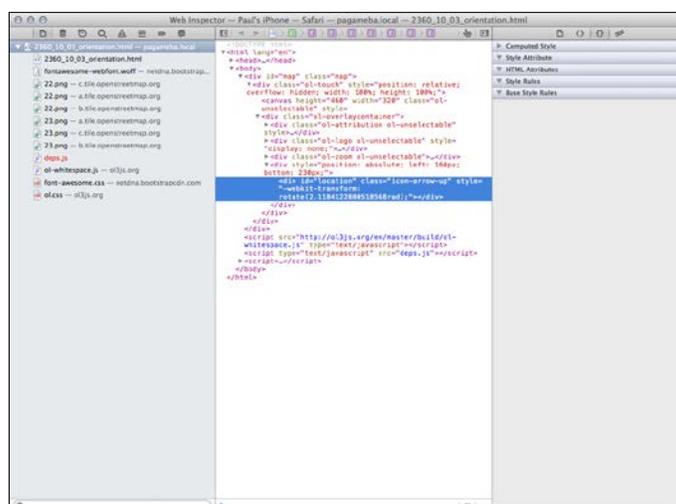
2. Next, you'll need to add the **Develop** menu to Safari on your computer, so open Safari and open the preferences (**Safari | Preferences**), and in the **Advanced** tab, check the **Show Develop menu in the menu bar** checkbox, as shown in the following screenshot:



3. Connect your device to your computer using a USB cable, launch Safari on your iOS device, and then you should see your device in Safari's **Develop** menu on your Mac, as follows:



4. If you have several web pages open in Safari on your iOS device, you will see them all listed. Click on the one that is the mobile example, and Web Inspector will open, as shown in the following screenshot:



What just happened?

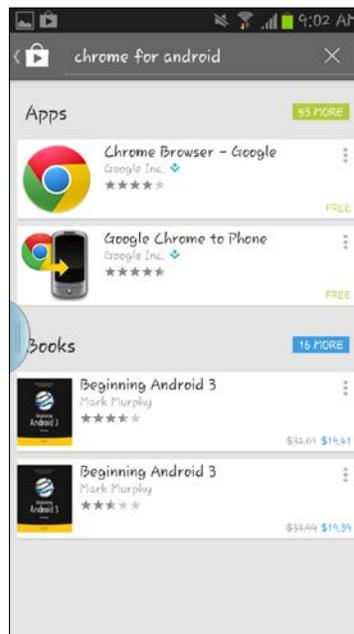
We just enabled some pretty powerful debugging capabilities for our mobile application development. In the first step, we turned on the Web Inspector option that lets us access debug information for the current web browser process in Safari. In the second step, we enabled the Developer menu for Safari on a Mac computer. Finally, when we connect an iOS device to a Mac computer with a USB cable, we can use Safari's web debugging capabilities with the mobile Safari browser.

Depending on your version of Safari, Web Inspector might appear differently. In any case, Web Inspector has basically the same capabilities as those of Chrome Developer Tools, which were introduced in *Chapter 2, Key Concepts in OpenLayers*, and you have full access to inspect the HTML created for your application, change CSS styles dynamically, run JavaScript code, and view logfiles.

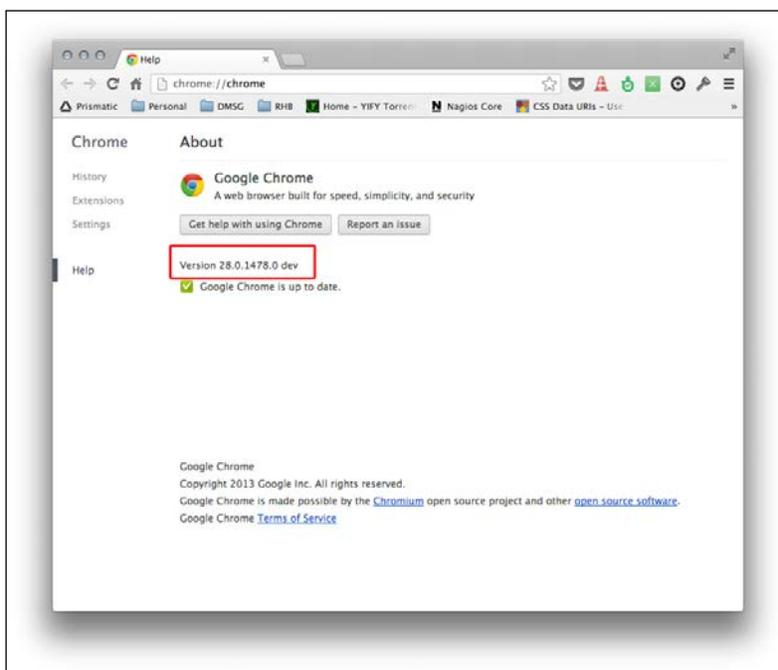
Debugging on Android

If you have an Android device, you can debug your web applications using the ADB Chrome extension and the Chrome DevTools introduced in *Chapter 2, Key Concepts in OpenLayers*. There are quite a few steps to get it all working, but it's worth it when you need it! So, here goes:

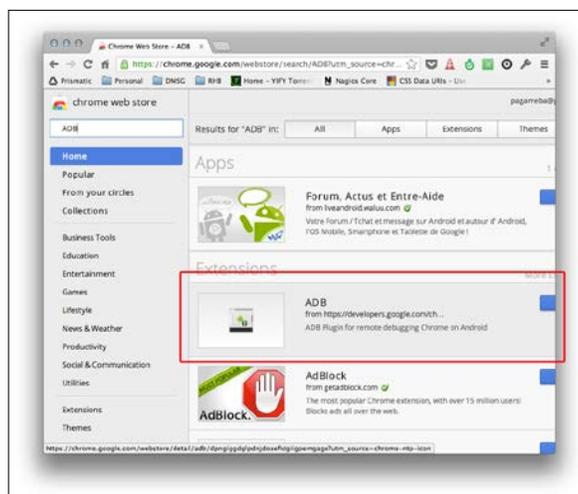
1. If Chrome is not already installed by default, install Chrome for Android version 28 or later from Google Play, and connect your device to your computer with a USB. Here's how your screen looks when you perform these actions:



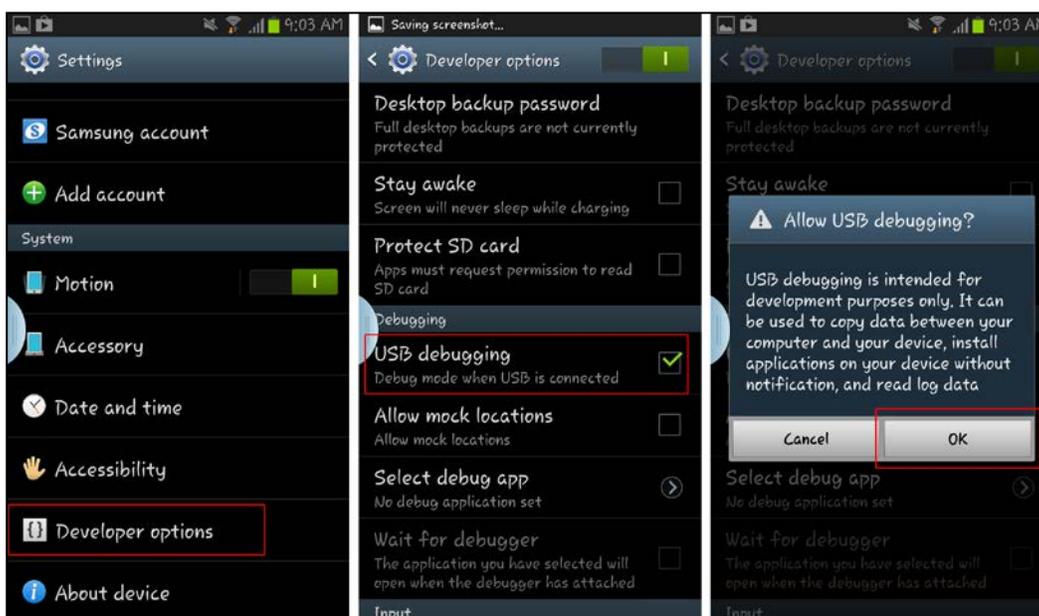
2. Install Chrome version 28 or later on your development machine. The following screenshot depicts the screen as it should look while performing this action:



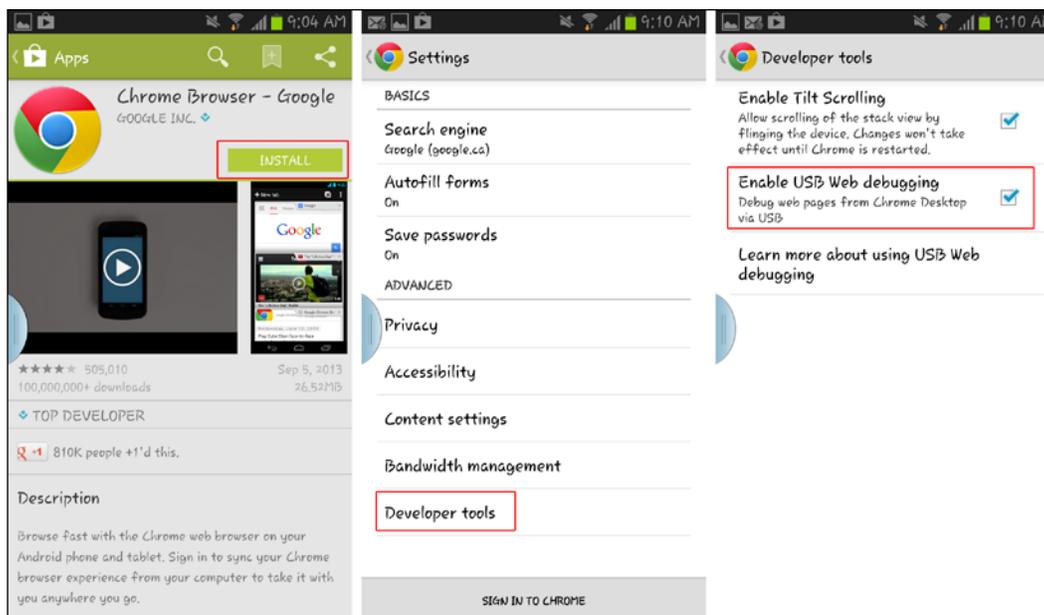
3. Install **ADB Chrome Extension** available in the Chrome web store by opening a new tab in Chrome, clicking the App Store icon, and then searching for **ADB**, as shown in the following screenshot:



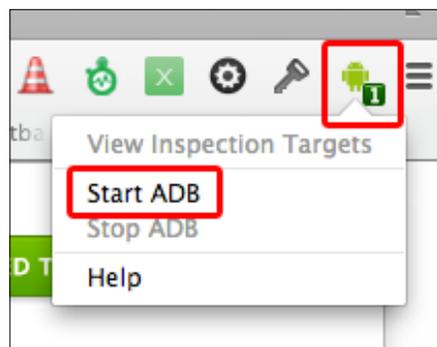
4. Enable USB debugging on your device by opening the **Developer options** settings panel and clicking the checkbox for USB debugging, as follows:
 - For Android 3.2 and older, go to **Settings | Applications | Development**.
 - For Android 4.0 and newer, go to **Settings | Developer**.
 - For Android 4.2 and newer, the **Developer options** panel is hidden by default. To make it available, go to **Settings | About phone** and tap **Build number** seven times. Return to the previous screen to find **Developer options**. Here's how the **Developer options** screens look during this process:



5. Connect your Android device to your computer with a USB cable.
6. Launch Chrome for Android on your device, open **Settings | Advanced | Developer Tools**, and check off the **Enable USB Web debugging** option, as shown in the following screenshots:



7. When you first connect your Android device to your computer, you might see an alert requesting permission to **Allow USB debugging**. To avoid seeing this again, check **Always allow from this computer**, and click on **OK**.
8. Start debugging in Chrome on your computer with ADB Chrome Extension by clicking on the ADB icon in the Chrome toolbar and selecting **Start ADB**, as follows:



9. Click on **View Inspection Targets** to open the **about:inspect** page that displays each connected device and its tabs.
10. Find the mobile device tab you want to debug, and click on the inspect link next to its URL.

What just happened?

Phew! First, we made sure that we installed Chrome for Android on the device and the latest version of Chrome on our computer. Next, we installed ADB Chrome Extension for Chrome. Then, we allowed USB debugging on the device. Finally, we launched ADB Chrome Extension to see it in action. You can now debug your mobile web application running on your device with the Chrome Developer Tools.



It is also possible to debug using Firefox on Android; see https://developer.mozilla.org/en-US/docs/Tools/Remote_Debugging/Firefox_for_Android for more information.

Debug anywhere – Web Inspector Remote (WEINRE)

Native debugging on mobile is great once you get it working, but what do you do when you don't have a USB cable with you, you have an iPhone but not a Mac, or you want to debug on some other device? There's a solution, of course, and the solution is to use **WEINRE (Web Inspector Remote)**, an open source package that gives you an almost native debugging capability for mobile devices.

WEINRE is part of the Apache Cordova project (<http://cordova.apache.org/>) and was pioneered by Patrick Mueller. We will talk about Apache Cordova in the next section.

Using WEINRE involves combining three separate components, as follows:

- ◆ **The debug server:** This is an HTTP server provided by WEINRE; it's used by the debug client and the debug target.
- ◆ **The debug client:** This is the Web Inspector user interface we will use to debug your application. It displays the **Elements** and **Console** panels, among other things.
- ◆ **The debug target:** This refers to both the machine running the browser that we want to debug and the web page being debugged.

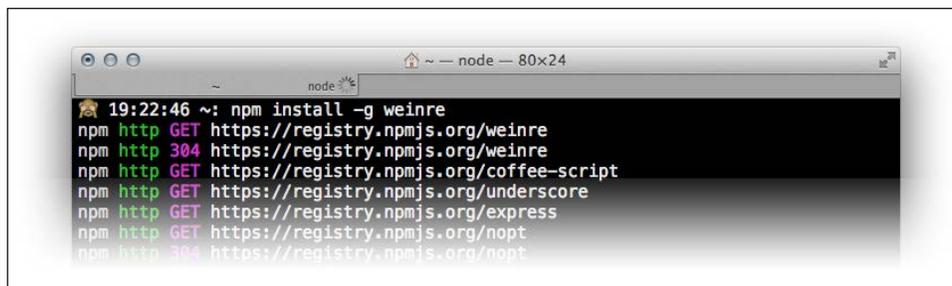
The debug client and the debug server run on our development computer and the debug target runs on the mobile device.

To activate the debug target, we will need to add some JavaScript code, provided by the debug server, into the web page.

Getting started with WEINRE

WEINRE is a **Node.js** application and is published as an NPM package. We've already talked about using Node.js and NPM to run a small server for editing features in *Chapter 8, Interacting with Your Map*. To install WEINRE then, all we need to do is open a command prompt and run the following command:

```
npm install -g weinre
```

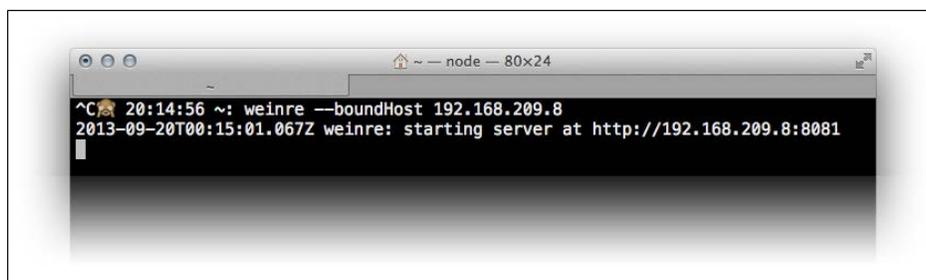
A terminal window titled "node" with a width of 80x24. The prompt is "~". The user enters the command "npm install -g weinre". The terminal shows the following output: "19:22:46 ~: npm install -g weinre", "npm http GET https://registry.npmjs.org/weinre", "npm http 304 https://registry.npmjs.org/weinre", "npm http GET https://registry.npmjs.org/coffee-script", "npm http GET https://registry.npmjs.org/underscore", "npm http GET https://registry.npmjs.org/express", "npm http GET https://registry.npmjs.org/nopt", and "npm http 304 https://registry.npmjs.org/nopt".

```
node 19:22:46 ~: npm install -g weinre
npm http GET https://registry.npmjs.org/weinre
npm http 304 https://registry.npmjs.org/weinre
npm http GET https://registry.npmjs.org/coffee-script
npm http GET https://registry.npmjs.org/underscore
npm http GET https://registry.npmjs.org/express
npm http GET https://registry.npmjs.org/nopt
npm http 304 https://registry.npmjs.org/nopt
```

This is how the command prompt would look when we run the preceding command. This command instructs NPM to install the WEINRE package globally, which will make the `weinre` command available to you.

To start WEINRE, we need to use the IP address of the development machine—see the beginning of this chapter if you don't remember it. Open a command prompt and run the following command:

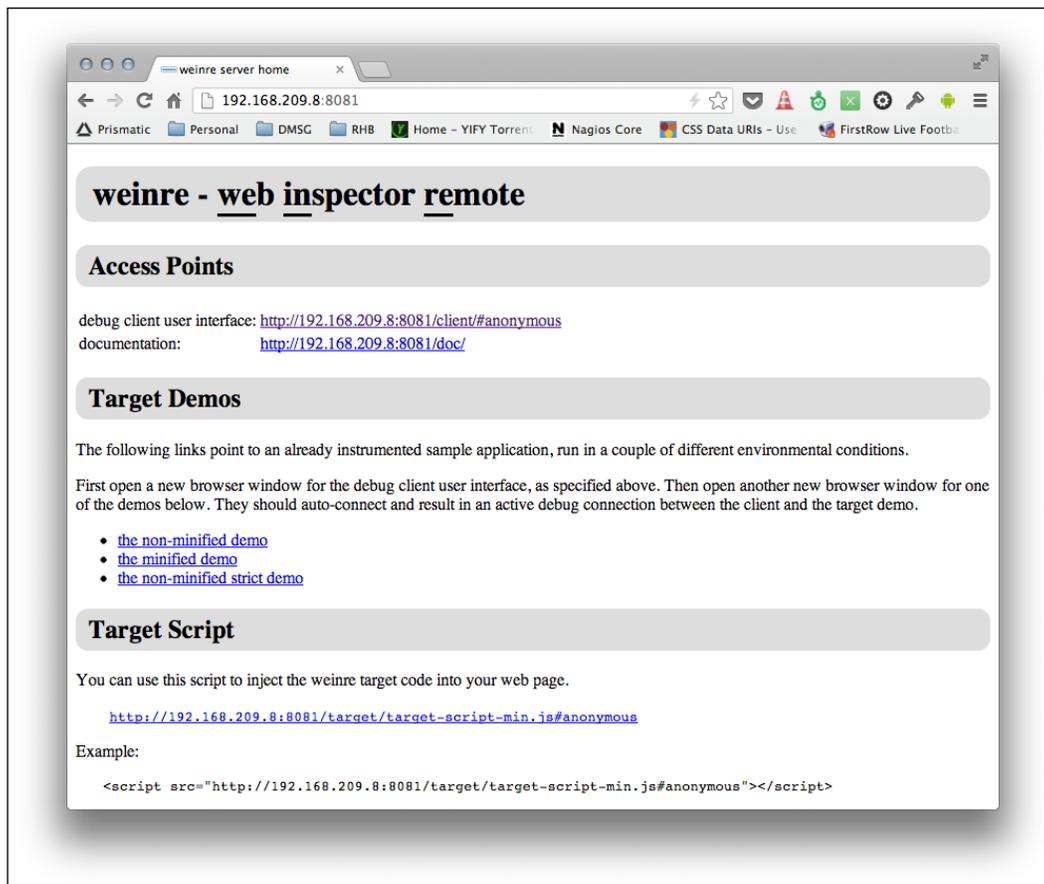
```
weinre -boundHost <your ip address>
```

A terminal window titled "node" with a width of 80x24. The prompt is "~". The user enters the command "weinre --boundHost 192.168.209.8". The terminal shows the following output: "20:14:56 ~: weinre --boundHost 192.168.209.8" and "2013-09-20T00:15:01.067Z weinre: starting server at http://192.168.209.8:8081".

```
node 20:14:56 ~: weinre --boundHost 192.168.209.8
2013-09-20T00:15:01.067Z weinre: starting server at http://192.168.209.8:8081
```

This is how the command prompt would look when we run the preceding command. The `boundHost` option allows the debug target's JavaScript to be loaded in a page on another machine, such as our mobile device. There are several other command-line options that you can supply to the `weinre` command; for the most part, you don't need them, but you can read about them in the WEINRE documentation at <http://people.apache.org/~pmuellr/weinre/docs/latest/Running.html>.

WEINRE starts a debug server and reports the URL at which the debug server page can be accessed. Copy this URL and open it in a web browser. The following is how the page will look when these actions have been performed:

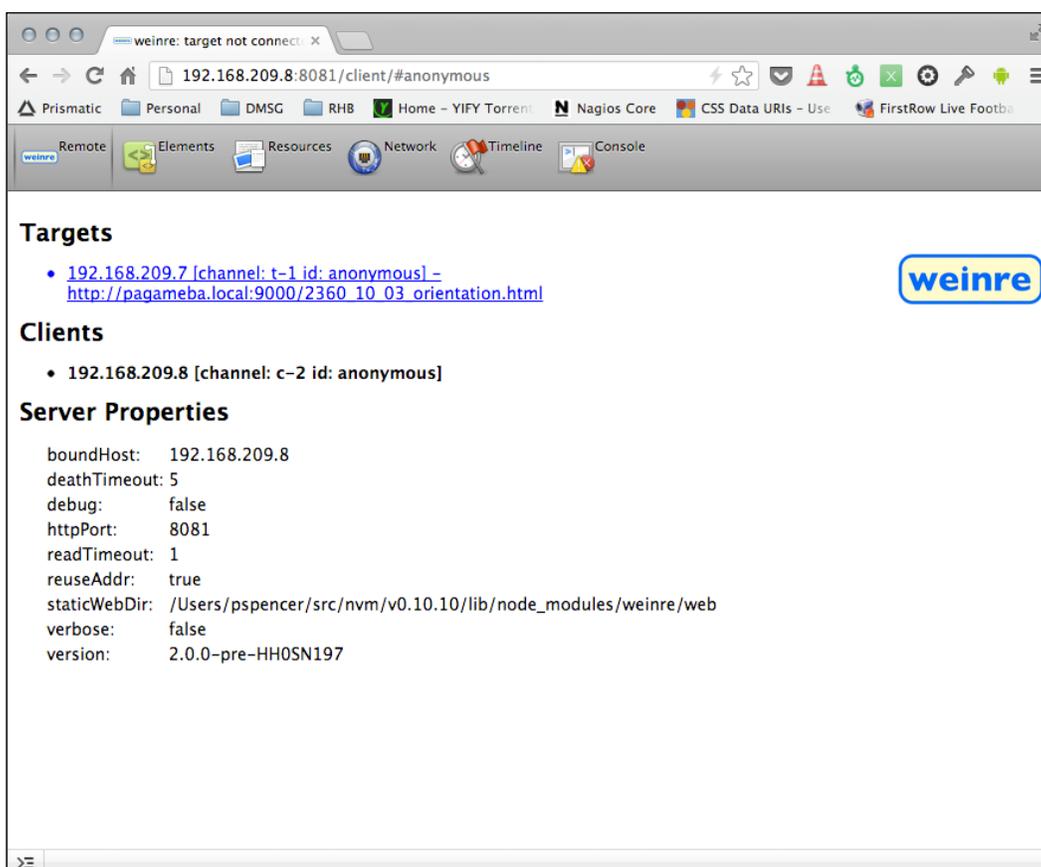


This page has the information and links we need to get started with debugging our mobile web application. The first section, **Access Points**, contains links to the **debug client user interface** and **documentation**. The second section, **Target Demos**, gives you some quick links to try out WEINRE debugging right away. Try them if you like. The third section contains the link to the JavaScript we will need to add to our mobile web page to activate the debug target code. Let's go ahead with this now.

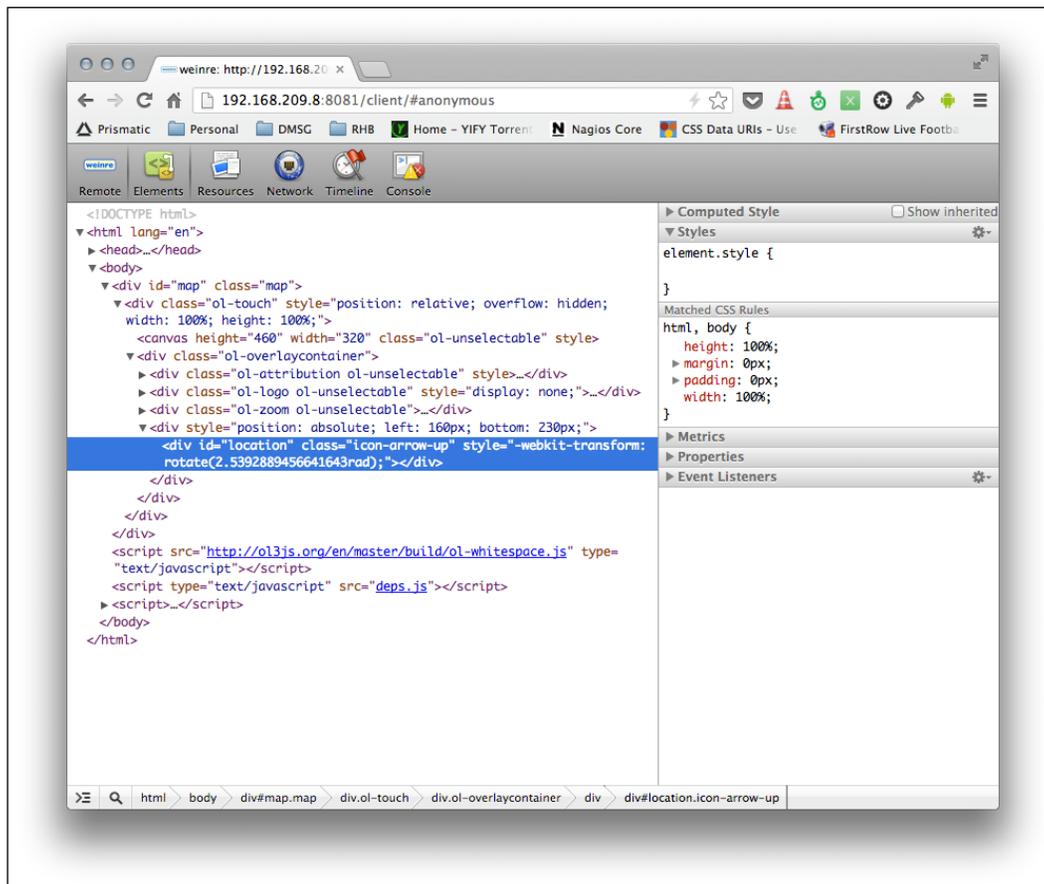
Open the mobile example page in a code editor. Copy the `<script>` tag from the following example in the target script section, and paste it into the example page just after the `<title>` tag, as follows:

```
<title>Mobile Examples</title>
<script src="http://192.168.209.8:8081/target/target-script-min.
js#anonymous"></script>
```

Now, for the big finale—load the mobile example on your mobile device, and then click on the link to open the **debug client** on your desktop machine. After that, this is how your screen will look:



The **Remote** tab shows the **debug target** connected and some other information. You can now click on the **Elements**, **Resources**, **Network**, **Timeline**, and **Console** tab. Click on the **Elements** tab to show the **Elements** panel. This is how your screen will look after performing these actions:



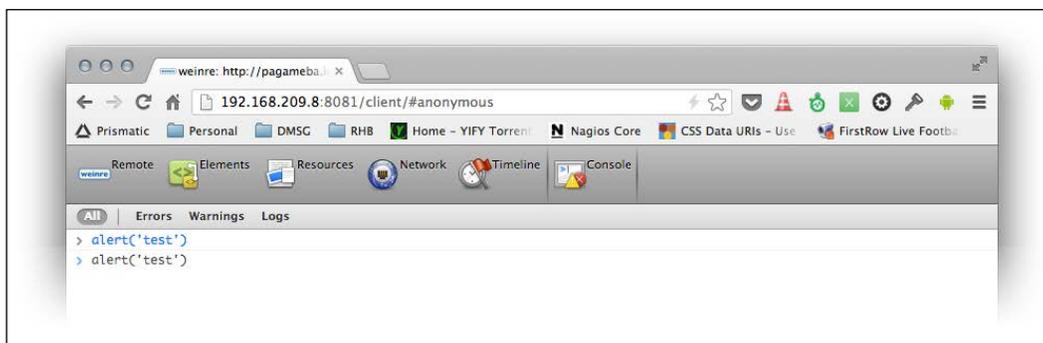
You can use the **Elements** panel just like Chrome Developer Tools and explore the DOM. Note that it can take a few moments for WEINRE to respond with information, so be patient and wait for it to appear.

The **Resources** panel shows WebSQL databases and data stored in the local storage and session storage. The **Network** panel shows XML HTTP requests issued after the page has loaded. Unlike Chrome Developer Tools, it can't capture the assets loaded by the page itself.

The **Timeline** panel can be used to display timing information about events and to track user-triggered events. Using this panel is beyond the scope of this book, but if you are interested, then check out the WEINRE documentation.

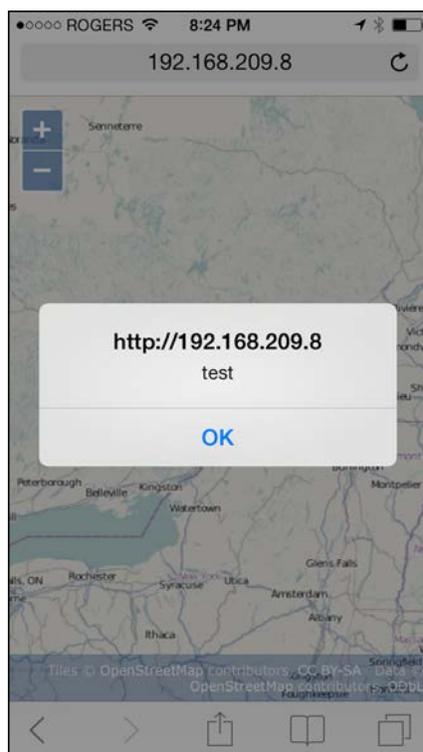
The last tab, **Console**, displays the JavaScript log and provides a command line for executing arbitrary JavaScript in your web page. Try typing the following command into the console and hit *Enter*:

```
alert('test');
```



Your screen will look like this when the preceding command has been entered.

You should see an alert pop up on your mobile device, as shown in the following screenshot:



The **Console** tab also shows log messages, and we can filter by message types (**Errors**, **Warnings**, and **Logs**). Some log messages are generated by the browser itself, typically when an error happens, and we can use WEINRE to see if errors are happening. We can also programmatically send messages to log in our code using methods of the global console object that are available in all web browsers.

WEINRE isn't as complete as native debugging with iOS and Android, but it can certainly help out at a pinch.

Going offline

One of the great challenges in delivering content to the mobile web is that mobile devices can easily be disconnected from the Internet. As users move around, they go in and out of range of WIFI and cellular networks, and the state of their network connection can change frequently. Native applications on mobile devices solve this problem by being installed on the device. Many native applications also cache content for offline use and are designed to handle the transient nature of mobile network connections. Web browsers, including mobile web browsers, typically cache web page content to help pages load faster. While this can help mobile web applications quite a bit, the cache managed by the web browser is unreliable, can be cleared by user settings, and might not keep critical content for your application. The cache also doesn't provide a mechanism to store generated data and stores only assets required to load a web page.

In this section, we will introduce three technologies that can help you with taking a web application offline:

- ◆ HTML5 ApplicationCache interface
- ◆ HTML 5 Storage
- ◆ Apache Cordova

The HTML 5 ApplicationCache interface

The HTML 5 ApplicationCache interface is designed to help address the unreliable nature of web browser caches by allowing a developer to control how content is cached for offline use. The `ApplicationCache` interface provides us with the following benefits:

- ◆ Developers can specify exactly which resources to cache and ensure that users can navigate to all the content regardless of their network state
- ◆ Developers can also specify which resources not to cache
- ◆ Content in `ApplicationCache` is not displaced by new content in the normal browser cache, so it is much more reliable

- ◆ Content is cached locally on the device, and so it will load much faster than across a network
- ◆ Developers can update content and have only that content transferred, reducing load on web servers

If you are thinking *Sounds great, lets get me some of that*, read on!

Taking advantage of the `ApplicationCache` interface is actually very simple, and there are three steps we need to take:

- ◆ Create a **MANIFEST** file
- ◆ Reference the MANIFEST file in an HTML page
- ◆ Serve the MANIFEST file from our web server correctly

Creating an `ApplicationCache` MANIFEST file

A MANIFEST file is a plain text file that you can create in any text editor. The easiest way to describe its content is by example, so let's take a look at a MANIFEST file and then describe it in detail:

```
CACHE MANIFEST
# version 2
CACHE:index.htmlscripts/app.jscss/styles.cssimages/logo.png
NETWORK:login.php
FALLBACK:images/large/ images/offline.jpg*.html /offline.html
SETTINGS:prefer-online
```

The first line is mandatory; it must contain the specific text `CACHE MANIFEST`.

The second line is a comment. Comments are any line starting with a `#` character. One important characteristic of `ApplicationCache` is that the browser will usually not replace cached content with an updated version from the server unless the MANIFEST file changes or the `prefer-online` setting is specified. It is a common convention to include a comment near the top of the MANIFEST file, indicating a date or version number. When content is updated, the date or version in the MANIFEST file can also be updated, which will trigger the browser to download changed content. The third line declares the `CACHE` section. The `CACHE` section explicitly declares URLs that will be stored in the `ApplicationCache`. This line can be optional. If it is omitted, any files after the first line will be considered part of the `CACHE` section up to the start of any other section. The following lines up to the `NETWORK` line define files, by URL, that are to be cached. Wildcards are not allowed in the `CACHE` section. Do not include the MANIFEST file in the list of files to be cached, or it will be very difficult for users to get updates. URLs can be relative or absolute and might point to resources on domains other than that of the page being loaded. Check the following line, for example:

```
CACHE:
http://another.server.com/logo.png
```

Next, comes the `NETWORK` section. This section contains a whitelist of resources that the browser will not cache (unless explicitly declared in the cache section), and which it is permitted to access when online. In this example, the browser can access `login.php` when online, and the results of loading that page will not be cached. This section is typically used to identify URLs that are part of a server API or content that cannot be used if it is out of date. URLs cannot contain wildcards, but a single wildcard character is allowed on a line by itself to indicate that any URL can be loaded. Check the following line for example:

```
NETWORK:  
*
```

The `FALLBACK` section defines alternate resources to be used if a particular resource is not available. Wildcards and path matching are allowed in this section. The first line of the `FALLBACK` section shows how you would display the image from `images/offline.jpg` for any image in the `images/large` path that is unavailable. In the next line, we specify that any HTML page that cannot be accessed should use `offline.html` instead. URL prefixes are allowed (a path to a folder for instance), but the wildcard character `*` is not permitted. Also, only URLs in the same domain as the web page can be listed in this section. As of writing this book, only one value is permitted in the final `SETTINGS` section, the `prefer-online` setting. If this is present in the `SETTINGS` section, then the browser will attempt to access the server version of resources before using the cached version.

Note the following rules for a MANIFEST file:

- ◆ The first line must contain the text `CACHE MANIFEST`.
- ◆ A line starting with the `#` character is considered a comment.
- ◆ Comments must be on their own line as the `#` character is a valid component of a URL.
- ◆ Any non-comment lines after the first line are implicitly part of the `CACHE` section up to the start of one of the other sections. Thus the `CACHE:` line is not strictly needed.
- ◆ Only spaces and tab characters are allowed for whitespace, and all other characters are considered part of a URL.
- ◆ There are four distinct section types. The allowed section names are `CACHE`, `NETWORK`, `FALLBACK`, and `SETTINGS`. A section is started by putting the section name followed by the `:` character.
- ◆ Sections can appear in any order and can be repeated.

Referencing a MANIFEST file in a web page

In order to trigger the use of an `ApplicationCache` MANIFEST file, you must include a reference to the MANIFEST file in your web page. This is done as an attribute of the `<html>` tag, as follows:

```
<html manifest="/myapp.appcache">
```

The value of the attribute is the URL to your MANIFEST file. Although the MANIFEST file can have any extension, it is standard practice to use `.appcache` as the file extension, and we recommend you follow this practice. The MANIFEST file must be delivered by a web server with `mime-type` of `text/cache-manifest`. The instructions for configuring a web server to serve particular files with a particular `mime-type` vary depending on the particular web server in use. Please consult the documentation for your web server to determine the best way to accomplish this.

Time for action – MANIFEST destiny

Let's take the MANIFEST file out for a spin with our mobile example. The first thing we need to do is decide which resources we want to be included in our application cache and which we want to be excluded. Our application is pretty simple, so we won't need to exclude anything. So, here's what we will do:

1. Open a text editor and create a new file. Save it as `myapp.appcache` next to your example's HTML file.
2. Determine which files to include in the cache. You can do this in several ways, but the easiest is to load your page into a web browser and look at the **Network** tab. Here's how your screen looks when the **Network** tab is pressed:

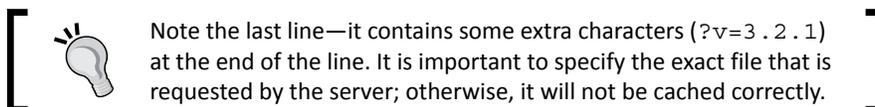
The screenshot shows the Chrome Developer Tools Network tab for the URL `http://localhost:9000/chapter11/2360_10_04_appcache.html`. The table below represents the data shown in the Network tab:

Name Path	Method	Status Text	Type	Initiator	Size Content	Time Latency	Ti
2360_10_04_appcache.html /chapter11	GET	200 OK	text/html	Other	(from c...	4 ms	
ol.css /assets/ol3	GET	200 OK	text/css	2360_11_04 a... Parser	(from c...	3 ms	
samples.css /assets/css	GET	200 OK	text/css	2360_10_04 a... Parser	(from c...	3 ms	
font-awesome.css /assets/css	GET	200 OK	text/css	2360_10_04 a... Parser	(from c...	95 ms	
ol.js /assets/ol3	GET	200 OK	applica...	2360_10_04 a... Parser	(from c...	452 ms	
fontawesome-webfont.woff?v=3.2.1 /assets/font	GET	304 Not Modif	applica...	2360_10_04 a... Parser	244 B 42.6 KB	305 ms	
22.png b.tile.openstreetmap.org/6/18	GET	200 OK	image/...	ol.js:450 Script	(from c...	0 ms	
23.png c.tile.openstreetmap.org/6/18	GET	200 OK	image/...	ol.js:450 Script	(from c...	0 ms	
22.png c.tile.openstreetmap.org/6/19	GET	200 OK	image/...	ol.js:450 Script	(from c...	0 ms	
23.png a.tile.openstreetmap.org/6/19	GET	200 OK	image/...	ol.js:450 Script	(from c...	0 ms	
22.png	GET	200 OK	image/...	ol.js:450 Script	(from c...	0 ms	

The first six lines are files requested directly by our application, and the remainder are map tiles loaded from the OpenStreetMap server. We'll explicitly cache the first six in our example.

3. Add the following lines to the file:

```
CACHE MANIFEST
# version 1
CACHE:
23600S_10_04_appcache.html
../assets/ol3/ol.css
../assets/css/samples.css
../assets/css/font-awesome.css
../assets/ol3/ol.js
../assets/font/fontawesome-webfont.woff?v=3.2.1
NETWORK:
*
```



4. Open the HTML file, and add a manifest attribute to the `<html>` tag, as follows:
`<html lang="en" manifest="myapp.appcache">`
5. Reload the application in your mobile browser. Everything should work normally.
6. Disconnect your mobile device from your computer, and disable cellular data and WIFI networking. On most devices, there is also an **airplane mode**, but this also disables your GPS.
7. Reload the application in your mobile browser once more. The application should load correctly.

What just happened?

We created an application cache MANIFEST file for our application, so it can load our application even when it has no network connection. The `CACHE` section contains the files we are explicitly using in our application. The `NETWORK` section contains the wildcard character to allow our application to access any URLs when we are online so that we can get map tiles. Now, when the mobile device is offline (it has no network connection), the application can still be loaded correctly.

Unfortunately, if you pan or zoom, you will start to see some blank spots. These are map tiles that are not cached by our browser. On the first load, you should see any map tiles that were loaded while we were online (in step 5). Any tiles you accessed prior to going offline might be available in the normal browser cache until it is cleared or they are displaced by newer content.

In summary, the `ApplicationCache` interface provides an easy and convenient mechanism to ensure content is available offline and to speed up loading of any web application by explicitly caching content in the browser for online and offline use. Unfortunately, for mapping applications, it doesn't solve the problem of accessing remote servers, including map tile sources, while offline. The next section, on HTML5 Storage, discusses part of the solution, and the final section, on Apache Cordova, provides another alternative.

Going native with web applications

Mobile web applications are a fast-growing market. Users with mobile devices expect access to all content on their mobile devices. While mobile web applications provide a great user experience in most cases, they often fall short of so-called native applications because they do not have access to convenient offline storage, capabilities of the physical device such as the camera, and data available to other applications, such as the user's contact list. Short of building a native application, there doesn't seem to be a way to access the full capabilities of mobile devices. But, do we really want to recode our great web application into native code for iOS, Android, Blackberry, Windows Mobile, and whatever other devices our users might have?

It turns out that we don't have to. On every major mobile platform, the web browser is also available as a component that can be embedded into a native application. This one fact means that it is possible to create native applications whose entire user interface is a web page and still have access to all the native functionality of the device. Doing this on every platform that you might want to support probably seems like a daunting task even if you know anything about coding native applications—or perhaps especially if you do!

Open source to the rescue again! Apache Cordova, a fantastic project of the Apache Foundation, provides the framework to create native applications from mobile web applications with almost no need to know anything about native development—and it works on all major mobile platforms. Not only will Cordova provide you with the tools to wrap your web application up into a native application, it also exposes the most common native capabilities to your web application, including:

- ◆ Access to device storage, allowing you to save content for persistent offline use, bypassing the temporary nature of browser caches, and providing much more storage capacity than would otherwise be available.
- ◆ Access to native hardware capabilities, including the camera, battery status, and others.
- ◆ Access to contacts and media.
- ◆ Access to native dialog.

Unfortunately, we can't cover using Apache Cordova in any detail in this book—there simply isn't enough room; it's enough material for an entire book by itself! If you need access to more than the web browser can provide on mobile devices though, we highly recommend that you check out the Apache Cordova website at <http://cordova.apache.org/>, where you will find lots of great information and starter projects to get you going on each platform.

Time for action – track me

Let's bring together what we've learned by expanding our application to track our movement over time and display it on the map. Recall that we covered vector features in *Chapters 6, Styling Vector Layers*, and *Chapter 5, Using Vector Layers*. So, here's what we will do:

1. We need a vector feature to capture our track. Add the following at the beginning of the `<script>` tag:

```
var trackStyle = new ol.style.Style({
  stroke: new ol.style.Stroke({
    color: 'rgba(0,0,255,1.0)',
    width: 3,
    lineCap: 'round'
  })
});
var trackFeature = new ol.Feature({
  geometry: new ol.geom.LineString([])
});
var trackLayer = new ol.layer.Vector({
  source: new ol.source.Vector({
    features: [trackFeature]
  }),
  style: trackStyle
});
```

2. We'll need to add `trackLayer` to the map, so add it to the array of layers where we create the map, as follows:

```
var map = new ol.Map({
  target: 'map',
  layers: [layer, trackLayer],
  view: view
});
```

3. And finally, we can update `trackFeature` as we move by modifying what happens when the geolocation object's position changes, as follows:

```
geolocation.on('change:position', function() {
  var coordinate = geolocation.getPosition();
  view.setCenter(coordinate);
  trackFeature.getGeometry().appendCoordinate(coordinate);
});
```

4. Load the application in your mobile device and move around enough to see your location changing. Perhaps go outside for a short walk!

What just happened?

We just created a very simple tracking application that follows our location and renders a line on the map to show where we've been. In step 1, we created a few new objects based on our knowledge of vector layers and features from *Chapters 6, Styling Vector Layers*, and *Chapter 5, Using Vector Layers*. First, we created a style object that draws our line in blue. Next, we created a feature object containing a `LineString` geometry to record our movements in. Lastly, we created a vector layer with a source that references our track feature using our style for blue lines. In step 2, we added the layer to the map. In step 3, we updated the geometry of the track feature by appending the latest position update coordinate to its `LineString` geometry.

Pop quiz – who does what?

Q1. Which OpenLayers class provides access to a mobile device's location?

1. `ol.GeoLocation`.
2. `ol.View`.
3. `ol.DeviceOrientation`.

Q2. Which OpenLayers class tells you which direction your mobile device is pointing in?

1. `ol.GeoLocation`.
2. `ol.View`.
3. `ol.DeviceOrientation`.

Q3. Which OpenLayers class would you use to center the map on your current location?

1. `ol.GeoLocation`.
2. `ol.View`.
3. `ol.DeviceOrientation`.

Summary

This brings us to the end of this chapter. We've seen that OpenLayers is basically mobile-ready out-of-the-box, and there's really not much we need to do to make it work in a mobile web browser. The `GeoLocation` and `DeviceOrientation` classes provide access to some useful information in a mobile environment, including our position, speed, altitude, and direction of travel, and we saw these in action. We can even tell which direction our device is pointing in. We've learned how to debug mobile applications and how to prepare them for working offline. We wrapped up with an example that records our movement over time using vector layers and features.

In the next and final chapter, we will be building a complete application from scratch using everything we've learned so far. We'll also be introducing the OpenLayers build tools and learning how to create a production-ready application.

11

Creating Web Map Apps

By now, we've covered all the parts of OpenLayers that are essential for making our own web map application. So far, we've been focusing on how to use the various different parts of OpenLayers. In this chapter, we'll put together those pieces that we've learned and demonstrate how to create an actual web map application with OpenLayers.

While we won't be introducing many new things in this chapter, we will put them together in ways we haven't before. Throughout this chapter, we'll:

- ◆ Cover common development strategies
- ◆ Learn how to interact with third-party data
- ◆ Build a web-mapping application from scratch using Flickr
- ◆ Deploy our applications and discuss what deployment means
- ◆ Discover how to build the OpenLayers library file

Development strategies

In this chapter, we'll be developing a web map application that loads in data from a third-party source (Flickr). The examples have been structured with iterative development in mind. What this means is that you start small and make many changes, gradually building up your web map from nothing into something useful. **Iterative development** is an important, popular, and effective way to develop applications. The core idea is that you create something simple, get it working, and then improve it. You can figure out more quickly what does and doesn't work by improving on, and learning from, the previous iterations.

Another strategy we'll make use of is **modular programming**. What this means, essentially, is that we try to keep things as discrete (or modular) as possible. By doing so, once we know a component works, we don't have to worry about it later.

Using geospatial data from Flickr

Because OpenLayers is so flexible, it's easy to make third-party software and data work with our maps. Sharing geospatial data is becoming more popular, with services such as Flickr and Twitter freely offering geospatially embedded data. Being able to visualize data often helps us to understand it. Using OpenLayers, we can place geospatial data (say, Twitter posts or Flickr images) on a map and get a clearer picture about the data.

Note on APIs

Many popular sites provide an **API (Application Programmer Interface)** that allows programmers to interact with their data. For instance, both Flickr and Twitter provide APIs that enable developers to view recent updates (photo uploads and tweets). These APIs (but not all APIs) let us get geospatial data that we can use with OpenLayers. Flickr provides some very easy-to-use methods to retrieve data with associated geographic information; so, we'll focus this chapter on building a web-mapping application around Flickr.

 You can find out more about APIs and what they support at various websites, a good one is <http://www.programmableweb.com>.

Accessing the Flickr public data feeds

While Flickr provides a very robust developer API, we'll only interface with Flickr via URL calls that provide access to feeds. Feeds provide information about data, and we can get different kinds of feeds (for example, a specific user's feed or the feed for all users combined). It's really quite easy to do; we just make a call to a URL and specify certain parameters. The base URL we'll call is `http://api.flickr.com/services/feeds/geo/?format=kml`. The `format` parameter can be a number of values—KML, JSON, RSS, SQL, and so on. We'll be using KML and JSON in this chapter. When calling this URL, a file in the format you ask for will be returned that contains information about the latest photos uploaded that have geographic information associated with them (that's what `geo` in the URL is for).

 Flickr's API documentation can be found at <http://www.flickr.com/services/api/>. More information about the Flickr feeds can be found at <http://www.flickr.com/services/feeds/>.

Specifying data

We can refine the data that is returned by adding additional parameters to the URL. You can specify a user's ID via the `ID` key, a group via the `g` key, and tags via the `tags` key. You can also specify other things, such as a certain coordinate and radius—for now, we'll just be focusing on the `tags` key.

How we'll do it

Let's create a web map application that will pull in data from Flickr and display it on a map. This will allow us to see, geographically, from where photos were submitted. We can, for example, search for bird photos and get an idea where some particular bird species might be common (or at least, commonly photographed and uploaded to Flickr).

The application will provide a search box to enter tags and refresh the map based on them, and allow you to click on points on the map to view the photo and details about it.

We'll break down the development of this application into small steps:

1. Download a static sample of the Flickr data.
2. Create a simple application to display it.
3. Add interactivity to view details about the photos.
4. Load the data in real time from Flickr.
5. Add a search box and refresh the data based on search terms.

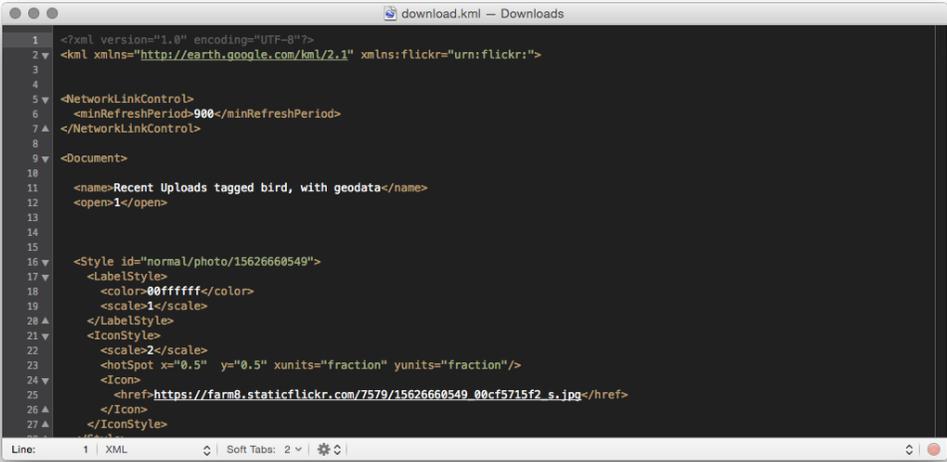
Okay, we've got a goal in mind and broken it down into some manageable steps—we'll start simple and improve in increments until we reach our goal. Let's get started.

Time for action – getting Flickr data

The first step in our application will require us to get data from Flickr. We'll request some data and save it locally.

1. The first step, is to figure out what sort of data we want to get. To simplify things, let's start with KML data. We'll use the URL we mentioned before, but we'll also specify a tag. Let's use `bird` as a tag. Open up this URL in your web browser, and you should be able to download it as a KML file from `http://api.flickr.com/services/feeds/geo/?format=kml&tags=bird`.
2. Save the file as `flickr_data.kml` and place it in your map directory.

3. Open up the file in your text editor and take a look at it. We won't be editing it, but just take a look to see how the data is structured. Notice that there are `style` tags—if we want, we can directly apply the styles from the file to our map (as we'll see soon).



```
1 <?xml version="1.0" encoding="UTF-8"?>
2 <kml xmlns="http://earth.google.com/kml/2.1" xmlns:flickr="urn:flickr:">
3
4
5 <NetworkLinkControl>
6   <minRefreshPeriod>900</minRefreshPeriod>
7 </NetworkLinkControl>
8
9 <Document>
10
11   <name>Recent Uploads tagged bird, with geodata</name>
12   <open>1</open>
13
14
15
16   <Style id="normal/photo/15626660549">
17     <LabelStyle>
18       <color>00ffffff</color>
19       <scale>1</scale>
20     </LabelStyle>
21     <IconStyle>
22       <scale>2</scale>
23       <hotSpot x="0.5" y="0.5" xunits="fraction" yunits="fraction"/>
24     </IconStyle>
25     <href>https://farm0.staticflickr.com/7579/15626660549_00cf5715f2_s.jpg</href>
26   </Icon>
27 </IconStyle>
```

What just happened?

We just downloaded the latest images in the KML format that contained a tag called `bird`. When you call the URL and pass in a tag, Flickr will return to you the latest images uploaded that have some geographic information associated with them. You may be wondering why we downloaded the KML file. If you remember from *Chapter 5, Using Vector Layers*, we can just create a vector layer and point to the Flickr URL, instead of a local file. Doing this adds complexity, however, because Flickr does not support **Cross Origin Resource Sharing**. When we download the KML file, we can access it directly. When we're in the development mode, we want to keep things as easy as possible to debug and fix. Once we get the code working to load the KML file we downloaded (in the next example), we don't need to worry about it anymore. When we develop our application and find bugs or errors with it, we don't have to spend much time tracking them down. We get the static file working, and we move on to the next task. We don't have to worry about the Flickr API going down, our requests not completing, or other things—we can focus on other parts. Once we get more parts of our application working, then we'll switch to using the dynamic URL. For now, let's use the static file.

Have a Go Hero – accessing the Flickr API

Make a request to the URL from the previous example. Try changing the `tags` parameter and notice how the returned file is different. Based on the parameters in the URL, Flickr will return different data.

A simple application

The first step in our iterative process, is to develop a simple application that displays the data we just loaded. Time to get back to coding.

Time for Action – adding data to your map

With the data from Flickr from the previous example, we have enough to get started. We'll create our simple application with an OSM base layer and a vector layer filled with the Flickr data on top of it:

1. Create a new HTML page for the application in the sandbox folder. For the sake of this chapter, we'll refer to this as `flickr.html`. We'll use the familiar structure. Also, we'll start with `ol-debug.js` and optimize it later:

```
<!doctype html>
<html>
  <head>
    <title>Flickr App</title>
    <link rel="stylesheet" href="../assets/ol3/css/ol.css"
type="text/css">
    <link rel="stylesheet" href="../assets/css/samples.css"
type="text/css">
  </head>
  <body>
    <div id="map" class="map"></div>
    <script src="../assets/ol3/js/ol-debug.js"></script>
    <script>
    </script>
  </body>
</html>
```

2. Now, add the following code to create our vector layer using the data we saved to the empty `<script>` tag. Adjust the `URL` property to point to where you saved your file:

```
var flickrSource = new ol.source.KML({
  url: '../assets/data/flickr_data.kml',
  projection: 'EPSG:3857'
```

```
});  
var flickrLayer = new ol.layer.Vector({  
  source: flickrSource  
});
```

- 3.** We also need a base map; let's use OSM:

```
var layer = new ol.layer.Tile({  
  source: new ol.source.OSM()  
});
```

- 4.** Lastly, create the view and map objects:

```
var center = ol.proj.transform([0,0], 'EPSG:4326', 'EPSG:3857');  
var view = new ol.View({  
  center: center,  
  zoom: 1  
});  
var map = new ol.Map({  
  target: 'map',  
  layers: [layer, flickrLayer],  
  view: view  
});
```

- 5.** We should see some points now that show the location of the images that were uploaded. Open up the application in your browser. You will see something like this, but with different pictures in different places:



What just happened?

We just loaded in the KML file as a vector layer, and OpenLayers uses the style information in the KML file to render it by displaying a thumbnail of the photograph as its icon on the map.

Styling the features

The automatic styles provided in the KML file make it a little difficult to see the photos, especially when we are zoomed out—the thumbnails of the photos are just too large. It'll be nice to make the thumbnails of the photos smaller, but we don't have any control over the default style provided with the KML file. However, we should be able to replace the default styles with our own and achieve the effect we want.

Time for action – creating a style function

We'll accomplish this in two steps. First, we'll replace the default style with a simple one, and then, we'll develop a new style to display smaller thumbnails:

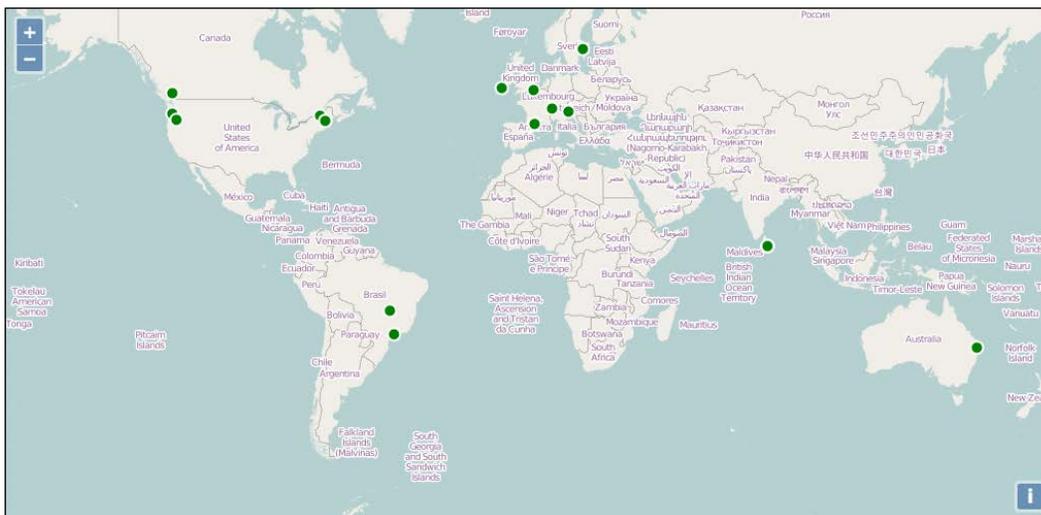
1. First, turn off automatic styling for the KML source by adding `extractStyles: false` to its options:

```
var flickrSource = new ol.source.KML({
  url: '../assets/data/flickr_data.kml',
  projection: 'EPSG:3857',
  extractStyles: false
});
```

2. Now, create a new function that will generate styles for our photos, we'll use a simple circle style for now:

```
function flickrStyle(feature) {
  var style = new ol.style.Style({
    image: new ol.style.Circle({
      radius: 6,
      stroke: new ol.style.Stroke({
        color: 'white',
        width: 2
      }),
      fill: new ol.style.Fill({
        color: 'green'
      })
    })
  });
  return [style];
}
```

3. That should do it, check out the result in the browser. This is what it looks like with the data saved in the `assets` folder, yours will look different if you downloaded new data:



What just happened?

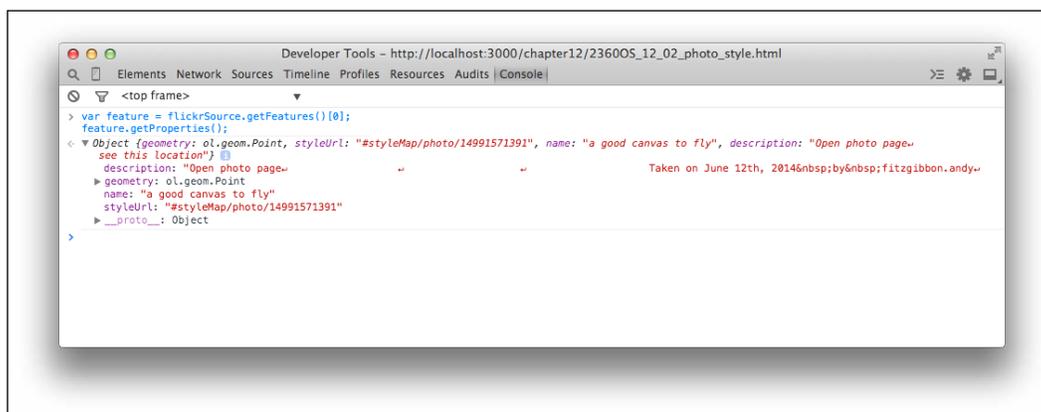
Great, we've replaced the automatic style extracted from the KML file with a simple one driven by a style function. Our style function returns an array containing our simple circle style. If you have been paying attention, you should have noticed that our style function is not at all efficient—we are creating a new copy of exactly the same style for every single feature! Don't worry though, this is a temporary state that we'll fix shortly by generating a unique style for each feature, based on its photo and we'll add caching when we do.

Creating a thumbnail style

We can use OpenLayer's icon style to display an image, we just need the URL to the photo. We can use the JavaScript console to take a quick look at what data is associated with each feature, so that we can figure out where the URL is stored. With the previous example running in your browser, open the JavaScript console and type the following commands:

```
var feature = flickrSource.getFeatures() [0];  
feature.getProperties();
```

This gets the first feature from the vector source and displays its properties, which should show you something like the following screenshot:



Switch to JSON

Well, that wasn't as useful as we'd hoped. The URL to the photo is not there, so what's happening? It turns out that the KML format includes style information and OpenLayers is smart enough to extract that information and automatically generate style functions for the features. Unfortunately, OpenLayers is also hiding all the extra information about the feature that we need. We need a different solution.

Time for action – switching to JSON data

We mentioned earlier that the Flickr feed API supports more than just the KML format. It also supports a variety of RSS versions and JSON. That sounds promising; let's see if we can do better with the JSON version. Refer to the following steps:

1. First, replace the KML source, `flickrSource`, with a generic vector source. Reload the page and make sure that everything still works. You should see the base map but no features (we'll add them shortly):

```
var flickrSource = new ol.source.Vector();
```

2. Next, we'll need to download the JSON version of our data by changing the format in the URL to `json`. Load the following URL in your browser and save the result to a new file called `flickr_data.json`:

```
http://api.flickr.com/services/feeds/geo/?format=json&tags=bird
```

3. Have a look at this file in your text editor. Note that it starts with `jsonFlickrFeed` (on the first line, this means that it is intended to be loaded as **JSONP**).



JSONP, or JSON with Padding, is a technique for loading JSON data from a remote server that avoids the restrictions of the same-origin policy. See <http://en.wikipedia.org/wiki/JSONP> for a good description of why and how JSONP works. For now, it is sufficient to know that JSONP will invoke a callback function and pass the data to it.

The next few lines appear to be metadata about the response—a title, description, date, and so on. What comes next seems to be what we want—an array of objects that represent photos, complete with links to photos and geographic locations. Perfect!

4. The data isn't in a format that OpenLayers understands; so, we'll have to load the data and turn it into features ourselves. We can use the jQuery `ajax` method to do this:

```
$.ajax({
  url: '../assets/data/flickr_data.json',
  dataType: 'jsonp',
  jsonpCallback: 'jsonFlickrFeed',
  success: successHandler
});
```

5. Now, we can add the `successHandler` function to process the data into features and add them to the map:

```
function successHandler(data) {
  var transform = ol.proj.getTransform('EPSG:4326', 'EPSG:3857');
  data.items.forEach(function(item) {
    var feature = new ol.Feature(item);
    feature.set('url', item.media.m);
    var coordinate = transform([parseFloat(item.longitude),
    parseFloat(item.latitude)]);
    var geometry = new ol.geom.Point(coordinate);
    feature.setGeometry(geometry);
    flickrSource.addFeature(feature);
  });
}
```


Then, we loop over all the items and turn each one into a feature. Each item is an object literal containing all the information we need for positioning and styling the photo. We create a new feature object and pass it this information, so that we can access it later for styling purposes:

```
var feature = new ol.Feature(item);
```

From looking at the properties of each photo, we see that the URL to the photo is stored in the `media` attribute under a key called `m`. This will be inconvenient to work with later; so, we create a new property called `url` with the value we want:

```
feature.set('url', item.media.m);
```

We need to create a new geometry object to represent the feature's location using the latitude and longitude of the photo (remembering to also transform the coordinates into the view's projection) and set it as the geometry of the feature:

```
var coordinate = transform([parseFloat(item.longitude),  
parseFloat(item.latitude)]);  
var geometry = new ol.geom.Point(coordinate);  
feature.setGeometry(geometry);
```

Finally, we added the feature to our vector source:

```
flickrSource.addFeature(feature);
```

Time for action – creating a thumbnail style

Now that we've got that sorted out, we should be able to create a thumbnail style for our photos reasonably easily:

1. As mentioned earlier, we will want to cache our feature styles. Add an empty object that can be used for this, just before our style function:
2. We can use the URL to the photo as the key for our cache entries. Remove all the existing code in the `flickrStyle` function and replace it with the following:

```
function flickrStyle(feature) {  
  var url = feature.get('url');  
  if (!cache[url]) {  
    cache[url] = new ol.style.Style({  
      image: new ol.style.Icon({  
        scale: 0.10,  
        src: url  
      })  
    })  
  }  
}
```

```
    });  
  }  
  return [cache[url]];  
}
```

What just happened?

We just updated our style function to return a more suitable style. In the first step, we created an object to act as a cache for our styles, so that we don't create them multiple times (that's inefficient!), and in the second, we updated our style function to create a new icon style for the feature, if one isn't in the cache already. Our icon style takes care of scaling the image to 10 percent of its original size so that it's not too big for the map area.

Turning our example into an application

So far, we've accessed data from Flickr, saved it to a file, added it to our map and created a simple photo thumbnail style. This is pretty cool, but we really haven't done much other than just load in the data, from an OpenLayers's point of view. It's useful, but we really haven't created a full-featured web application just yet. So, let's focus on how to build a more useful web-mapping application. To do this, we'll basically need to do two general things:

1. Add some interactivity to our map.
2. Use live data. We shouldn't have to manually download a data file every time we want new data—our web application should do it automatically.

Let's focus on the first part, and then change the data source after we develop some interactivity.

Adding interactivity

We need to decide what interactivity we'd like to provide to make our application interactive for our users. We'd like our users to be able to click on a photo and see relevant information. For this, we can use the select interaction. What should happen when we select a feature? We'll want to show information about the feature we clicked on, and that information is the Flickr photo itself and any associated attributes. So, let's keep things for now and show the photo's information below the map when a feature is selected.

Time for action – adding the select interaction

So, let's go ahead and add a select interaction to our application:

1. To add feature selection ability, create a `select` interaction. We'll add events soon, but for now, let's just create the control and add it to the map and then activate it. Add this at the end of the main `<script>` tag after all the other code:

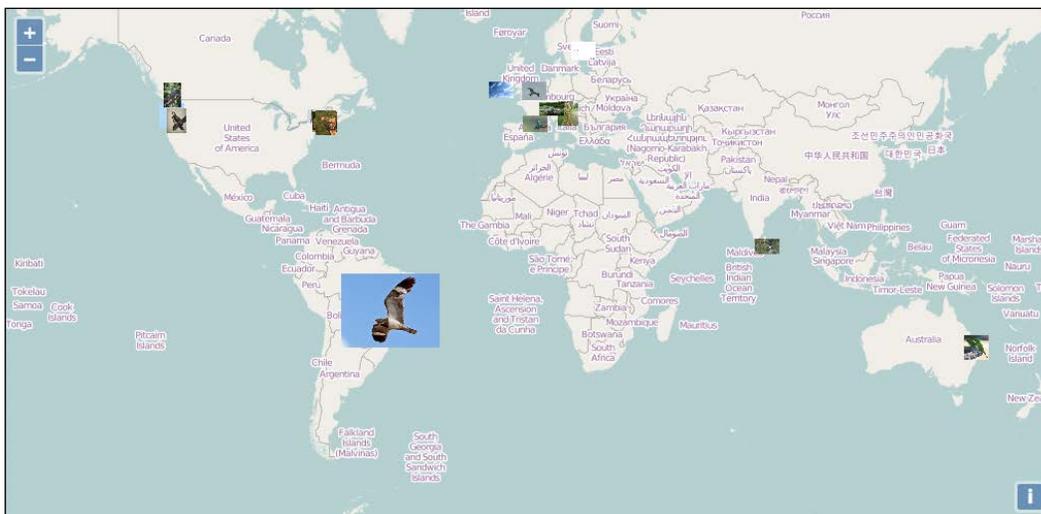
```
var select = new ol.interaction.Select({
  layers: [flickrLayer]
});
map.addInteraction(select);
```

2. If you try this out, you'll see that when you click on a feature or a cluster, it turns into a blue dot with a white stroke around it. This is the default style for selected point features, and isn't really what we want. A simple thing for us to do is to make the photo larger when it is selected. The select interaction has a `style` option that allows us to do this. We'll create a new function to return a selected style by making a copy of our `flickrStyle` function and cache object, using a larger scale value, and using the new style function with the select interaction:

```
var selectedCache = {};
function selectedStyle(feature) {
  var url = feature.get('url');
  if (!selectedCache[url]) {
    selectedCache[url] = new ol.style.Style({
      image: new ol.style.Icon({
        scale: 0.50,
        src: url
      })
    });
  }
  return [selectedCache[url]];
}

var select = new ol.interaction.Select({
  layers: [vectorLayer],
  style: selectedStyle
});
```

3. If you try this now, you should see a photo get larger when you click on it:



What just happened?

We just added some interactivity to our map. Let's recap how we did this.

The first step, was to add a select interaction to the map, configured to select features from our vector layer:

```
var select = new ol.interaction.Select({
  layers: [flickrLayer]
});
map.addInteraction(select);
```

The default selection style wasn't appropriate; so, we added a new function for styling selected features. We created a new cache object for selected styles, so that we could use the URL as the value for caching, and the style we used was the same thumbnail style but with a larger photo.

Have a go hero

We've duplicated the style code, which was easy to do and doesn't really introduce any problems in the runtime efficiency of our code. However, duplicated code can cause maintenance problems in real applications and some effort should be made to avoid obviously duplicate code. Try refactoring the style-related code to eliminate duplication as much as possible. You'll still need separate functions for the select interaction and the vector layer, but the code inside each layer looks like a candidate for moving into a new consolidated function that takes `scale` as a parameter.

Time for action – handling selection events

The next step is to display some information about photos when they are selected. To do this, we'll need to listen for an event on the select interaction's collection of selected features and retrieve the features that were selected. Our plan is to have some photo information display when we select features:

1. Let's go ahead and get the framework for this set up first, by simply creating a `<div>` tag that will appear below the map. In your HTML code, add the following line after the map's `<div>` tag:

```
<div id='photo_info' ></div>
```

2. The select interaction doesn't provide events directly related to features being selected or deselected, but it does maintain a collection of selected events and the collection object has events for adding and removing items. First, get a reference to the selected features:

```
var selectedFeatures = select.getFeatures();
```

3. Now, we can listen for the add event. For now, let's put the URL of the selected photo into our `photo_info` `<div>` tag:

```
selectedFeatures.on('add', function(event) {  
    var feature = event.target.item(0);  
    var url = feature.get('url');  
    $('#photo-info').html(url);  
});
```

4. We should also handle the case where a feature is removed from the selection by clearing the `photo_info` `<div>` tag:

```
selectedFeatures.on('remove', function(event) {  
    $('#photo-info').empty();  
});
```

5. Try it out! When you select a photo by clicking on it, you should see the URL to its image appear below the map. When you click elsewhere on the map, the selected photo should be unselected and the information should be removed.

What just happened?

We used the select interaction to respond to the user selecting photos. While there is no direct way to do this, we can use the `add` and `remove` events of the collection returned by `getFeatures` to update our `photo_info` div with some information about the selected photo.



The `description` property seems like a great thing to display. It's nicely formatted and includes some interesting information for some photos. Unfortunately, all that nice formatting only shows up if we insert the description as HTML into our page. Injecting untrusted HTML into a page, without first sanitizing it, makes your application prone to **XSS (Cross-site scripting)** attacks, a technique for injecting and executing unauthorized JavaScript into web pages. You should never inject HTML from an untrusted source into a web page. Even though it might seem safe to trust Flickr, we'll be prudent and avoid the `description` property by creating our own description from other information available.

Time for action – displaying photo information

We need a programmatic way to display the information about our photos in the web page. This means taking data about the selected features and creating HTML elements for them. For the purpose of this chapter, we'll create an HTML template and populate it with data from the feature. While there are many different approaches and libraries for implementing HTML templates, our needs are simple; so, we'll do it without depending on another library.

We'll need several HTML elements to display each piece of information, and a way to specify where in the elements we want to put what information. We could write the template as a JavaScript string, but then we couldn't put line breaks into the HTML and it will be difficult to read in the code. Instead, we'll use the same technique that most templating libraries use—a `<script>` tag with the `id` and `type` attributes set to something other than `text/javascript`. We'll explain how it works later. We'll use brace brackets `{` and `}` around key words to indicate where we want to place specific information.

1. The first step is to create a template. We can add it anywhere inside the `<body>` tag, by convention, they are usually added after everything else and just before the `</body>` tag at the end:

```
<script type="text/html" id="photo-template">
  <a href="{link}" target="_blank" title="Click to open photo in
new tab" style="float:left; "></a><br>
  <p>Taken by <a href="http://www.flickr.com/people/
{author_id}" target="_blank" title="Click to view author details
in new tab">{author}</a> on {date_taken} at lat: {latitude} lon:
{longitude}</p><br>
  <p>Tagged in <b>{tags}</b></p>
</script>
```

2. Next, we need a function that takes a feature and creates an HTML representation of it by combining the feature's properties with our template. Add the following function anywhere in our main script tag, preferably just before we create the select interaction:

```
function photoContent(feature) {
```

```

var content = $('#photo-template').html();
var keys = ['author','author_id','date_taken','latitude','longitude','link',
           'url','tags','title'];
for (var i=0; i<keys.length; i++) {
  var key = keys[i];
  var value = feature.get(key);
  content = content.replace('{'+key+'}',value);
}
return content;
}

```

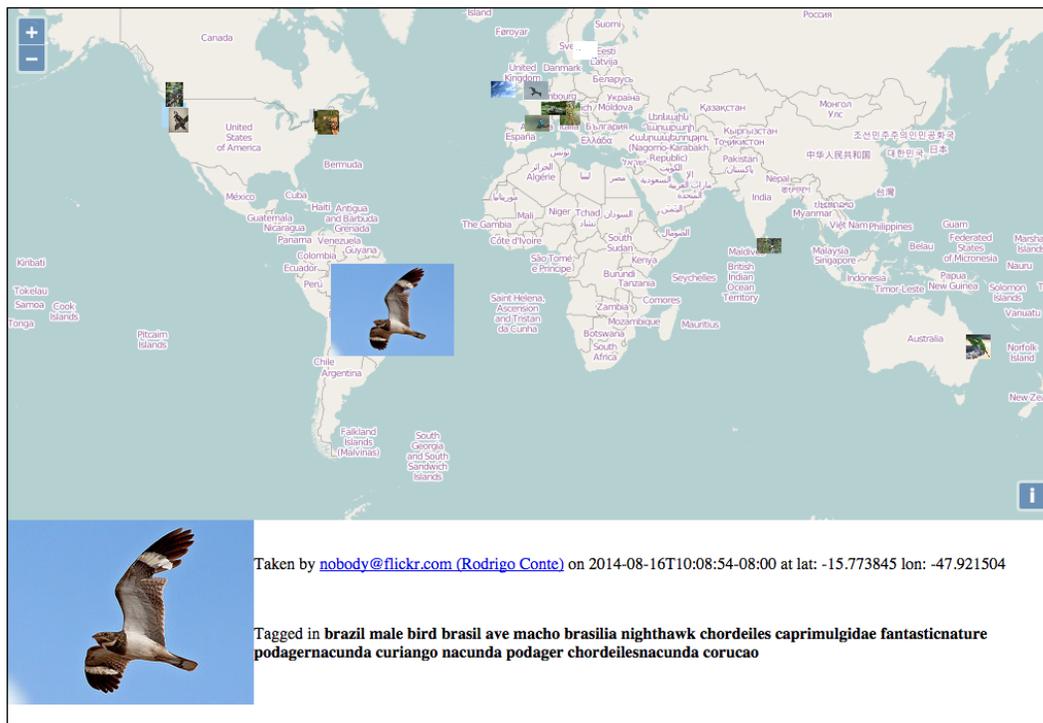
3. Now, we can update our select interaction's event handler and use our templating function to get HTML content for each selected photo:

```

selectedFeatures.on('add', function(event) {
  var feature = event.target.item(0);
  var content = photoContent(feature);
  $('#photo-info').append(content);
});

```

4. And that's it, now we should see some useful information about each photo when it's selected. Go ahead and try it out.



Taken by [nobody@flickr.com \(Rodrigo Conte\)](#) on 2014-08-16T10:08:54-08:00 at lat: -15.773845 lon: -47.921504

Tagged in **brazil male bird brasil ave macho brasilia nighthawk chordeiles caprimulgidae fantasticonature podagernacunda curiango nacunda podager chordeilesnacunda corucao**

What just happened?

We just built a simple templating system that lets us put feature properties into an HTML template and injected the results into the page to show information about each feature in the selected cluster. Let's review each step in detail.

In the first step, we created our HTML template by putting the HTML code we want to display for each photograph into a `<script>` tag. This probably sounds strange, but it is a technique used by many template libraries. The `<script>` tag has a `type` attribute that tells the browser how to interpret its content. When we are writing JavaScript, the value of the `type` attribute is `text/javascript`. If the `type` attribute is not specified, all browsers will assume that the type is just this—`text/javascript`. However, if the type is set to something else that the browser does not recognize, such as `text/html`, then the browser will ignore both the tag and its contents. It is still in the DOM, however, and we can retrieve its content using jQuery's `html()` method, just as we will with any other HTML element. This allows us to write readable HTML that can be accessed programmatically, without having to worry about it showing up in the web page.

The template content is self-explanatory. We used an anchor tag around the image and some `<p>` tags for extra information about the author and keywords that the photo was tagged with. We placed brace brackets around a keyword in each place we wanted to insert some information dynamically from a feature property. To keep it simple, the keywords will match the feature property names. Thus, the following line in the template will get replacements for `{link}` and `{url}` from the current feature:

```
<a href="{link}" target="_blank" title="Click to open photo in new  
tab"></a><br>
```

In the second step, we added a function that generates HTML content for a given feature by replacing placeholders in the template with actual values. The first step is to get the content of the template as a string, for which we use jQuery's `html()` method:

```
var content = $('#photo-template').html();
```

Next, we have an array of the property names we want to process replacements for.

```
var keys = ['author', 'author_id', 'date_taken', 'latitude', 'longitude',  
'link',  
'url', 'tags', 'title'];
```

For each of these, we get the value of the previous property from the feature:

```
for (var i=0; i<keys.length; i++) {  
  var key = keys[i];  
  var value = feature.get(key);
```

Finally, we replaced the placeholder (the key wrapped in brace brackets) with the value and when all replacements were done, we returned the resulting string:

```
    content = content.replace('{'+key+'}', value);
  }
  return content;
```

In the last step, we made use of our function to get HTML for the selected feature and added it to the page:

```
$('#photo_info').append(content);
```

Using real time data

The data we've loaded (`flickr_data.json`) is from a third-party source, but it's only fresh up to the point that we download it. Our application will load the data in real time when the page is loaded. Now that everything is functional with static data, it's time to get dynamic and load data in real time.

Time for action – getting dynamic data

In this exercise, we'll change our code to fetch the data from Flickr when the page loads, rather than using a previously downloaded file. As you'll see, this is quite straightforward.

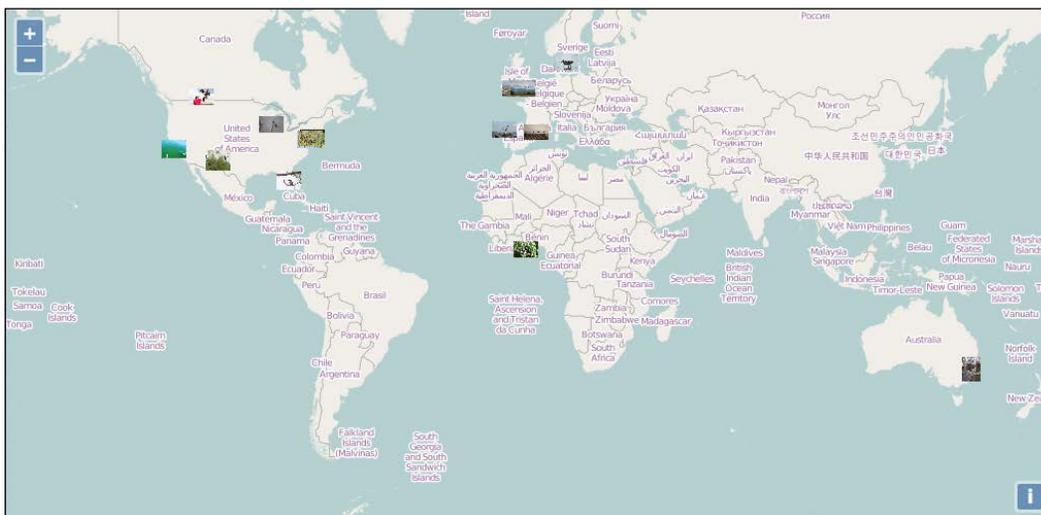
1. Recall that when we switched over to the static JSON data, we entered the following URL into our browser to download the JSON data:

```
http://api.flickr.com/services/feeds/geo/?format=json&tags=bird
```

2. We should be able to use this URL with our `$.ajax` function and load data directly from the live feed rather than our static file. Go ahead and modify the URL:

```
$.ajax({
  url: 'http://api.flickr.com/services/feeds/
geo/?format=json&tags=bird',
  dataType: 'jsonp',
  jsonpCallback: 'jsonFlickrFeed',
  success: successHandler
});
```

3. Reload the browser and you should see different photos loaded than in your saved JSON file.



What just happened?

By simply replacing the URL for our AJAX function with the live Flickr feed URL, we can now load the latest available data. No other changes were needed.

Wrapping up the application

Showing bird pictures from around the world is nice—but what about giving users the ability to show a photo with any tag they want? That's what we'll do next. So far, we've created a map that lets users interact with Flickr data. As far as we're concerned, we're more or less done with the interaction part. Now, we'll focus on changing the data source part. Currently, we're only asking for photos with the `bird` tag, but we want to allow that to be any tag.

An important concept in application development is to keep things modular. This basically means that we try to write out applications in such a way that we can take out, and put in, different parts without drastically changing the rest of our code. In this case, we will leave the interaction part of our code alone (what we've done so far at least) and focus mainly on the code that retrieves data.

The plan

What needs to happen? Well, let's think this through. We want the user to be able to specify any tag they want. We want to allow multiple tags. This means we'll need to change the URL that the `$.ajax` function is loading, but only after the user specifies some tags. We'll want to create a function to wrap the `$.ajax` call and come up with a way to change the URL based on the selected tags. We'll also need to deal with removing existing features when the tags change.

Changing the URL

So, we know we need to allow a variable that specifies the `tags` parameter in the URL to be based on user input. We'll need to create an input box that will allow the user to specify tags. We'll also have a submit button that will, when clicked, call a function that updates the `$.ajax` method's URL with the specified parameters.

Time for action – adding dynamic tags to your map

Let's add some more interaction to our map now. We'll add an input box that will change the requested Flickr data based on the user's input:

1. First, we'll add an input box and button to the HTML page. We'll put them into a div after the map and before the photo information:

```
<div id="search" style="position: absolute; top: 10px; right:
10px; padding: 5px; background-color: rgba(255,255,255,0.5);">
  <input type="text" placeholder="Search photos by tag(s)"
  style="width: 200px">
  <button type="button">Search</button>
</div>
```

2. Next, we'll need to replace our `$.ajax` call with a function that will get called when the button is clicked. This function will do three things. First, it will clear the existing features from the map. Next, it will clear any selected photo info. Finally, it will request new data from Flickr with the appropriate tags:

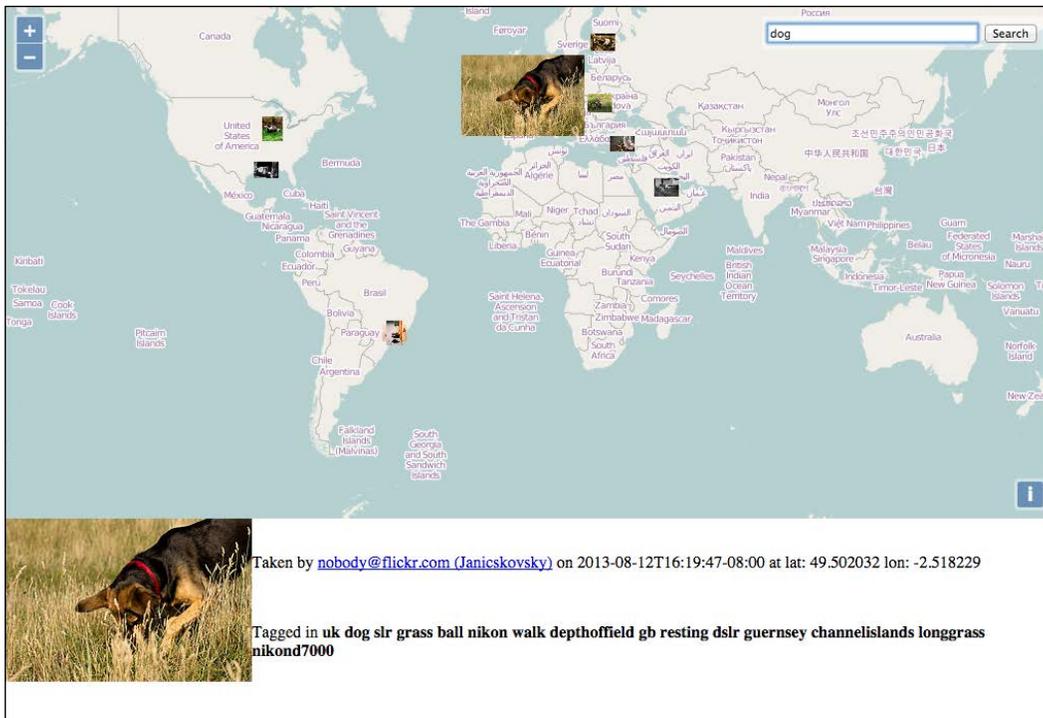
```
function loadFlickrFeed(tags) {
  selectedFeatures.clear();
  flickrSource.clear();
  $('#photo-info').empty();
  $.ajax({
    url: 'http://api.flickr.com/services/feeds/geo',
    data: {
      format: 'json',
      tags: tags
    },
  },
```

```
    dataType: 'jsonp',  
    jsonpCallback: 'jsonpFlickrFeed',  
    success: successHandler  
  });  
}
```

3. Now, we'll need to make the button call this function when it is clicked. We'll use jQuery for this. Add the following after the `loadFlickrFeed` function:

```
$(document).on('click', '#search button', function() {  
  var value = $('#search input').val();  
  var tags = value.split(' ').join(',');  
  loadFlickrFeed(tags);  
});
```

4. Open up the page and you should see an input box over the map. When you change the value and hit the button next to it, the `loadFlickrFeed` function will get called and refresh the vector layer. Try typing in various tags (or multiple tags separated by a comma) and hitting the button:



What just happened?

We just updated our Flickr application to allow user input that affects what data is shown. We did this in a sort of modular way—we didn't have to change any of the previous code we wrote. Instead, we just created a function that clears the existing features and loads new ones based on the selected tags. Now that we've written an application, let's talk a little bit about how to deploy it.

Deploying an application

What does it mean to deploy an OpenLayers (or any other) application? Basically, deploying something means that we're switching from a development mode to a production mode; we're releasing something for the rest of the world to see.

The production application should be as fast and bug free as possible. As we want the production version to be accessed as quickly as possible, this will often include removing things we used in the development environment and tweaking the production environment to better handle a lot of users. This also means using files that are as small in size as possible. While fully optimizing a web application is beyond the scope of this book, there are a couple of things we can do with OpenLayers to help optimize our JavaScript file size: create a custom build of OpenLayers and compile our code with the OpenLayers code.

 There are many other things we should do to better prepare our production environment, such as using caching, as well as combining and minimizing our website's assets. These, and other practices, are outside the scope of this book, but further information can be found at http://en.wikipedia.org/wiki/Web_performance_optimization#Best_practices.

Creating custom builds

OpenLayers provides an easy way to create a custom build of the library to include in your page that contains only the things you need. Throughout this book, we've been including a file called `ol.js` (or `ol-debug.js`), a file that contains all the functionality (classes, functions, and so on) that OpenLayers provides. So far, this has been great—we've been developing up to this point, so we want to be sure that we have access to all the classes that we may use.

Benefits of serving small files

Well, the `ol.js` file we've been using is around 391 KB, and the debug version is 3.5 MB! Both are quite large files to load, especially since they contain only JavaScript code. Even though large file sizes aren't as much of an issue as they were years ago, when everyone was on slower connections, a large JavaScript file in a production environment is something we want to avoid if at all possible. This is especially true for mobile environments, where users pay for data plans and data speeds can be highly variable.

We want all our files in a production environment to be as small as they can absolutely be. This will allow users to download the files faster (since there is less to download), which decreases the page's loading time (saves on bandwidth expenses). Faster page loads (even if the speed is only perceived) will greatly enhance the user's experience. Fortunately, we can greatly reduce the size of the OpenLayers library file with a build tool provided by OpenLayers.

Two approaches to optimization

To optimize your application code for production, there are two approaches you can take:

- ◆ **Combined:** The build tool combines all your JavaScript files into a single file containing both the OpenLayers 3 code and your application code.
- ◆ **Separate:** The build tool creates a custom version of the OpenLayers library code with only the parts you need. Your application code is kept separate.

The following table shows the advantages and disadvantages of each approach:

Approach	Advantages	Disadvantages
Combined compilation	<ul style="list-style-type: none">◆ Maximum optimization of the compiled JavaScript code.	<ul style="list-style-type: none">◆ More complicated to annotate your code with comments that allow closure compiler to optimize your code.◆ Requires externs, particularly when using third-party libraries.◆ Closure compiler doesn't always work well with third-party code. In particular, it doesn't work well with module loaders.

Approach	Advantages	Disadvantages
OpenLayers and application code separate	<ul style="list-style-type: none"> ◆ Creates a custom build of OpenLayers 3 tailored to your needs. ◆ Application code does not have to be type-annotated for the closure compiler. ◆ Can use other JavaScript compression techniques (such as http://lisperator.net/uglifyjs/) for the application code and third-party libraries. This can often achieve nearly equivalent compression and avoid many of the pitfalls of the closure compiler with third-party libraries. 	<ul style="list-style-type: none"> ◆ The build size is higher than the all-in-one compilation. ◆ Defining the exports for a custom build can be difficult to get right.

Before going further, you will need to follow the installation process for Python, Java, and Node following the guide in *Appendix B, More details on Closure Tools and Code Optimization Techniques*. These tools are required to create custom builds of OpenLayers.

The standard release archive for OpenLayers does not contain the build tools we require. Additionally, the build tools provided with OpenLayers work only with code cloned from a Git repository. The instructions for this book are designed for version 3.0.0 of OpenLayers. To make sure that you are using the correct version, you can check out the v3.0.0 branch of the repository using the following command:

```
git checkout -b v3.0.0
```

If you have already run the OpenLayers build tools on a version other than v3.0.0, it is recommended to remove the `build` and `node_modules` folders and start again.

What does the compiler do?

We'll briefly cover how the closure compiler works to optimize your code, as we will need to understand it a little bit to use it properly. More detailed information can be found in *Appendix B, More details on Closure Tools and Code Optimization Techniques*.

The closure compiler optimizes code by applying a series of transformations to your code. Covering all of these is the topic for a whole book in itself, but for our purposes it does three basic things:

- ◆ Safely rewrite your code into a more optimal form
- ◆ Remove unused code
- ◆ Rename objects, methods, and property names to shorter versions

Rewriting code

When the compiler rewrites your code, it will attempt to use language features that reduce the overall size of your code and execute more efficiently. This can include the following:

- ◆ Removal of extraneous white space
- ◆ Consolidation of variable declarations
- ◆ Restructuring of loops

Generally, these changes are safe and do not change the logic or functionality of your code. They simply take advantage of language features to fit your code into less space.

Removing unused code

The compiler will also attempt to remove the so-called dead code. Dead code is any function that the compiler determines will not be called by the application. It is sometimes difficult for the compiler to automatically determine what code your application will use, especially if you are creating a separate build. In these cases, we need to tell the compiler what things we need to keep even though they might be considered dead code. This is generally done in two ways depending on our strategy. If we are creating a combined build, the compiler can generally determine what functions we will need automatically, but it doesn't know what files to include in the first place. To help the compiler, we add code to register these dependencies. If we are creating a separate build, the compiler doesn't have our code to analyze; so, we have to use a different technique. In this case, we will provide an explicit list of functions to keep in the compiled library.

We will cover both techniques shortly.

Renaming objects, functions, and properties

The final compiler technique we need to discuss is the renaming strategy. Generally, when we are writing code, we use descriptive names for functions and variables. This makes code much more readable to ourselves and others, and it's much easier to remember names that mean something when writing our code. However, these long names take up space—1 byte per character—and when they are used repeatedly, it can really add up. The JavaScript engine in a browser doesn't really care about our descriptive names though. A name like *X1* is just as good as **GeoJSONParser**, and as long as it is used in the right places, we can save 11 bytes for every use of **GeoJSONParser** by replacing it with *X1*. Using short names is not practical for application developers, but it is something that can be done really well by a compiler.

Unfortunately, this is one of the biggest *gotchas* of using the Closure Compiler. It renames objects, functions, and properties very aggressively and makes them effectively unusable by external code. There are two main problems we need to be aware of concerning this renaming.

When creating a standalone build of OpenLayers, we need to make sure that the objects, functions, and parameters we need are not renamed. This is done using **exports**, which will be covered later in this chapter.

When creating a combined build of OpenLayers with our application code, we no longer have to worry about exports because our use of the OpenLayers objects, functions, and properties will be taken into consideration by the compiler and renamed appropriately. However, if we use other third-party libraries (for instance, jQuery), the closure compiler does not know about them and will rename our use of their objects, functions, and properties. There are two things we can do to tackle the second problem. First, we can provide special JavaScript files, called **externs**, which define the objects, functions, and properties of external libraries. The compiler can then correctly avoid renaming parts of our code that we need to preserve. The second, is to use string values in key places, because the compiler will never rename a string value. This technique relies on the ability for JavaScript code to reference object properties using array-like syntax. For instance, if we have a property `name` on an object `foo`, normally, we would reference it like the following:

```
foo.name = 'test';
```

The compiler might rewrite this code like the following:

```
XB.XC='test';
```

If `foo` is an object coming from some external library that relies on `name`, our code may break in unusual ways. To prevent this, we can use the array-like notation with a string value to avoid renaming:

```
foo['name'] = 'test';
```

We'll see an example of this in our next example.



Exports and externs are quite similar. The first is for choosing the library code you want to expose the third-party code, whereas the second, is to stop the default renaming behavior for the third-party code. To fully grasp the difference, you should refer to the official topic on *Do Not Use Externs Instead of Exports!* at <https://developers.google.com/closure/compiler/docs/api-tutorial3#no>.

Creating a combined build

Now that we have a working OpenLayers build environment and understand a little background, let's take a look at optimizing our application using the first technique—a combined build.

Time for action – creating a combined build

There are a few steps we need to take to create a combined build. These are as follows:

1. First, we will remove our JavaScript code from the HTML page and create a separate file for it. Go ahead and copy the contents of the `<script>` tag that contains all the JavaScript code into a file and save it as `flickr_combined.js`. You can, of course, call it something different but the remainder of this example will refer to it by this name. If you choose a different name, make sure to change all the references appropriately.
2. Now, delete the JavaScript and the script tag from your HTML file. At this point, we can create a new `<script>` tag to load `flickr_combined.js` and everything should work as before. If you want to try this, go ahead but remember to remove the script tag afterwards. We won't be using `flickr_combined.js` directly.
3. In order for the closure compiler to find the exact parts of OpenLayers that our application needs, we need to tell it what parts we are using. The closure compiler then removes any code we won't need and produces an optimal build. When creating an all-in-one build, the mechanism for doing this is to add `goog.require` statements to our JavaScript file. Let's go ahead and do that now. Add the following at the top of your `flickr_combined.js` file:

```
goog.require('ol.Feature');
goog.require('ol.geom.Point');
goog.require('ol.interaction.Select');
goog.require('ol.layer.Tile');
goog.require('ol.layer.Vector');
goog.require('ol.Map');
```

```
goog.require('ol.proj');
goog.require('ol.source.OSM');
goog.require('ol.source.Vector');
goog.require('ol.style.Icon');
goog.require('ol.View');
```

If you are using the `ol-debug.js` build of OpenLayers, then this change will continue to work. If you are using `ol.js`, however, it will not work as the `goog` namespace is not exported in the optimized build of OpenLayers.

The OpenLayers build tool runs inside the OpenLayers directory. The easiest way for OpenLayers to find your code is to copy it into the `ol3` directory. Go ahead and copy `flickr_combined.js` into the `ol3/build` directory now.

4. Next, we need to create a configuration file that is used by the build tool to control what the Closure Compiler does. Create a file called `flickr_combined.json` file within the `ol3/build` directory and give it the following content. We'll go over the parts of this file afterwards:

```
{
  "exports": [],
  "src": ["src/**/*.js", "build/flickr_combined.js"],
  "compile": {
    "externs": [
      "externs/closure-compiler.js",
      "externs/geojson.js",
      "externs/jquery-1.7.js",
      "externs/oli.js",
      "externs/olx.js",
      "externs/proj4js.js",
      "externs/vbarray.js"
    ],
    "define": [
      "goog.dom.ASSUME_STANDARDS_MODE=true",
      "goog.DEBUG=false"
    ],
    "jscomp_error": [
      "accessControls",
      "ambiguousFunctionDecl",
      "checkEventfulObjectDisposal",
      "checkRegExp",
      "checkStructDictInheritance",
      "checkTypes",
      "checkVars",
      "const",
      "constantProperty",

```

```
    "deprecated",
    "duplicateMessage",
    "es3",
    "es5Strict",
    "externsValidation",
    "fileoverviewTags",
    "globalThis",
    "internetExplorerChecks",
    "invalidCasts",
    "misplacedTypeAnnotation",
    "missingGetCssName",
    "missingProperties",
    "missingProvide",
    "missingRequire",
    "missingReturn",
    "newCheckTypes",
    "nonStandardJsDocs",
    "suspiciousCode",
    "strictModuleDepCheck",
    "typeInvalidation",
    "undefinedNames",
    "undefinedVars",
    "unknownDefines",
    "uselessCode",
    "visibility"
  ],
  "extra_annotation_name": [
    "api", "observable"
  ],
  "compilation_level": "ADVANCED",
  "output_wrapper": "// OpenLayers 3. See http://ol3.js.org/\n(function(){%output%})();",
  "use_types_for_optimization": true,
  "manage_closure_dependencies": true
}
```

5. Now, we have the parts we need to build our combined file. Open a command prompt or terminal and change to the `ol3` directory. Execute the following command:

```
node tasks/build.js build/flicker_combined.json build/flicker_combined.built.js git status
```
6. Copy the resulting file named `flicker_combined.built.js` back into the working directory of your application code.

7. Change the `<script>` tag that loads the `ol-debug.js` script to point to the new JavaScript file, for instance:

```
<script src="flickr_combined.built.js"></script>
```

8. Reload your application page and everything should still be working.

What just happened?

We created a custom build of OpenLayers combined with our application code using the provided build tools. We'll review the steps but first, let's take a look at the resulting file sizes:

	Files Used	Net Size
Before (debug build)	<code>ol-debug.js</code> (3.3 MB) <code>flickr_combined.js</code> (3.7 KB)	3.3 MB
Before (optimized build)	<code>ol.js</code> (382 KB) <code>flickr_combined.js</code> (3.7 KB)	385.7 KB
After	<code>flickr_combined.built.js</code> (153 KB)	153 KB

As you can see, our final built file is less than half the size of the full OpenLayers build. Okay, now let's review how we did it.

For the OpenLayers build tools to work, they need our application's JavaScript and a configuration file. We first extracted the JavaScript from our HTML into a separate file, then added some extra lines of code to help the Closure compiler understand what parts of OpenLayers we use by adding `goog.require` statements. Figuring out what you are using from OpenLayers can be a bit tricky in larger applications, but using searching for `ol.` (that's `ol` followed by a period) will identify the correct things.

The next step, was to create a configuration file for the build tool. This configuration file is written in the JSON format, which looks a lot like JavaScript. The configuration file has several parts to it:

- ◆ `exports`: This identifies specific objects and methods in the OpenLayers library that should not be renamed when creating an optimized build. We'll see how this works in the next example, but for this example, we left it empty because we are combining our application code with OpenLayers.
- ◆ `src`: This identifies all the source JavaScript files that the compiler should consider when creating the optimized build. We say *consider* because not all the code will be included in the output. In our configuration file, we can specify the path to the OpenLayers source files (`src/**/*.js`) and our application file (`build/flickr_combined.js`).

- ◆ `compile`: This contains directives specific to the Closure compiler. Modifying this section requires advanced knowledge of the Closure compiler and we won't be covering it in this book. It is normally sufficient just to copy this section to each new configuration file that you create. The one exception is the `externs` array. The `externs` array identifies files that contain type hints for the closure compiler. If you are using a third-party library in your application code, you will need to provide an externs file for that library to prevent the compiler from renaming function and property names in your code. For instance, we are using jQuery with our application and have included the `jquery-1.7.js` externs file provided with OpenLayers. Externs for other libraries can be found at <https://github.com/google/closure-compiler/tree/master/contrib/externs>.

With our application code prepared and a configuration file, we then run the command-line build tool providing it the name of the configuration file and the name of the JavaScript file to create:

```
node tasks/build.js build/flicker_combined.json build/flicker_combined.  
built.js
```

We then copied the resulting file, `flicker_combined.built.js`, back into our application folder and updated the script tag to load this file instead of `ol-debug.js`. The net result is an impressive drop in file size and the elimination of one JavaScript file to load.



In large applications, it is not uncommon to have your JavaScript code separated out into different files based on some logical breakdown of the code. OpenLayers, for instance, has 330 separate JavaScript files. When you have a lot of different files, the net effect of combining them all into a single file is much more apparent to the user.

Creating a separate build

While the combined build creates a single JavaScript file that contains both OpenLayers library code and your application code, a separate build creates a single JavaScript file that contains just the OpenLayers code required by your application. The main difference with this approach is that we will not use `goog.require` to tell the compiler what parts of OpenLayers we want to use. Instead, we will use the `exports` property of the configuration file. The other difference, is that we will not include our application source file in the `src` configuration.

Time for action – creating a separate build

Unlike before, we don't need to move our application code into a separate file. Unless you kept a copy of the application from before the previous example, however, we'll need to fix up our HTML file a little bit for this example. This example assumes you are starting with the previous example:

1. Create a copy of `flickr_combined.js` and call it `flickr_separate.js`. As always, you may use a different name but make sure it is consistent! You might also want to make a copy of your HTML file and use it for the rest of this example.
2. Edit `flickr_separate.js` and remove all the `goog.require` statements from the beginning of the file.
3. Add a new `<script>` tag to load `flickr_separate.js` after the `<script>` tag that loads the combined build file:

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

4. Now, we need to create our custom build of OpenLayers. First, we'll need a configuration file. Let's create a new file named `flickr_separate.json` in the OpenLayers build directory. Give it the following content:

```
{
  "exports": ["ol.Map",
    "ol.Map#",
    "ol.View",
    "ol.animation.*",
    "ol.control.*",
    "ol.layer.Tile",
    "ol.proj.*",
    "ol.source.OSM",
    "ol.source.Vector",
    "ol.source.Vector#getFeatures",
    "ol.source.Vector#addFeature",
    "ol.source.Vector#removeFeature",
    "ol.layer.Vector",
    "ol.interaction.Select",
    "ol.interaction.Select#getFeatures",
    "ol.interaction.Select#on",
    "ol.Observable#on",
    "ol.Feature",
    "ol.Feature#get",
    "ol.Feature#set",
    "ol.geom.Point",
    "ol.style.Style",
    "ol.style.Fill",
```

```
"ol.style.Stroke",
"ol.style.Circle",
"ol.style.Text",
"ol.style.Icon"
],
"src": ["src/**/*.js"],
"compile": {
  "externs": [
    "externs/bingmaps.js",
    "externs/bootstrap.js",
    "externs/closure-compiler.js",
    "externs/example.js",
    "externs/geojson.js",
    "externs/jquery-1.7.js",
    "externs/oli.js",
    "externs/olx.js",
    "externs/proj4js.js",
    "externs/tilejson.js",
    "externs/topojson.js",
    "externs/vbarray.js"
  ],
  "define": [
    "goog.dom.ASSUME_STANDARDS_MODE=true",
    "goog.DEBUG=false"
  ],
  "jscomp_error": [
    "accessControls",
    "ambiguousFunctionDecl",
    "checkEventfulObjectDisposal",
    "checkRegExp",
    "checkStructDictInheritance",
    "checkTypes",
    "checkVars",
    "const",
    "constantProperty",
    "deprecated",
    "duplicateMessage",
    "es3",
    "externsValidation",
    "fileoverviewTags",
    "globalThis",
    "internetExplorerChecks",
    "invalidCasts",
    "misplacedTypeAnnotation",
```

```

    "missingGetCssName",
    "missingProperties",
    "missingProvide",
    "missingRequire",
    "missingReturn",
    "newCheckTypes",
    "nonStandardJsDocs",
    "suspiciousCode",
    "strictModuleDepCheck",
    "typeInvalidation",
    "undefinedNames",
    "undefinedVars",
    "unknownDefines",
    "uselessCode",
    "visibility"
  ],
  "extra_annotation_name": [
    "api", "observable"
  ],
  "jscomp_off": [
    "es5Strict"
  ],
  "compilation_level": "ADVANCED",
  "output_wrapper": "// OpenLayers 3. See http://ol3.js.org/\
n(function(){%output%})();",
  "use_types_for_optimization": true,
  "manage_closure_dependencies": true
}
}

```

5. Now, we can build our custom version of OpenLayers. Execute the following in a command prompt or terminal in the `ol3` directory, as we did before:

```
node tasks/build.js build/flickr_separate.json build/flickr_
separate.ol.js
```

6. Copy the resulting `flickr_separate.ol.js` back to your application folder next to `flickr_separate.js`.
7. Finally, change the script tag that loads `flickr_combined.js` to point to this new file:

```
<script src="flickr_separate.ol.js"></script>
```

8. Load your HTML page and everything should work just as it did before.

What just happened?

We just created a custom build of the OpenLayers library that contains only the code we need, and which exports only the things we actually use. The resulting library is a little bit larger—177.5 KB vs 156.5 KB—because the compiler is preserving the names of the objects, functions, and properties that we have exported. Let's review these steps.

First, we adapted our previous example and modified a copy of our application code to remove the `goog.require` statements. Those won't be needed for the compiler, and in fact, won't work with our custom build because the `goog` namespace is not exported.

Next, we created a new configuration file for the compiler. You probably noticed that it's nearly identical to the one from the previous example. In fact, there are two differences and they are very important. First, we removed our application source from the build by removing it from the `src` property. Second, we explicitly listed the names of objects and functions we want exported in the `exports` section.

Populating `exports` is really the trickiest part of creating a separate build. As with the combined build, a search of your code for `ol.` will identify all the main classes that you are referencing and these can be included directly in the `exports` array. However, exporting a class does not automatically export any of its properties or methods. We also need to know what methods we call on all objects that are exported. In some cases, we don't actually call any methods on the objects we created, but in other cases, we do. Finding these methods is a bit more time consuming as it requires manually reading the code.

When adding a method name to the exports list, we write it with the object name first, a `#` symbol, and then the method name, for instance see the following:

```
ol.Map#getSize
```

It is also possible to export all methods of an object by using `*` instead of a method name after the `#` symbol. While this is quick and easy, it will produce much larger builds than necessary in most cases.

Summary

You've reached the end of the book! In this chapter, we built a simple web map application that grabs Flickr data based on user input. We covered some development concepts throughout the chapter, such as attempting to keep our code modular. We learned how to interact with other third-party APIs, and built an application from the ground up. Lastly, we talked about deployment and learned how to use the OpenLayers build script. Now that you've finished reading this book (I hope you've enjoyed it), you should be able to go out and make your own impressive web maps!

A

Object-oriented Programming – Introduction and Concepts

When you need to make a custom map using the OpenLayers 3 library, you need to grasp the common programming sentences and vocabularies.

Why? It's because OpenLayers relies on JavaScript, a programming language based on object-oriented programming (OOP). Knowledge about OOP is shared amongst programmers. Without this knowledge, it will be difficult to talk about programming issues, for example, on a forum.

We will see that behind complex words lie simple concepts. In fact, everyone uses OOP concepts on a daily basis but without being aware of it.

In this appendix, we will cover:

- ◆ What object-oriented programming is
- ◆ How OOP in the OpenLayers 3 API context can be useful

Let's talk about how object-oriented programming works from a theoretical and technical level.

What is object-oriented programming?

Object-oriented programming is a programming paradigm. It added a new way to manage code by using the concept of *object* as opposed to procedural programming where code follow the reading order. By using OOP, you gain reusability of code. The main gain is related to encapsulation or separation of concern. Each object has his own *life*.

To understand object orientation, let's take a simple example—animals. Your cat is a class. If you have four cats, you have four objects of type cat. Each of them has different properties name, age and sex values. A cat can move. In OOP terms, move is a method of the class cat.

Let's review some questions that can help you understand keywords and concepts we will implicitly use.

What is an object?

An object can be considered a *thing* that can perform actions and has properties. The action defines the object's behavior. For instance, the cat can jump. Your cat's age is eight so the property value is 8.

In pure OOP terms, an object is an instance of a class.

In an OpenLayers context, imagine you want a side-by-side map where you prepared a div with `id` attribute equal to `map1` and another one for the `id` attribute with the value `map2`. You will use the JavaScript `new` operator to declare two instances of the `ol.Map` class like following:

```
var map1 = new ol.Map({
  target: 'map1'
});
var map2 = new ol.Map({
  target: 'map2'
});
```

An instance means that each object based on the class has it own properties values.

In our example, the `target` property is different for the `map1` and `map2` objects.

What is a class?

A class can be considered as an extensible program-code-template.

When you already know OOP, you use the word class to declare it but in JavaScript, the class is known as a function. Also, functions are used as constructors.

The following excerpt from OpenLayers illustrates how a class looks:

```
ol.Map = function(options) {  
  }  
}
```

We also recommend you inspect the full `ol.Map` class at <http://openlayers.org/en/v3.0.0/apidoc/map.js.html> after reviewing the following information box to discover on your own the class methods and properties.



We will abusively use classes to describe object-oriented programming but the truth is that JavaScript is based on prototypes and not classes. We chose to simplify the explanation as more people understand OOP based on classes. The main goal is to explain inheritance in particular. To learn the difference, we recommend going to https://developer.mozilla.org/en-US/docs/Web/JavaScript/Guide/Details_of_the_Object_Model for more.

What is a constructor?

To instantiate an object, you need to use the `new` keyword on a JavaScript function.

For example, when using `new ol.Map()`, the function `ol.Map` is called the constructor. It's the function you use with the `new` keyword to create an object. You can give options to the constructor.



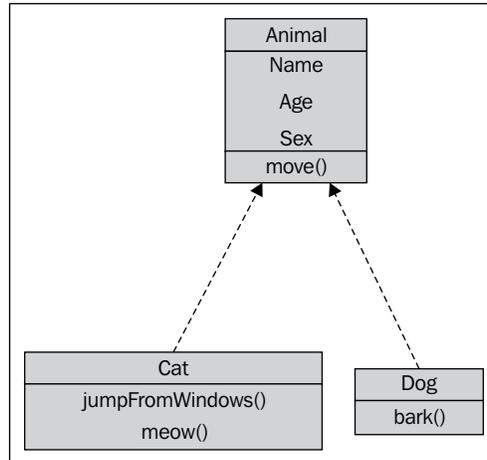
There are other ways to create an object but to keep thing simple, we chose to restrict our explanation to the most common way when using the OpenLayers library. If you want to go further, go to https://developer.mozilla.org/en-US/docs/Web/JavaScript/Guide/Working_with_Objects.

What is inheritance?

Inheritance is the ability of a new class to be created, from an existing class by extending it. With this, you use the **DRY (Don't repeat Yourself)** principle. For example, you can reuse method or properties from a parent class. Don't sweat, it's time to explain!

Imagine after describing your cat, you also want to describe your dog in OOP.

Cats and dogs are not the same but they share some characteristics like their name, their sex or their age or they ability to move. However, a cat can jump from windows whereas a dog can't. We don't want to maintain two classes because they have common properties. You can achieve this by using a new class called animal. It can be represented like the following diagram:



In your code, instead of declaring every common property and method twice, you declare that your `Cat` class inherits from the `Animal` class, so you can reuse properties and methods from the parent class. `Cat` and `Dog` are subclasses of the `Animal` class. You can also say that the `Cat` class extends the `Animal` class.

Why do you think it's useful to review this abstract concept?

It's because you need to figure out the relations between OpenLayers 3 library components. The library heavily uses inheritance and for creating your own components, it's a requirement.

What is an abstract class?

It's a class you use to define properties for other class that need to inherit it properties and / or methods but you never directly instantiate this class. The `animal` can be considered as an abstract class. However, in OpenLayers, the `ol.source.XYZ` isn't an abstract class, although `ol.source.OSM` is its child class.

What is a namespace?

Namespace helps you to organize your code by grouping it logically, and also by separating variables from the global.

You can declare a namespace with something like below:

```
var app = {  
  main: ""  
}
```

or

```
var app = {};  
app.main = {};
```

The `ol.*` classes in the API documentation illustrate the namespace purpose <http://openlayers.org/en/v3.0.0/apidoc/>.

What are getters and setters?

Methods are actions you can use within the object. Getters and setters are special types of methods. A setter's purpose is to set property within the object, whereas a getter is to get property from the object.

In OpenLayers, most classes inherit from the `ol.Object` class. This class is fundamental for using setters and getters within the library. The excerpt from the official documentation is quite clear about them:

"Classes that inherit from this have predefined properties, to which you can add your own. The pre-defined properties are listed in this documentation as Observable Properties, and have their own accessors; for example, `ol.Map` has a `target` property, accessed with `getTarget()` and changed with `setTarget()`. However, not all properties are settable. There are also general-purpose accessors, `get()` and `set()`. For example, `get('target')` is equivalent to `getTarget()`."

Let's have a look at the API and understand how it uses the OOP concepts.

After reviewing the most important principles, let's inspect the API to sort out how to analyze it with OOP concepts.

For this, we will reuse the `ol.source.XYZ` API documentation, <http://openlayers.org/en/v3.0.0/apidoc/ol.source.XYZ.html>. First, let's start with the content on top of the page.

The screenshot shows the top of the `ol.source.XYZ` API documentation page. The title is `ol.source.XYZ` with the subtitle "Layer source for tile data with URLs in a set XYZ format." Below the title, there is a section for the constructor: `new ol.source.XYZ (options)` with a link to the source code at `src/ol/source/xyzsource.js, line 19`. A table lists the options for the constructor, with columns for Name, Type, and Description. The options are `options`, `attributions`, `crossOrigin`, `logo`, `url`, and `urls`. Below the table, there is a section for "Fires:" with a list of events, including `change`. At the bottom, there are sections for "Subclasses" and "Extends".

Constructor with options → `new ol.source.XYZ (options)` src/ol/source/xyzsource.js, line 19

File name and line number to find the constructor code. Note that there are two separate links here

Name	Type	Description
<code>options</code>	XYZ options.	
<code>attributions</code>	<code>Array.<ol.Attribution> undefined</code>	Attributions.
<code>crossOrigin</code>	<code>null string undefined</code>	Cross origin setting for image requests.
<code>logo</code>	<code>string olx.LogoOptions undefined</code>	Logo.
<code>url</code>	<code>string undefined</code>	URL template. Must include <code>{x}</code> , <code>{y}</code> or <code>{-y}</code> , and <code>{z}</code> placeholders.
<code>urls</code>	<code>Array.<string> undefined</code>	An array of URL templates.

Fires:

- `change` - Triggered when the state of the source changes.

Those classes inherits from ol.source.XYZ → **Subclasses**

- `ol.source.MapQuest`
- `ol.source.OSM`
- `ol.source.Stamen`

ol.source.XYZ inherits from ol.source.TileImage → **Extends** `ol.source.TileImage`

The illustration above is self-explanatory. You should follow the link for the constructor function, the subclasses to inspect properties, and methods subclasses inherits and discover provided properties and methods from `ol.source.TileImage`.

Using the following screenshot, you will be able understand inheritance:

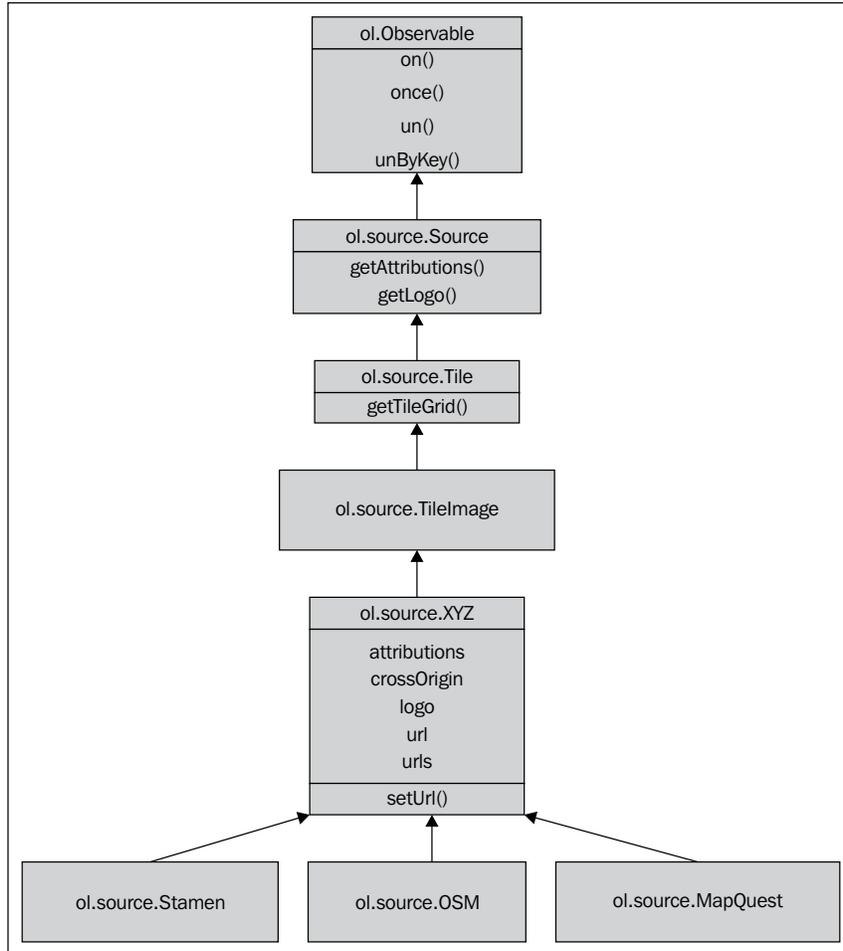
The screenshot displays a list of methods with their parameters, return types, and source file locations. Annotations on the right side of the image point to specific methods and their source files:

- getAttributions ()** (Array.<ol.Attribution>) **Inherited** (src/ol/source/source.js, line 96) ← Methods coming from ol.source.Source in source.js
- getLogo ()** (string|olx.LogoOptions|undefined) **Inherited** (src/ol/source/source.js, line 105) ← Methods coming from ol.source.Source in source.js
- getTileGrid ()** (ol.TileGrid.TileGrid) **Inherited** (src/ol/source/tilesource.js, line 170) ← Method coming from ol.source.Tile in tilesource.js
- ON (type, listener, opt_this)** (goog.events.Key) **Inherited** (src/ol/observable.js, line 65) ← Methods coming from ol.Observable in observable.js
- ONCE (type, listener, opt_this)** (goog.events.Key) **Inherited** (src/ol/observable.js, line 78) ← Methods coming from ol.Observable in observable.js
- setUrl (url)** (string) (src/ol/source/xyzsource.js, line 74) ← Method sets on xyzsource.js, without inheritance

Each method entry includes a 'Returns:' section with a description of the return value. The 'ON' and 'ONCE' methods also include a table with columns for Name, Type, and Description, detailing the parameters.

Looking at the screenshot, we are able to figure out most of the inheritance. We deduced the exact class inheritance by hovering over the inherited keyword with the mouse to see the URL that gives us a hint about it.

Within the previous screenshot, for readability, we had to remove the full `ol.source.XYZ` class description. If we include and follow all the available methods, the relationships between `ol.source.XYZ` class methods and properties and their parent and child classes, the result will be as follows:



Going further

For a more complete abstract about object-oriented programming, check out https://en.wikipedia.org/wiki/Object-oriented_programming.

For a review concerning JavaScript object-oriented programming, head on to https://developer.mozilla.org/en-US/docs/Web/JavaScript/Introduction_to_Object-Oriented_JavaScript.

B

More details on Closure Tools and Code Optimization Techniques

Closure Tools are a set of utilities used for web development. It is mainly supported by Google, but is open source under the Apache License Version 2.0, a well-established permissive license. The name Closure Tools hides under it a lot of subtools, which will make your life as an apprentice developer easier. It includes a JavaScript optimizer, a JavaScript library, a templating library, a style checker and style fixer, and at last, a stylesheet language. Just to illustrate how powerful this set can be, think that most Google JavaScript applications, such as Gmail or Google Maps, use these components.

Why are we introducing you to these tools?

The OpenLayers 3 library itself depends on the Closure Library, the JavaScript library attached to Closure Tools. Its main goal is to leverage cross-browser support. You also know you can write your application in pure JavaScript.

However, you can also consider Closure for advanced uses like creating your own component such as controls and buttons with special behavior inherited from an existing OpenLayers component. You will also get some useful UI components. It is also a good toolset to achieve better file compression when you want an efficient web mapping application, using the Closure Compiler, another utility from the Closure Tools bundle.

We will not review all Closure Tools but only the most useful. Specifically, we will cover the following topics:

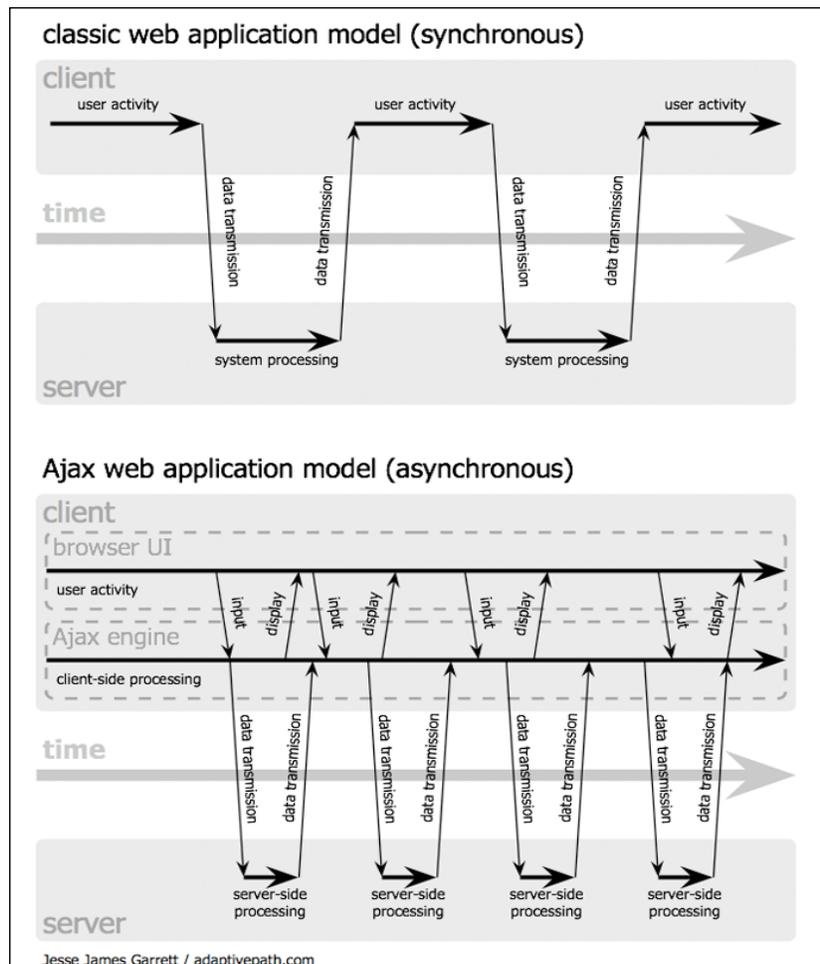
- ◆ Understanding the Closure Tools concepts
- ◆ How to use the Closure Library and a small review of the main components' families
- ◆ Why Closure Compiler is different from others compiler tools
- ◆ How to use it with Closure Library and with other JavaScript libraries. Application of Closure Tools in OpenLayers for improving our way of developing web-mapping applications
- ◆ The use of the already hidden workflow in OpenLayers code that relies on Closure Tools
- ◆ Best practices for creating readable code and how to detect and fix errors using both Closure style checker and style fixer

The Closure Tools philosophy

If you have ever done a bit of web development, and in particular, JavaScript, you must have heard about jQuery, the most popular JavaScript library with more than 50 percent of the worldwide websites using it. To not reinvent the wheel, the OpenLayers development team chose Closure Library rather than jQuery. Why was this decision made? For a better understanding, you need a bit of history of the Web.

Ensuring optimum performance

In the olden days, there wasn't a lot of JavaScript. All applications were created using simple HTML and CSS. There was dynamic content when reloading a full page using a server-side such as PHP or Java. However, people wanted a smoother web navigation experience. With the way AJAX works it was possible, as illustrated in the following figure, and people began to focus more and more on the client-side:



The main two problems associated with this evolution are:

- ◆ The more files you have, the more your browser will wait to display pages. The issue here comes from the processing cost to ask for the file, wait for it and then use it. This behavior is called latency. For example, imagine you are at the checkout counter at the supermarket; if ten clients buy one apple, the billing will take longer, than if one client buys ten apples.
- ◆ The second drawback of this evolution is that browsers have to load more and more resources such as images, CSS, and JavaScript.
- ◆ The bigger the files are, the longer it will take to retrieve and process the content. The main cause for this is the limited bandwidth. For example, when you are cooking pasta, the more water you put in, the longer you have to wait for the pasta to cook.

When you are at home, you don't really suffer from bandwidth restriction, but in other cases, you will always suffer from high latency. If you are planning to work on mobile support with limited bandwidth, high latency, and a browser with limited memory, it can be a pain.

A good part of the solution lies in compression.

You have three levels of compression available for JavaScript, depending on technology:

- ◆ Combine without compacting all JavaScript in one file
- ◆ Combine and compact all JavaScript in one file
- ◆ Combine, compact, and obfuscate the code

For performance, the last method will work the best, and the Closure Library is the only JavaScript library able to work this way, when combined with Closure Compiler.

Closure Tools, in particular, Closure Library and Closure Compiler are among the best tools to deal with this case.

Although both tools are tightly related, we will review the most useful functions related to Google Closure Library and later explain how to use Closure Compiler to optimize code.

Introducing Closure Library, yet another JavaScript library

Although the OpenLayers 3 development team chose Closure Library mainly for performance purposes, it is not the only reason.

To demonstrate, let's try some functions with Closure Library.

The basics

We will review the most useful functions when you chose to use the Closure Library. It will also help for understanding OpenLayers 3 internal code, based on Closure, when making custom components. Let's start with DOM functions.

Time for action – first steps with Closure Library

Although we can download the library on our computer, to remain simple, we will use a remote JavaScript library version.

- 1.** Create an HTML page using your text editor and cut and paste the following code:

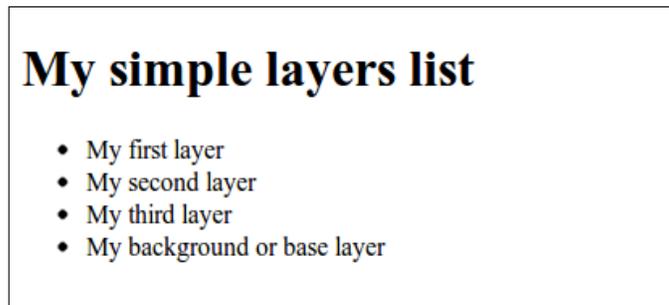
```
<!DOCTYPE html>
<html>
  <head>
    <title>Dom manipulation</title>
```

```
<script src='https://rawgit.com/google/closure-library/master/
closure/goog/base.js'></script>
<script>
  goog.require('goog.dom');

  </script>
</head>
<body>
  <ul id="my_layers_list">
    <li>My first layer</li>

    <li>My second layer</li>
    <li>My third layer</li>
    <li>My background or base layer</li>
  </ul>
  <script>
    var my_layers_list = goog.dom.getElement('my_layers_list');
    var myTitle = goog.dom.createDom('h1');
    var myText = goog.dom.createTextNode("My simple layers
list");
    goog.dom.append(myTitle, myText);
    goog.dom.insertSiblingBefore(myTitle, my_layers_list);
  </script>
</body>
</html>
```

2. Open your browser to see the following result:



What just happened?

In order to understand the code, let's review the lines related to the Google Library:

```
<script src='https://rawgit.com/google/closure-library/master/closure/
goog/base.js'>
</script>
```

Load the library base from a remote file. The code hosted on Github, needs to use a third-party website `https://rawgit.com` to be able to serve the `.js` files:

```
goog.require('goog.dom');
```

This line is the way to say *make available the function from goog.dom namespace of the library*. If you forget this call, every function call starting with `goog.dom` will fail. This call adds a call to `<script src='https://rawgit.com/google/closure-library/master/closure/goog/base.js'>` and must be separated in a dedicated `<script>` tag.

The goal here is to load only required functions and to keep your JavaScript clean with namespacing. Namespace enables separation of functions based on a common name. The chosen namespace for the Google Library is `goog`, so every function based on the library will start with `goog`. In this case, the `goog.dom` namespace is created. To discover the available functions in the namespace, you can use your JavaScript debugger and type `goog.dom` `var my_layers_list = goog.dom.getElement('my_layers_list');`. This line selects from DOM the element with an attribute ID, `'my_layer_lists'`.

`var myTitle = goog.dom.createDom('h1');` creates an `<h1>` tag in an HTML fragment, an element separated from the DOM, which you plan to add later to the web page DOM:

```
var myText = goog.dom.createTextNode("My simple layers list");
```

The following code line adds a text node, the visible element in HTML you will see in a web page.

```
goog.dom.append(myTitle, myText);
```

Add the text node to the `<h1>` tag. That is, the two previous *floating* elements `<h1>` `</h1>` and `My simple layers list` became: `<h1>My simple layers list</h1>`

```
goog.dom.insertSiblingBefore(myTitle, my_layers_list);
```

Add the combined fragment to the DOM: it will be visible in your browser. We choose to use the `insertSiblingBefore` method. Its purpose is to add a fragment in the DOM before a reference DOM element. So, the text with `<h1>` tags will appear before the list.

With this example, we have reviewed a small subset of the `goog.dom` functions.

You will need them, for example, for interactivity like displaying an element with a color change, or for having an application that reacts to a click of a button.



Google library is an ever evolving JavaScript library

In a real context, outside experimentations such as the first Closure Library code example, you will need to retrieve it using an **SCM (Source Code Management)** software. Its goal is to follow every change in the code. It is one of the most useful tools for developers. The one you need is called Git. Don't worry about it at the moment, we will need it in the *Installing the OpenLayers development environment* section. For now, just remember the URL to get the code from <https://github.com/google/closure-library>

To give you an overview of the most useful functions, we have mentioned below some statistics on the most used namespaces and sub-namespaces' functions in the OpenLayers 3 library. We also chose to keep the functions at the first level such as `goog.require()`. You can make the distinction between functions and namespaces with the open parenthesis. We also ordered the list in the following table:

Namespace and sub-namespaces	Numbers of occurrences
<code>goog.require()</code>	1436
<code>goog.asserts</code>	812
<code>goog.isDef()</code>	765
<code>goog.isNull()</code>	349
<code>goog.provide()</code>	295
<code>goog.object</code>	289
<code>goog.base()</code>	196
<code>goog.inherits()</code>	168
<code>goog.events, goog.vec</code>	136
<code>goog.dom</code>	113
<code>goog.array</code>	100
<code>goog.exportProperty()</code>	81
<code>goog.math</code>	72
<code>goog.isDefAndNotNull()</code>	68
<code>goog.getUid()</code>	39
<code>goog.style</code>	35
<code>goog.isString()</code>	22
<code>goog.bind()</code>	21
<code>goog.string</code>	14
<code>goog.partial()</code>	13

Namespace and sub-namespaces	Numbers of occurrences
<code>goog.isArray</code>	12
<code>goog.global</code>	11
<code>goog.addSingletonGetter(, goog.dispose(</code>	9
<code>goog.log, goog.uri.utils</code>	5
<code>goog.functions, goog.Uri, goog.now(</code>	4
<code>goog.net, goog.isFunction(, goog.isObject(</code>	3
<code>goog.async, goog.isNumber(</code>	2
<code>goog.color, goog.debug, goog.fs, goog.fx, goog.json, goog.userAgent, goog.isBoolean(, goog.Uri(</code>	1

Let's talk about `goog.require` and `goog.provide`. The Google Library, and hence the OpenLayers internal code, manages dependencies using these two declarations. In a file, `goog.require` helps declaring required functions needed in the application code, whereas the `goog.provide` is the opposite: it permits declaring that some functions are within a file. These declarations combined with Closure Compiler usage help solve dependencies between the various library files and also with the application code. Reusing these dependencies will enable combining code for production.

Other important functions are `goog.inherits` and `goog.base`: you will find them to apply inheritance concepts already evoked in *Appendix A, Object-oriented Programming – Introduction and Concepts*.

With previous functions, you might think that some functions not at the top of the list are not useful, but you shouldn't. In fact, we invite you to review them because the code for the core of a JavaScript library differs from the code application to use it. In particular, look at `goog.userAgent` functions or `goog.style`.



To have an overview of the available functions, the recommended way is to visit the official website, <https://developers.google.com/closure/library/>, to review the API, <http://docs.closure-library.googlecode.com/git/index.html>. For samples, look at the available demos you have to use at <https://github.com/google/closure-library/tree/master/closure/goog/demos/>. It's a great complementary help to the API, in particular to get an overview of the `goog.ui` components.

Next, let's head to an example to make your own component using Closure Library.

Custom components

When a component is not available, you will have to write some application code or for reuse purpose, make your own. In this section, we will first review some of the concepts of JavaScript applied with Google Closure Library. After this, we will see one of the official sample code to understand how to use the library to create your own customized component.

Inheritance, dependencies, and annotations

Let's start with the inheritance. It should ring a bell; otherwise, you should review *Appendix A, Object-oriented Programming – Introduction and Concepts*. This example will be enough to introduce you to other key concepts of the library:

```
<!DOCTYPE html>
<html>
  <head>
    <title>Inheritance</title>
    <script src='https://rawgit.com/google/closure-library/master/
closure/goog/base.js'></script>
  </head>
  <body>
    <script>
      //Parent Class
      goog.provide('myNamespace.layer.Layer');
      /**
       * @constructor
       */
      myNamespace.layer.Layer = function (options) {
        this.color_ = options.color || 'grey';
      }
      myNamespace.layer.Layer.prototype.getColor = function () {
        return this.color_;
      }
      //Sub Class
      goog.provide('myNamespace.layer.Vector');
      /**
       * @constructor
       * @extends {myNamespace.layer.Layer}
       */
      myNamespace.layer.Vector = function (options) {
        goog.base(this, options);
        if (options.style) {
          this.style_ = options.style;
        }
      }
    </script>
  </body>
</html>
```

```
    goog.inherits(myNamespace.layer.Vector, myNamespace.layer.Layer);  
    //Create a new instance of Vector layer and call to method from  
parent class.  
    var myVector = new myNamespace.layer.Vector({  
        color: 'white',  
        style: 'myStyle'  
    });  
    console.log(myVector.getColor());  
</script>  
</body>  
</html>
```

Launch it in your browser with the debugger, like Google Developer Tools, opened.

Let's review the code for the main lines:

```
<script src='http://closure-library.googlecode.com/svn/trunk/closure/  
goog/base.js'>  
</script>
```

This inserts the call to Closure Library:

```
goog.provide('myNamespace.layer.Layer');
```

This declares the parent namespace (and class) with `goog.provide`:

```
/**  
 * @constructor  
 */  
myNamespace.layer.Layer = function (options) {  
    this.color_ = options.color || 'grey';  
}
```

This declares the parent constructor:

```
myNamespace.layer.Layer.prototype.getColor = function () {  
    return this.color_;  
}
```

This adds a method to the prototype of the object:

```
goog.provide('myNamespace.layer.Vector');
```

This declares the children's namespace (and class) with `goog.provide`:

```
/**  
 * @constructor  
 * @extends {myNamespace.layer.Layer}  
 */
```

```
myNamespace.layer.Vector = function (options) {
  goog.base(this, options);
  if (options.style) {
    this.style_ = options.style;
  }
}
```

This declares the children's constructor and specifies who the parent is, in comments with `@extends`.

In the function, `goog.base(this, options);` can be replaced with `myNamespace.layer.Layer.call(this, options);` for a pure JavaScript alternative. It says to call the options from the current constructor:

```
goog.inherits(myNamespace.layer.Vector, myNamespace.layer.Layer);
```

This makes `myNamespace.layer.Vector` inherit from its parent `myNamespace.layer.Layer`.

```
var myVector = new myNamespace.layer.Vector({
  color: 'white',
  style: 'myStyle'
});
console.log(myVector.getColor());
```

This instantiates `myNamespace.layer.Vector` with options and makes a console call to get the method call to the parent class in order to retrieve the color.

Until now, we mainly covered Closure Library, but this knowledge can be reused in OpenLayers. You will see that OpenLayers application code can really look like Closure Library.

Have a go hero – analyze a real OpenLayers case

To see the similarity between Closure Library and OpenLayers application code, we will review inheritance in a real OpenLayers context. So, we will ask you to review an official example available at <http://openlayers.org/en/v3.0.0/examples/custom-controls.html>.

It will also be a good opportunity to review inheritance knowledge from *Chapter 2, Key Concepts in OpenLayers*; *Chapter 9, Taking Control of Controls* and *Appendix A, Object-oriented Programming – Introduction and Concepts*.

This example contains the following JavaScript content:

```
/**
 * Define a namespace for the application.
 */
window.app = {};
var app = window.app;

//
// Define rotate to north control.
//

/**
 * @constructor
 * @extends {ol.control.Control}
 * @param {Object=} opt_options Control options.
 */
app.RotateNorthControl = function(opt_options) {

  var options = opt_options || {};

  var anchor = document.createElement('a');
  anchor.href = '#rotate-north';
  anchor.innerHTML = 'N';

  var this_ = this;
  var handleRotateNorth = function(e) {
    // prevent #rotate-north anchor from getting appended to the url
    e.preventDefault();
    this_.getMap().getView().setRotation(0);
  };

  anchor.addEventListener('click', handleRotateNorth, false);
  anchor.addEventListener('touchstart', handleRotateNorth, false);

  var element = document.createElement('div');
  element.className = 'rotate-north ol-unselectable';
  element.appendChild(anchor);

  ol.control.Control.call(this, {
    element: element,
    target: options.target
  });
};
```

```
};
ol.inherits(app.RotateNorthControl, ol.control.Control);

//
// Create map, giving it a rotate to north control.
//

var map = new ol.Map({
  controls: ol.control.defaults({
    attributionOptions: /** @type {olx.control.AttributionOptions} */
    ({
      collapsible: false
    })
  }).extend([
    new app.RotateNorthControl()
  ]),
  layers: [
    new ol.layer.Tile({
      source: new ol.source.OSM()
    })
  ],
  renderer: exampleNS.getRendererFromQueryString(),
  target: 'map',
  view: new ol.View({
    center: [0, 0],
    zoom: 2,
    rotation: 1
  })
});
```

These questions are for improvement:

- ◆ Where does the code instantiate the `RotateNorthControl` component?
- ◆ What is the parent class?
- ◆ Where are the constructors and its methods?
- ◆ What is the difference between the two methods (hint in the comments)?
- ◆ Where do you declare inheritance (hint: `ol.inherits` is an alias to `goog.inherits`)?

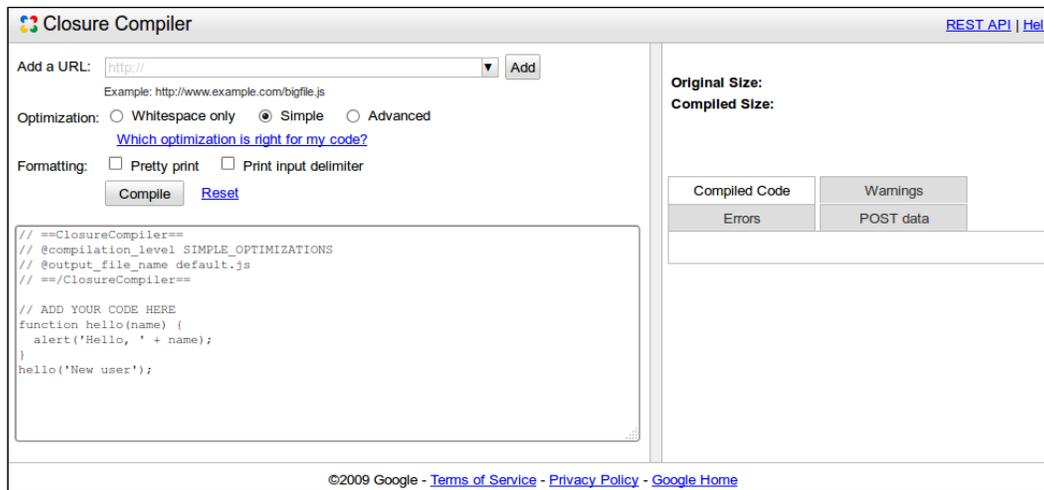
Until now, we focused on Closure Library. However, as we mentioned at the start of this chapter, for performance, we need to use Closure Compiler as well. It is time to do it!

Making custom build for optimizing performance

This appendix is dedicated to Closure Tools to help you understand how to optimize your mapping applications. We will directly try Closure Compiler and after that review how to use it in a real OpenLayers case.

Time for action – playing with Closure Compiler

The more we can learn without installing tools the better it is to lower the learning entry. So, we will use the Closure Compiler online tool. Go to the official URL, <http://closure-compiler.appspot.com> and you will get the following screenshot:



To display the ability of the Closure Compiler to compress files, we will ask you to try it online. Perform the following actions:

1. Cut and paste only the JavaScript content from inheritance use case replacing the `// ADD YOUR CODE HERE` section in the left-hand text area.
2. Push on the **Compile** button and wait. You will see the **Compiled Code** tab going green.
3. Write on a paper or a spreadsheet **Original Size** and **Compiled Size**. You can also copy the generated code.
4. Change **Optimization** parameters to **Whitespace only** (**Simple** is the default that we have already tried) and note down the **Original Size** and the **Compiled size** again.

5. Repeat the last step with **Optimization** parameters set to **Advanced**.

The screenshot shows the Closure Compiler interface. The 'Add a URL' field contains 'http://'. The 'Optimization' section has 'Advanced' selected. The 'Formatting' section has 'Pretty print' and 'Print input delimiter' unchecked. The 'Compile' button is visible. The output area shows the following information:

Compilation was a success!

Original Size: 386 bytes gzipped (903 bytes uncompressed)

Compiled Size: 130 bytes gzipped (134 bytes uncompressed)

Saved 66.32% off the gzipped size (85.16% without gzip)

The code may also be accessed at [default.js](#).

The compiled code is shown in a box:

```
function b(a){this.a=a.color||"grey"}function c(a){b.call(this,a);goog.b(c,b);console.log((new c({color:"white",style:"myStyle"})).a);}
```

At the bottom of the interface, it says: ©2009 Google - [Terms of Service](#) - [Privacy Policy](#) - [Google Home](#)

What just happened?

The results you get from your experiment are as follows:

Compression level	Original size	Original gzipped size	Save percentage	Compiled size	Compiled gzipped size	Save gzipped percentage
WHITESPACE	940 bytes	391 bytes	45.21%	515 bytes	238 bytes	39.13%
SIMPLE	940 bytes	391 bytes	52.77%	444 bytes	224 bytes	42.71%
ADVANCED	940 bytes	391 bytes	85.74%	160 bytes	141 bytes	66.75%

Let's take a look at the results of the different optimizations mode to compare:

◆ The **WHITESPACE** mode:

```
goog.provide("myNamespace.layer.Layer");myNamespace.
layer.Layer=function(options){this.color_=options.
color||"grey"};myNamespace.layer.Layer.prototype.
getColor=function(){return this.color_};goog.provide("myNamespace.
layer.Vector");myNamespace.layer.Vector=function(options)
{goog.base(this,options);if(options.style)this.style_=options.
style};goog.inherits(myNamespace.layer.Vector,myNamespace.layer.
Layer);var myVector=new myNamespace.layer.Vector({color:"white",st
yle:"myStyle"});console.log(myVector.getColor());
```

As you can see, everything is preserved. You only made the code compact by removing white space.

◆ The **SIMPLE** mode:

```
var myNamespace={layer:{}};myNamespace.layer.Layer=function(a)
{this.color_=a.color||"grey"};myNamespace.layer.Layer.prototype.
getColor=function(){return this.color_};myNamespace.layer.
Vector=function(a){myNamespace.layer.Layer.call(this,a);a.
style&&(this.style_=a.style)};goog.inherits(myNamespace.layer.
Vector,myNamespace.layer.Layer);var myVector=new myNamespace.
layer.Vector({color:"white",style:"myStyle"});console.
log(myVector.getColor());
```

As you can see the compiler has done a substituting job by replacing all the `goog` functions. The only remaining namespaced function is `goog.inherits`. The function arguments are also renamed. It remains quite readable. If you replace the JavaScript from the example with this one, you can always call in your console the function with their original names.

◆ The **ADVANCED** mode:

```
function b(a){this.a=a.color||"grey"}function c(a)
{b.call(this,a);a.style&&(this.c=a.style)}goog.b(c,b);console.
log((new c({color:"white",style:"myStyle"})).a);
```

As you can see in this case, most of the code is renamed. The code in itself will have the same behavior but you can't call it with the original functions you wrote.

The **ADVANCED** way of doing it is the more efficient way to compress, but it requires extra work as compared to the **SIMPLE** mode. In particular, you need to add extra comments to be able to run the compiler. We gave you a working example, but removed the text `@constructor` on the sample code and run again the **ADVANCED** mode and observe. Because of this mode when you are using foreign code such as an external library, you have to mention preserve this code from renaming. For this, you have to declare what we call **externs**. If you don't have available externs with the library you are using, your code will fail to execute correctly.

Do not worry at the moment! The OpenLayers tools we will review already support jQuery externs, for example. We recommend that you go to the dedicated web pages from Google because it's an advanced feature (<https://developers.google.com/closure/compiler/docs/api-tutorial3>) and because we will review later how to solve it in the OpenLayers 3 context. You can also solve the problem using only the **SIMPLE** mode but you will lose a part of the gain of Closure Tools.

We will now see the application of what we learned so far in OpenLayers.

Applying your knowledge to the OpenLayers case

When you choose to release your application online and you need performance for your web mapping applications, you need to perform certain steps.

Closure Compiler enables you to do so at the JavaScript level. In the OpenLayers project, some tools facilitate the use of Closure Compiler.

These tools, such as Closure Compiler, depend on three languages: Python, Java, and Node. We will quickly review the install process to run it.

Installing the OpenLayers development environment

We will review how to install the environment on the different operating systems. We will start with Python. Then, we will install NodeJS. Next, we will do a Java installation and we will end with other tools such as Git installing.

Closure Compiler requires 2.x series of Python. You can install it using the following instructions for Microsoft Windows and Linux. For Mac OSX, Python is already bundled.

Microsoft Windows (as administrator)

Go to <http://www.python.org/downloads/> and follow these steps:

Click on the link referring to the latest Python 2.x series (2.7.9 at writing time). Next, click **Download** on the **Windows x86 MSI Installer** or **Windows X86-64 MSI Installer**, depending of your Microsoft Windows architecture.

1. You also need to add Python to the PATH variable.
2. For this, right-click on **My Computer** and click **Properties**. Go to the **Advanced System Settings** link in the left column. In the **System Properties** window, click the **Environment Variables** button. You can now, on the bottom part of the System variables, click on **Edit Path** and add the path at the end of the string, `;C:\Python27;C:\Python27\Scripts`.

Linux

You need to open a command line as `superuser`:

On a RedHat-based OS:

```
yum install python python-setuptools
```

On Ubuntu/Debian OS:

```
apt-get install python python-setuptools
```

On every OS, open a command line (for MS-DOS, go to open Command Prompt or Bash for Linux/Mac OSX) and type:

```
python --version
```

It will echo something such as **Python 2.7.5**.

For all OS, you must install `pip`, a packet manager for Python.

Download it at <https://bootstrap.pypa.io/get-pip.py> and then execute the following code line:

```
python get-pip.py
```

Now, let's examine the Node.js installation process.

Installing Node.js

It's quite easy. We will not rely on external packages but only official binaries. Check out the official website at <http://nodejs.org/download/>.

Microsoft Windows

Just download the binary, and then execute the installer. Nowadays, except if you have an old Windows XP, you should download the 64 bit **Windows Installer (.msi)**.

Linux

Instructions are for both RedHat-based OS and Ubuntu/Debian OS.

1. Go to the download page to get the 64-bit **Linux Binaries (.tar.gz)**, except if for any reason, you are using an old 32-bit Linux.
2. From the command line, you can do it as `su` or by adding `sudo`:

```
mkdir /opt/node && chmod -R 777 /opt/node/
```
3. Uncompress the downloaded directory.
4. Move the content to the new `/opt/node` directory.

5. Then, add to the `~/.profile` file the following:

```
export PATH=$PATH:/opt/node/bin
```

Mac OSX

Download and run the `.dmg` file. Open a terminal and type `node`. If you get an error, add the following to the `~/.profile` file:

```
export PATH=$PATH:/usr/local/bin
```

After this quick Node.js installation review, let's install Java.

Installing Java

We have assumed you started from scratch. You may already have Java installed. Mostly, it will be the **JRE (Java Runtime Environment)**. JRE is enough to execute Java, but we can also use the developer-oriented JDK (Java Development Kit).

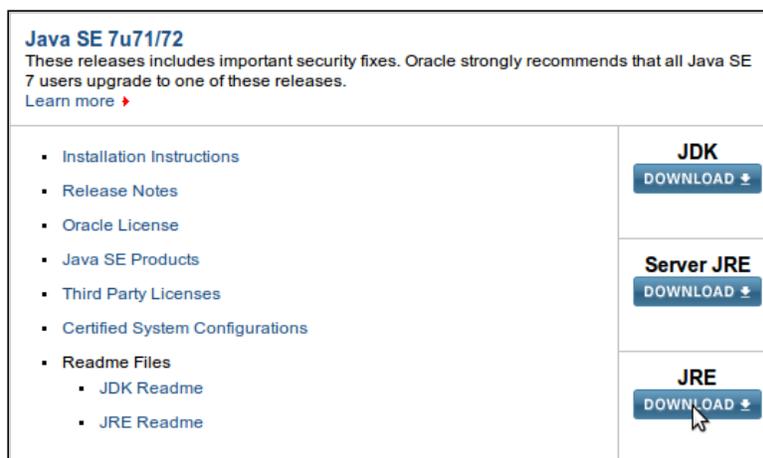
Before downloading a new JRE, try to see if you already have Java installed. For this, open a command prompt and type the following:

```
java -version
```

If the feedback is not something like `java version "1.7.0_xx"`, you should consider installing the JRE. The returned version must be `1.7.0_xx` (`xx` is the exact version) and it should not be `1.6.0_xx` or `1.8.0.xx`. At the writing time, the version was `1.7.0_72`.

Independent of the OS, head to <http://www.oracle.com/technetwork/java/javase/downloads> for downloading the file you require to have Java **JRE (Java Runtime Environment)**.

As there are many links, you will find the following screenshot with the mouse indicating the link to follow:



Microsoft Windows

After download, run the installer and set the `PATH`, as for Python.

Here, you will need to add a new system environment variable called `JAVA_HOME` with the value `C:\Program Files\Java\jrexxx` or `C:\Program Files (x86)\Java\jrexxx`, depending on your architecture (32 or 64 bit). You will follow the same recipe described to change `PATH` in Python but instead of editing an existing variable, you will add it.

After, add at the end of the `PATH` environment `;%JAVA_HOME%\bin`.

Linux

On a RedHat-based OS:

Retrieve the RPM from the URL retrieved by following the screenshot **JRE Download** button and perform the following command as `superuser` (depending on your java version):

```
rpm -ivh jre-7u72-linux-x64.rpm
```

On an Ubuntu/Debian OS, get the `tar.gz` Linux file instead of the RPM file:

```
tar xvzf jre-7u72-linux-x64.tar.gz
mv jre1.7.0_72 /opt/ && chmod -R 777 /opt/jre1.7.0_72
```

In `~/.profile`, add the following content at the end of the file:

```
export JAVA_HOME=/opt/jre1.7.0_72
export PATH=$PATH:$JAVA_HOME/bin
```

Mac OSX

Run the `.dmg` file and add to the `~/.profile` file:

```
export JAVA_HOME=/Library/Java/Home
export PATH=$PATH:$JAVA_HOME/bin
```

Installing Git

In the information box about Closure Library, we mentioned an SCM called Git. Now, it's time for installation. Let's see how it works on a different OS.

Microsoft Windows

Head to the **msysGit** project, <https://msysgit.github.io>, download the installer by clicking on the **Download** link and execute it.

After installation, add to the `PATH`, as for Python, the string; `C:\msysgit\bin\;C:\msysgit\bin\mingw\bin`

Linux

On a RedHat-based OS:

```
yum install git-core
```

On an Ubuntu/Debian OS:

```
apt-get install gitMac OSX
```

Go to the Mac installer website, <http://code.google.com/p/git-osx-installer/>, and install it.

Now that you have Git, you can install other tools.

Now, everything is ready! So, let's start to use the Closure Compiler to better understand how to optimize your code to display faster maps. We will review how to use the OpenLayers development workflow to make your custom application.

Local OpenLayers development reloaded

Although we have seen that you can use a simple call to an external JavaScript file to make your application, it's better to prepare for deployment and use custom build.

Time for action - running official examples with the internal OpenLayers toolkit

We will inspect reusing the workflow for developing the OpenLayers core library to run the official examples. For this purpose, start with the following step:

1. Download the project code in your command line:

```
git clone https://github.com/openlayers/ol3.git
cd ol3
git checkout v3.0.0
```
2. Install Node and Python additional libraries with:

```
npm install
sudo pip install -r requirements.txt
```
3. Run from the command line, on Windows, `build.cmd checkdeps` or `./build.py checkdeps` on Linux / Mac OSX. It will return if dependencies are solved to proceed to the next step.

4. To retrieve Closure Compiler and use the automatic configuration from the OpenLayers project, launch on Microsoft Windows:

```
build.cmd
build.cmd host-examples
build.cmd serve
```

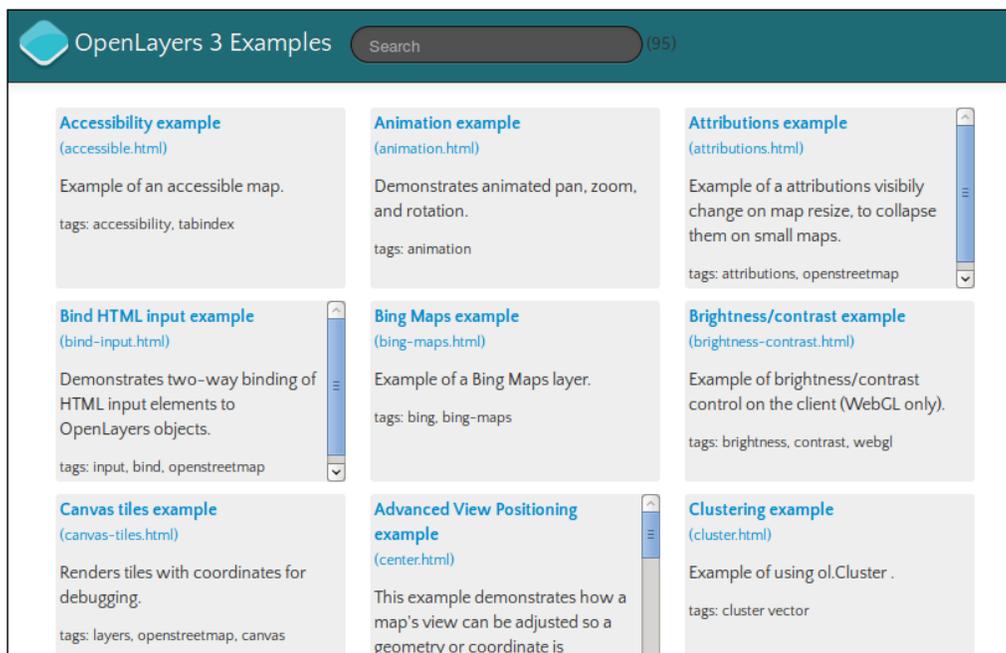
5. On Linux / Mac OSX:

```
./build.py
./build.py host-examples
./build.py serve
```



You may need an offline API, if for example, you're working in public transportation or without a network connection. To generate it, execute the `./build.py apidoc` or `build.cmd apidoc`. Then, open it with `http://localhost:3000/build/hosted/HEAD/apidoc/`. You can also get it directly from the `v3.0.0.zip` file, downloaded from *Chapter 1, Getting Started with OpenLayers*.

6. Now, open your browser at `http://localhost:3000/examples/` and open Google Chrome Developers Tools. You will see the examples like the one you get on the official website that follows:



7. Explore the examples and watch for the **Elements**, **Network**, and **Sources** panel, in particular the JavaScript calls.
8. Then, navigate to `http://localhost:3000/build/hosted/HEAD/examples/attributions.html`.
9. Try to add the URL of the examples `?mode=whitespace` or `?mode=simple`, or `?mode=raw`.

What just happened?

We serve files on a small web server. In the first case, the `loader.js` file retrieves the dependencies and adds for each required files the script tag with the `src` attribute. In the second case, we chose to open the hosted files, the ones you get when you browse the official website, `http://openlayers.org`.

In the second case, depending on the provided values for the `mode` parameter, we will load different files for the OpenLayers 3 library:

- ◆ **Raw:** This loads each input via its own `<script>` tag. This does not run the Compiler, so no checks are performed.
- ◆ **Whitespace:** This loads all of the JavaScript code concatenated together with all white space and comments removed.
- ◆ **Simple:** This loads the JavaScript as compiled with `SIMPLE_OPTIMIZATIONS` enabled. Without an option in the URL, this loads the JavaScript as compiled with `ADVANCED_OPTIMIZATIONS` enabled.

Hey! These options look familiar, where did we see them?

Remember that we had mentioned to you that OpenLayers tools are using Closure Compiler. Let's see how OpenLayers takes benefits from it.

OpenLayers 3 default build tool advantages

When you changed examples with the **raw** mode, you may have noticed (in particular by filtering the script in the **Network** panel) that the loaded files number greatly differs from the URL without it. What can make this difference? Let's see some practical uses to understand.

Removing the unused code feature

We waited until now to review the removal of the unused code feature related to Google Closure Compiler.

As we already said, when you switch between examples, you load different files. How does it work?

Open your browser **Network** panel. Open the URL for one of the official examples and add `?mode=raw`.

Then, in the console, type `console.log(paths.length);`.

Just compare the length between the examples. If your example in the URL is `animation.html`, inspect also the `animation-require.js` files, you will see that there are some lines beginning with `goog.require('...')`. The loader gets the name from the file via `loader?id=examplename`, and with the `goog.require` indications from `examplename-require.js`, Closure Compiler generates the list of files to load for the example.

When Compiler does not find the required `goog.require` statements, it excludes the files and the resulting build file is smaller. On mobile applications, it is invaluable. Just be careful to not break your application, for example, if you forget to add a statement.

Making your custom build

When you run `./build.py` or `build.cmd`, you have something such as `2014-12-10 18:41:23,358 build/ol.js: node tasks/build.js config/ol.json build/ol.js`. We will reuse the beginning command to compile the `ol.js` file again and play with the Closure Compiler builder included in the OpenLayers 3 toolkit. The `ol.json` file is used to provide parameters to Closure Compiler to make the build and `ol.js` is the output result.

To build, you have two choices:

- ◆ Build the code to make it work with a separate `.js` lightened build
- ◆ Build the code by including the OpenLayers library code, together with the script file

At the moment, you have a shared JSON file for all examples in `config/examples-all.json`. We will reuse it.

Time for action - building your custom OpenLayers library

We will reuse the `animation` sample, from the local OpenLayers installation, to try out both ways of building code:

- 1.** Copy the `animation.html` and `animation.js` files from the examples folder into `animation-exports.html` and `animation-exports.js`.
- 2.** Create a file `config/ol-animation-exports.json` inspired by the `config/examples-all.json` with the following content:

```
{
  "exports": ["ol.Map",
    "ol.Map#*",
    "ol.View",
    "ol.animation.*"],
```

```
"ol.control.*",
"ol.layer.Tile",
"ol.proj.*",
"ol.source.OSM"
],
"src": ["src/**/*.js"],
"compile": {
  "externs": [
    "externs/bingmaps.js",
    "externs/bootstrap.js",
    "externs/closure-compiler.js",
    "externs/example.js",
    "externs/geojson.js",
    "externs/jquery-1.7.js",
    "externs/oli.js",
    "externs/olx.js",
    "externs/proj4js.js",
    "externs/tilejson.js",
    "externs/topojson.js",
    "externs/vbarray.js"
  ],
  "define": [
    "goog.dom.ASSUME_STANDARDS_MODE=true",
    "goog.DEBUG=false"
  ],
  "jscomp_error": [
    "accessControls",
    "ambiguousFunctionDecl",
    "checkEventfulObjectDisposal",
    "checkRegExp",
    "checkStructDictInheritance",
    "checkTypes",
    "checkVars",
    "const",
    "constantProperty",
    "deprecated",
    "duplicateMessage",
    "es3",
    "externsValidation",
    "fileoverviewTags",
    "globalThis",
    "internetExplorerChecks",
    "invalidCasts",
    "misplacedTypeAnnotation",
    "missingGetCssName",
    "missingProperties",
    "missingProvide",
```

```
    "missingRequire",
    "missingReturn",
    "newCheckTypes",
    "nonStandardJsDocs",
    "suspiciousCode",
    "strictModuleDepCheck",
    "typeInvalidation",
    "undefinedNames",
    "undefinedVars",
    "unknownDefines",
    "uselessCode",
    "visibility"
  ],
  "extra_annotation_name": [
    "api", "observable"
  ],
  "jscomp_off": [
    "es5Strict"
  ],
  "compilation_level": "ADVANCED",
  "output_wrapper": "// OpenLayers 3. See http://ol3.js.org/\n(function(){%output%})();",
  "use_types_for_optimization": true
}
}
```

3. In the `animation-exports.js` file, remove the `goog.require` statements.
4. In `animation-exports.html`, change the `script src` attribute from `loader.js?id=animation` to `../build/ol-animation-exports.js` and add a new script reference with `<script src="animation-exports.js"></script>`.
5. Compile the `ol-animation-exports.js` file from the root `ol3` folder using the following command:

```
node tasks/build.js config/ol-animation-exports.json build/ol-animation-exports.js
```
6. Launch `./build.py serve` or `build.cmd serve` and open your browser at `http://localhost:3000/examples/animation-exports.html`.
7. Stop the server and again copy the `animation.html` and `animation.js` from the `examples` folder into `animation-combined.html` and `animation-combined.js`.

8. At the bottom of the HTML code, change the code to only get two JavaScript calls:


```
<script src="jquery.min.js"></script>
  <script src="../build/ol-animation-combined.js"></script>
```
9. Copy the previous `config/ol-animation-exports.json` into `config/ol-animation-combined.json`.
10. Set exports to `[]` and add at the end of the array, contained in the `src` value, the `.js` files declaration to get a result like the following:


```
"src": [
  "src/**/*.js",
  "examples/animation-combined.js"
]
```
11. Add in the beginning of the `examples/animation-combined.js` file the code from `resources/example-behaviour.js`.
12. Remove the line `externs/example.js`, from the `config/ol-animation-combined.json` file.
13. Compile the code with:


```
node tasks/build.js config/ol-animation-combined.json build/ol-animation-combined.js
```
14. Serve files and open the browser to: `http://localhost:3000/examples/animation-exports.html`

What just happened?

Until now, to facilitate learning, we used code for samples within the HTML. For compressing code, firstly, you need to have all your JavaScript code in a separate `.js` file.

In the first case, we used exports in the **ADVANCED** mode. At the functional level, exporting means that you want to stop obfuscating variables, for example, renaming variables and properties to shorter ones. The advantage of this, is that you can use code from outside the library, in a third-party JavaScript file. It can help you, for example, in designing a subset of the OpenLayers 3 library for specific use cases or making your own library based on the OpenLayers 3 and a custom code augmenting the default.

At the code level, to know what we want to export, we reuse the content from `goog.require` statements in the example. These statements are deduced from the code namespaces and constructors. If you limit yourself to these statements to declare exports, when compiling and executing code, you will get some errors stating `undefined` in the browser debugger console. Mostly, it means you protect the constructor but you didn't choose some functions to protect. To protect from variable renaming, you will need to use the `*` character. It's what we have done with `ol.Map#*` or `ol.proj.*`.

In the `ol.Map#*` case, we said that we wanted to protect all functions from `ol.Map.prototype` to be renamed by using the `#` character. In the `ol.proj.*` use case, we just protected the all `ol.transform` namespace.

For externs, we will not go in to the details of how they work, but you just have to understand that it's a way to protect code from other libraries to be renamed by Closure Compiler by declaring their variables' and functions' signatures.

If we review the other parameters in the first JSON file, the most important ones are:

- ◆ `src`: This helps define where your compiler has to search for code when managing dependencies. Those dependencies are declared by declarations in code.
- ◆ `compilation_level`: This can be set to **ADVANCED**, **WHITESPACE_ONLY**, or **SIMPLE**. We chose to look at the **ADVANCED** case, because once we have understood how to work with the advanced option, the others can be worked on easily.
- ◆ Another quite important parameter is `use_types_for_optimization`. In fact, it highlights the importance of comments also known as annotations. We will start by quoting the official Closure Compiler documentation:

"The Closure Compiler can use data type information about JavaScript variables to provide enhanced optimization and warnings. JavaScript, however, has no way to declare types. Because JavaScript has no syntax for declaring the type of a variable, you must use comments in the code to specify the data type."

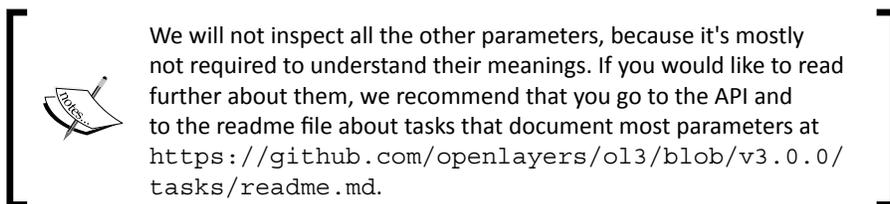
From this, we can deduce that you can use Closure Compiler without always using comments but comments can help you catch errors using variables type checking based on comments (based on a standard called JSDoc).

It's also useful, because when Closure compiler uses the **ADVANCED** mode, the compiler renames variables to decrease the build size and annotations act as hints for the tool. Moreover, the commenting code is anyways a good practice to maintain code: do not hesitate to use them. Navigate to the official Closure Compiler documentation (<https://developers.google.com/closure/compiler/docs/js-for-compiler>) to see the exact grammar.

Another good tip related to annotations is the fact that adding an annotation `@api` (specific to OpenLayers) is the way to export a function when you use OpenLayers 3 default build system.

For instance, you can add `@api` to `ol.Ellipsoid` and `ol.Ellipsoid.prototype.vincentyDistance` in the file `src/ol/ellipsoid/ellipsoid.js` (for reference, see `src/ol/map.js` line 160). Then, launch `node tasks/build.js config/ol.json build/ol.js` and reuse the generated `ol.js` instead of the usual one. You will see that you can use, in your application code, the following code:

```
var ellipsoid_wgs84 = new ol.Ellipsoid(6378137, 1/298.257223563);
var distance_ol3_vincenty = ellipsoid_wgs84.vincentyDistance([5, 34],
[12, 56])
```



If we dive into the case where we build everything together, the essential part is the inclusion of the `build/ol-animation-combined.js` file in the `src` array parameter.

As we removed the script tag calling `resources/example-behaviour.js` from `animation-combined.html`, we had to combine `resources/example-behaviour.js` with `examples/animation-combined.js` files. It's because adding a file into `src` array is not enough. You need `goog.require` into the file to be combined with the main OpenLayers 3 library code.

With the inclusion of `resources/example-behaviour.js`, the other important part was to remove the `externs/example.js` line, in order to unprotect the `exampleNS` namespace, so that we can rename it.

You should also note that in both reviewed case, compression can be achieved because of already mentioned `goog.require` and `goog.provide`. At the code level, they allow you to create a dependencies tree to gather each required function and variable within OpenLayers core library code source files.

If you inspect the size of the resulting files, you will see that although we have more content in the `ol-animation-combined.js` file than `ol-animation-exports.js`, the first one weighs 190Ko (65Ko manually `gzip` compressed), whereas the second size is 212Ko (71Ko manually `gzip` compressed).

The conclusion is that compiling everything together is the best solution to gain size in your code.

Now, try to reuse this knowledge in your own OpenLayers samples build.

Have a go hero – applying code optimization to other OpenLayers samples

Now that you have all the basic knowledge about OpenLayers toolkit to compress code, try and apply it your own project.

To improve your skills, you can perform the same task we did in the previous *Time for action* section, but using a different example. You can use the JSON files from the build/examples because they may help you to solve building dependencies. Be careful, if you rely only on those files, it will not work the expected way if you use the export method or you change JavaScript calls in samples HTML files.

To try it out.

1. You have to create an HTML and a JavaScript file.
2. You have to change the paths in samples.
3. Test them by interacting with your samples; it may work when they are loading, but they will fail later when clicking and panning.

You have to change the paths in samples, and then test them by interacting with your samples; it may work when they are loading, but they will fail later when clicking and panning.

Using externs

Remember we told you that without externs, you can't use external libraries in the **ADVANCED** mode? We recommend you comment out or remove externs, to see what will happen if we don't use them. In particular, try to remove jQuery externs, and try to build the examples from *Time for action*.

What do you see? If you don't have any ideas, you can see that externs' keywords refers to some JavaScript files. If you need, for example, to use a library such as Underscore (another JavaScript Library to use more functional programming), just copy the externs, add your path to the JSON file, say, "`../externs/underscore.js`", and after this, you are ready to use your library in the Closure Compiler **ADVANCED** mode.

To find out about externs, go to this Closure Compiler web page: <https://github.com/google/closure-compiler/wiki/Externs-For-Common-Libraries>

If you require another less common library, find it using a search engine or by generating it with this tool: <http://blog.dotnetwise.com/2009/11/closure-compiler-externs-extractor.html>

In the worst case, you will be stuck and will only be able to use the **SIMPLE** mode or to use the exports method, building a minimum Openlayers core library.

Pop quiz– advanced mode

Q1. When using the OpenLayers 3 toolkit, your code is not working in the **ADVANCED** compilation mode, although it's perfectly fine in the **SIMPLE** mode, what can be the cause (multiple choices accepted)?

1. You didn't declare `goog.require`
2. You forgot to use `goog.inherits`
3. You didn't use `goog` functions in your custom code
4. You used an external library without externs
5. You forgot comments in a constructor function

Now, we have seen mainly an underlying way to compress the JavaScript code; we will introduce you to syntax and styles in JavaScript code. When you start to write more than ten lines of code, it starts to become an obligation!

Syntax and styles

Syntax and styles are the way to keep your code clean and to share it. You can always do dirty work, but for maintainability of long term, it is a must to enforce some rules.

For this, we rely on Closure Linter, one of the Closure tools. It also requires Python to run. We already installed it with `pip install -r requirements`; so, let's see how to use it. Later, we will see some alternatives.

Time for action – using Closure Linter to fix JavaScript

We will retrieve one file from the previous OpenLayers library Version 2.12.

For this, download the file `Map.js` from <https://raw.githubusercontent.com/openlayers/openlayers/release-2.12/lib/OpenLayers/Map.js>.

Type the following command:

```
gjslint Map.js
```

You will get 605 errors with messages like below:

```
----- FILE : /home/thomas/Map.js -----
Line 1, E:0001: Extra space at end of line
Line 7, E:0200: Invalid JsDoc tag: requires
Line 266, E:0131: Single-quoted string preferred over double-quoted string.
Line 982, E:0120: Binary operator should go on previous line "+"
Line 1106, E:0002: Missing space before "("
```

```
Line 1131, E:0002: Missing space after "function"  
Line 1089, E:0110: Line too long (83 characters).  
Found 605 errors, including 0 new errors, in 1 files (0 files OK).
```

Some of the errors reported by GJSLint may be auto-fixable using the `fixjsstyle` script. Please double-check any changes it makes and report any bugs. The script can be run by executing:

```
fixjsstyle Map.js
```

So now, make a copy of the `Map.js` file to save it in an eventual case where the fixer would suffer from a bug. Then, execute the following recommended line:

```
fixjsstyle Map.js
```

You will see:

```
fixjsstyle Map.js Fixed 582 errors in /home/thomas/Map.js  
WARNING: Line 1089 of /home/thomas/Map.js is now longer than 80 characters.
```

Relaunch the `gjslint` again:

```
gjslint Map.js
```

You now have only 23 errors. Really good compared to the previous 605 errors. You can ignore, in this case, errors like:

- ◆ **E:0200: Invalid JsDoc tag:** This requires OpenLayers 2 code; do not use Closure so requires tag is not available
- ◆ **E:0110: Line too long (n characters):** Sometimes, you need more than 80 lines in your code so ignore it, in particular for an existing code like the one used

Be aware, that you can use options to comply more or less to the language but can't customize everything. You are also encouraged to play with the options. To discover them, execute the following command:

```
gjslint --help
```

For example, try the `--strict` options that check also your file indentation and you get 1867 errors or use the recursive option `-r` to apply check on a every JavaScript files in a directory.

We use a practical approach, but to understand the adopted code style, we invite you to go to the Google JavaScript Guide at <http://google-styleguide.googlecode.com/svn/trunk/javascriptguide.xml>, in particular, if you don't want to fix all your code at the end of your project.

We gave you some information about the raw use of the Linter, but like for other cases, you already can check your code in the default OpenLayers development environment. Just launch `./build.py lint` or `build.cmd lint`, depending on your OS.

Although syntax and styles are considered as good practices. Good practices are not rules; you choose to respect them more or less. Never forget that consistency is important, particularly when you need to share your code with other people. We reviewed how to do it with Closure Linter but this is not the only way. Let's broaden your vision.

Coding styles alternatives and tools

It is always easier to use the same tools for all your JavaScript, but we advise that you be curious about other JavaScript coding styles for improving your knowledge and choose the coding style that fits you.

We recommend that you not only look at <https://github.com/rwldrn/idiomatic.js> but also at big library projects.

For example, check out the following links:

- ◆ **jQuery Core Style Guide:** <http://contribute.jquery.org/style-guide/js/>
- ◆ **MoTools:** <https://github.com/mootools/mootools-core/wiki/Syntax-and-Coding-Style-Conventions>
- ◆ **Dojo Toolkit Style Guide:** <http://dojotoolkit.org/community/styleGuide>

To enforce your own coding style and share it, the most valuable tools are as follows:

- ◆ **jsHint:** <http://www.jshint.com>
- ◆ **JsLint:** <http://www.jslint.com>

Although those tools are interesting, the errors you receive when using them on your files are not always clear. So, we advise that you look at <http://jshinterrors.com>.

Summary

In this appendix, we learned a lot about the Closure Tools. It is always important to understand how things work to be able to track why your code is not working. Without this review, when using, for example, the **ADVANCED** mode, you will stay stuck and end up keeping the default file for production. If you do so, you are losing partly the OpenLayers 3 philosophy: this version is a rewrite to have a better API and to get performances.

In the first part of the appendix, we learned why performance is important. Next, we saw how to reuse Closure Library or how to overload default OpenLayers 3 components. We then inspected how to practically use Closure Compiler itself in the OpenLayers development context.

Finally, we introduced you to some tools to improve your overall code quality. In this case, only remember this citation from `idiomatic.js`:

"All code in any code-base should look like a single person typed it, no matter how many people contributed."

C

Squashing Bugs with Web Debuggers

OpenLayers is, at a fundamental level, not doing anything that is conceptually too hard to grasp. It gets map data from a server, and puts them together. From a technical level, however, there is a lot of work going on, and it might seem magical how it all works together so well.

Fortunately, there are many tools to dispel any potential magical thinking we might have and show us how OpenLayers is working behind the scenes. Google Chrome Developer Tools, the included debugger in Google Chrome browser, is one such great tool. Speeding up development time, viewing network communication, and squashing bugs are just a few things that Chrome Developer Tools, and other web development tools, do that make them hard to live without.

To really use OpenLayers effectively and to its full potential, we need to understand how it works. In this appendix, we'll try our best to do just that, by using web development tools to examine OpenLayers' inner workings. By doing so, we'll accomplish two things. First, we'll become familiar with these tools, which will significantly help us when developing our maps. Secondly, and more importantly for now, we'll gain a better understanding of how OpenLayers works.

We'll do another tour about plugins and functions that can improve your experience in Chrome Developers Tools and can help you develop your OpenLayers debugging skills. To finish, the last topic will be how to work with other browsers when debugging. You may not be aware, but Google Chrome and its Developers Tools is around one-third of the browser market.

In this chapter, we'll cover the following topics:

- ◆ What Google Chrome Developers Tools is and other development tools
- ◆ Use of each debugger panels
- ◆ Using the JavaScript Command Line Console panel
- ◆ Showing useful tools in addition to the Chrome default debugger
- ◆ Introducing web development tools for dealing with cross-browsers development in particular

Introducing Chrome Developer Tools

Chrome Developer Tools, also called Chrome DevTools, is the built-in debugger included in Google Chrome browser, a free cross-platform browser. Other modern- and standards-based browsers, such as Mozilla's Firefox, Apple's Safari, Opera, and Microsoft Internet Explorer (8+) also work well for debugging web-based applications and sites.

Chrome DevTools and other web development tools make the web development process much easier and quicker. What do we mean by this? With these tools, we can change anything on our site on the fly without editing or saving any files. We can type in JavaScript code with a command-line interface and execute it immediately. We can view all the requests that our web page sends to servers, along with the server's reply. For example, if our map isn't able to get back map images from the server, we can examine the requests our page is making and find out if we have any typos or haven't set up our map layer properly.

Using these tools makes it a lot easier to develop not only an OpenLayers mapping application, but any web application, and makes it easier to fix any bugs we encounter in the process. The choice to use Google Chrome as the first tool for debugging instead of other debuggers is motivated by its large support for mobile testing, the best built-in tools for debugging at the time of this writing, its support for all OS (Windows, Mac, Linux) and some others features. We'll focus mainly on Google Chrome in this chapter and refer back to it throughout the book. Other tools such as Mozilla's Firefox, Internet Explorer (8+), and Apple's Safari's developer tools work just as well (although some functionality may vary).

Getting started with Chrome Developer Tools

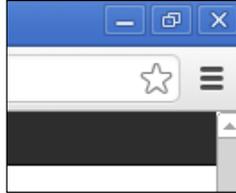
To discover this tool, firstly, Google Chrome browser needs to be installed.

So, go to its dedicated download area at <http://www.google.com/chrome/> and install it. Depending of your OS, the format for installing the software will be an `.exe`, a `.dmg`, a `.deb` or an `.rpm` file.

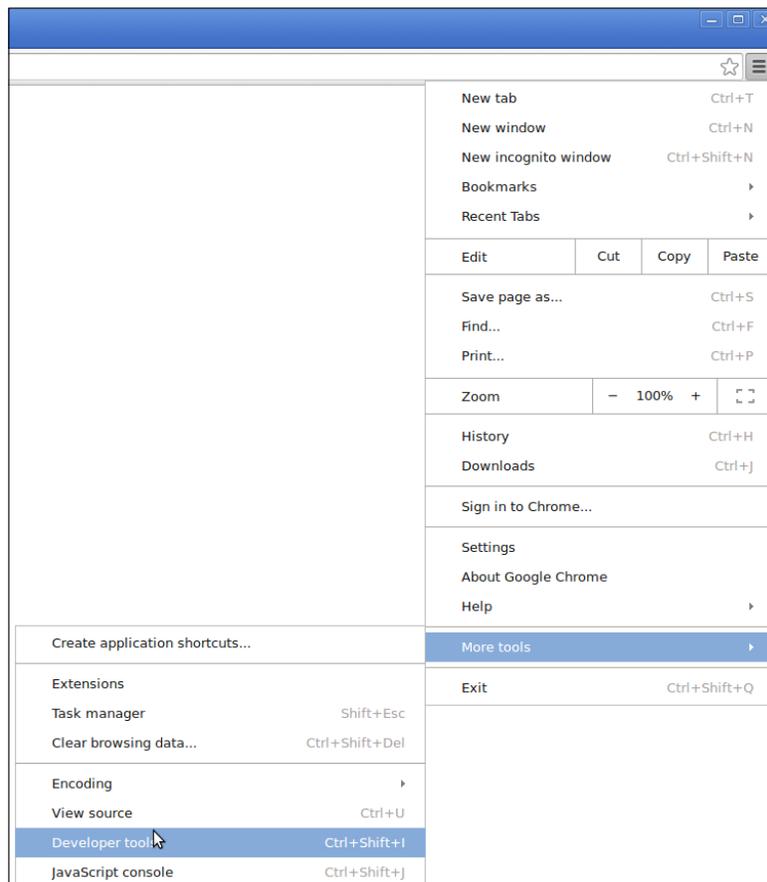
Time for action – opening Chrome Developer Tools

After the Chrome installation, let's open Chrome DevTools:

1. To do so, go in the upper-right window of Chrome and click on the icon with the three horizontal bar like the following screenshot:



2. Then, go to the **More tools** menu and click on the **Developer Tools** submenu, as shown in the following screenshot:



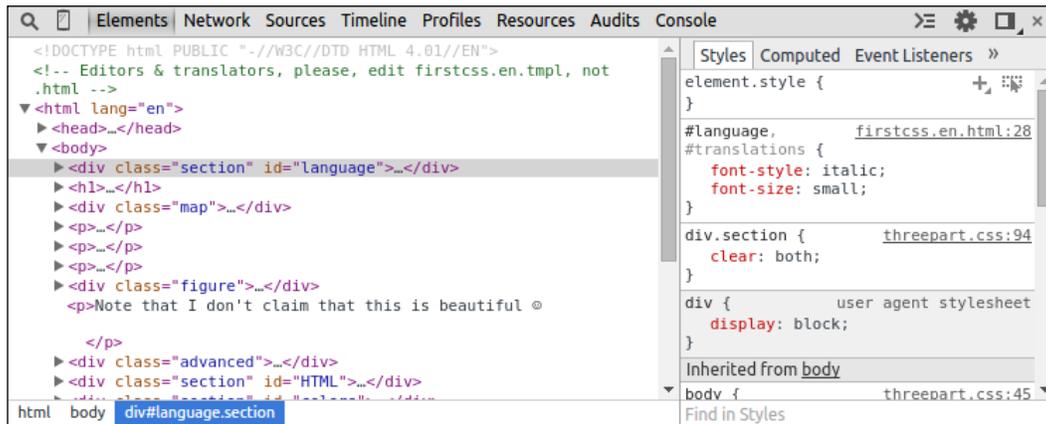
What just happened?

After clicking on the panel activation, the browser windows has been split to display a panel.

An alternative way to open this panel is to right-click in a web page and to click on **Inspect**.

You can also find the keyboards shortcut for this at <https://developers.google.com/chrome-developer-tools/docs/shortcuts>.

Now, let's take a look at what the tool looks like after its activation:



 The top row starts with a Page Inspector icon and Toogle device mode icon, which is useful for mobiles. Then, multiple panels with textual descriptions such as **Elements** or **Network** provide specific functionality (they look and act similar to tabs, but the technical term is *panels*). The upper row end on the right has a Show Console icon, a Settings icon, a Detached/attached debugger icon and a close button. The position of the icons may change over time as Google Developer Tools is updated; but general functionalities should remain (more or less) the same.

The following content will cover the top row icons from left to right, excluding panels.

Explaining Chrome Developer debugging controls

In this section, we will see each button in the Chrome Developer Developer Tools to review the available functions you can perform with the debugger.



- ◆ The **Page Inspector(1)** icon: This icon, a magnifying glass, is the HTML Inspector. When you click on it, the mouse cursor will identify HTML elements on the web page. So, when the mouse hovers over anything on a website, the element will be outlined in blue and the HTML panel will open up and show you the element your mouse is over.
- ◆ The **Toggle Device mode(2)** icon: This is when you need to test different mobile screen resolutions or you want to use simulation for Geolocation. It's a component in the Google Developer Tools that have changed several times. So, we prefer to redirect you to official doc <https://developer.chrome.com/devtools/docs/device-mode> as it may change again.
- ◆ It's the various panels **(3)** we will review just after all the tool bar options reviews.
- ◆ The **Console(4)** icon: This icon is a way to display the console, a tool for exploring JavaScript. You click on it to display a new window below the bottom row. When activated, the grey icon changes to blue. We will explore it further when describing the console panel. Just before this icon, you will see **errors** and **warnings** appear if there are any in the web page you are browsing.
- ◆ The **Settings(5)** icon: this icon displays a new panel with three vertical tabs. The first one is dedicated to the **General** settings. The second is **Workspace**. Its goal is to make the editing done in the **Sources** panel persistent. The last, **Shortcuts**, is the reminder of all shortcuts needed to be efficient when using the debugger. It contains more or less the information available in the shortcuts web page provided some pages before.
- ◆ The **Attached/detached debugger(6)** icon: This enables you to display the debugger with fullscreen web page with a separated window or with the debugger view integrated in the current page (aligned to bottom or right). To switch between those modes, click or click and hold access the several options.
- ◆ **Cross(7)**: This enables you to close the browser debugger.

Panels

The top row set of controls is called panels; each panel provides a different type of function. The panels act like tabs (the two terms can be used interchangeably), but Chrome Developer Tools refers to them as *panels* in the documentation. Let's go over each panel, since they are, essentially, what makes up Chrome DevTools. We will not go over these panels from left to right, but instead we will look at the most important ones for beginners first.

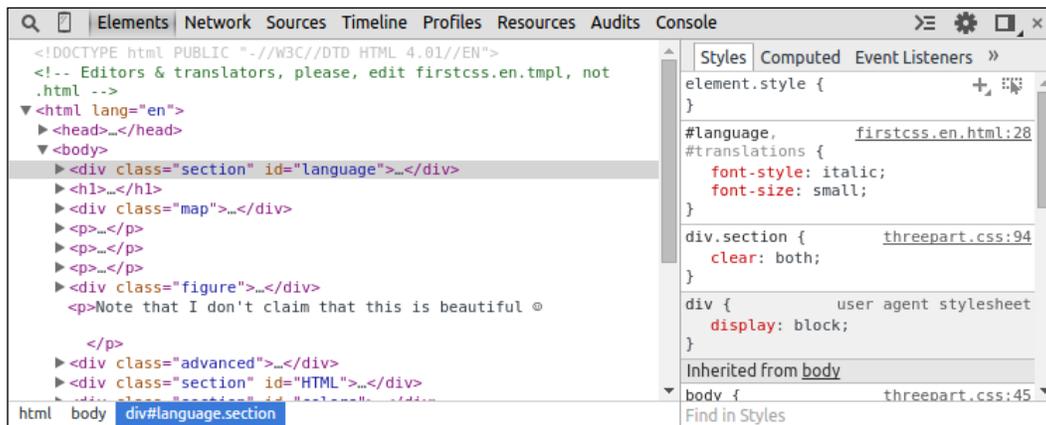
The Elements panel

The **Elements** panel provides not just a display of the HTML source code, but also the ability to quickly edit any HTML element and its associated style. It allows users to add, remove, and move HTML elements, edit HTML attributes, and change nearly anything about the page without having to save any files. It also can track when attributes or elements are created, changed, or removed. This helps to make web development much easier and faster.

How it works

Chrome DevTools automatically builds a tree structure from HTML code, giving the ability to expand and hide each HTML tag. It is important to note that the code you see in the HTML panel is a generated HTML code—the code in the panel may not be exactly the same as the page's source code (because the browser is interpreting the HTML to be able to show a page content).

Here is what the **Elements** tab looks like when Chrome DevTools is opened while viewing a web page:



On the left-hand side, Chrome DevTools shows the HTML of the page. It's possible to right-click on any tag and do various things—such as copying the HTML to the clipboard, deleting the element, changing the tag attributes, and more.

On the right-hand side, the associated style information for the selected element is displayed. Properties can be added or modified and will instantly appear on the page, like in the preceding capture image example (at <http://www.w3.org/Style/Examples/011/firstcss.en.html>), with the `div` element with `id` attribute value to `language`. Looking at the CSS on the right-hand side, there is a definition for the `language` `id` but only `font-size` and `font-style` properties are defined. We also see that some other styles are coming from the `body` element parent. The `<div>` tag inherits from `body` the `color #333333` or the `font-family` properties.

 If you are unfamiliar with HTML or CSS, the WebPlatform site is a great resource. For more information on HTML, visit <http://docs.webplatform.org/wiki/html>, and for CSS, visit <http://docs.webplatform.org/wiki/css>.

What does this mean? Well, Chrome DevTools lists all inherited style information, and parent element styles propagate down to all their child elements (each child has all its parent's styles, unless the child overrides a style, which doesn't happen in this example).

By double-clicking on pretty much anything in the HTML or CSS list, you can quickly change values and names. Any change you make will immediately show up on the page, which makes it very easy to change style in real time and see how the page is affected without having to edit and save any files.

When you're playing with CSS, you can disable a property with a left click on the left part of the CSS property. You can try this on `font-size` to see visual change. For CSS, when the code really inherits from a lot of properties, we advise you to go to sub-panel **Computed** on the right part of **Elements** panel. You get the summary overview for each property. Play around with it a bit—if you mess anything up, you can just reload the page in Chrome.

When editing pages with Google Chrome Developer Tools, any changes you make will disappear when you refresh the page. You are not editing the actual web server's files with Google Chrome Developer Tools—instead, you are editing a copy that is on your computer that only you can see when you make changes to it. So, if you make changes and want them to be saved, you'll have to edit your actual source code.

 In fact, one way to directly edit and save content within Google Chrome Developer Tools is to rely on the **Workspace** ability we already have evocated when clicking in the Settings icon. Check out the official Chrome Developer browser documentation at <https://developer.chrome.com/devtools/docs/workspaces>.

Until now, we focused on the right part of panel elements. Let's see how to manipulate and inspect DOM elements in the left **Elements** window.

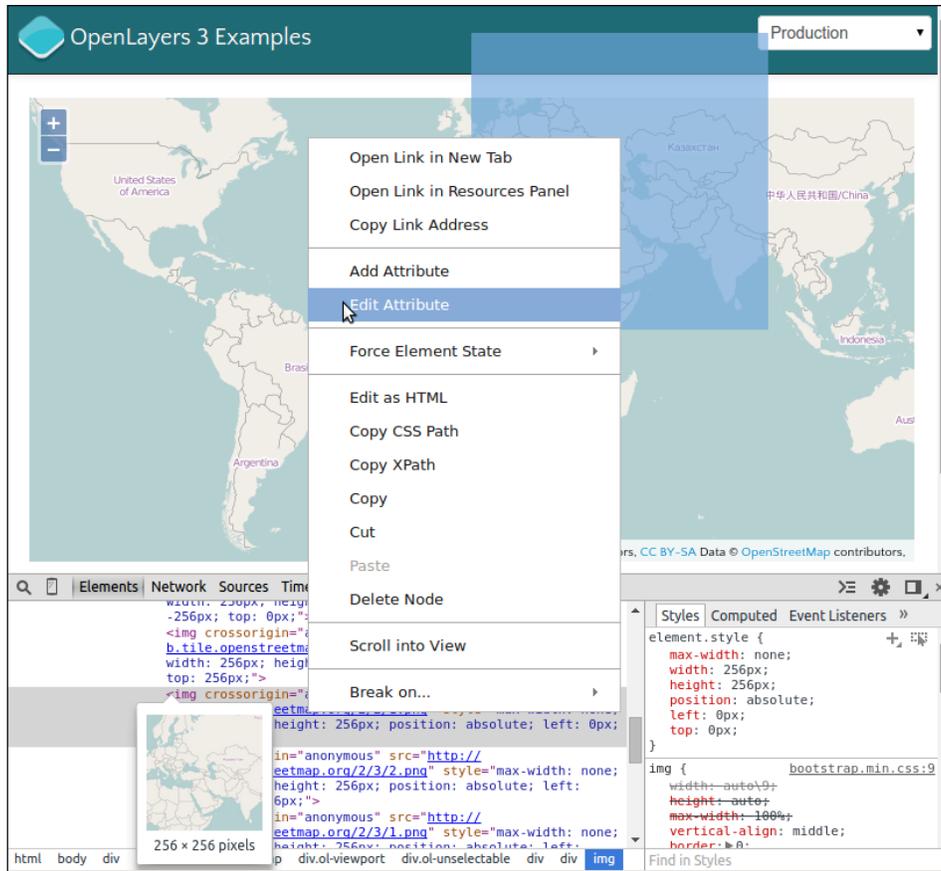
Time for action – using DOM manipulation with OpenStreetMap map images

Reusing knowledge about OpenLayers renderers from *Chapter 3, Charting the Map Class* and OpenStreetMap from *Chapter 4, Interacting with Raster Data Source*, let's review how to manipulate the DOM and changing OpenStreetMap tiles sources on the fly.

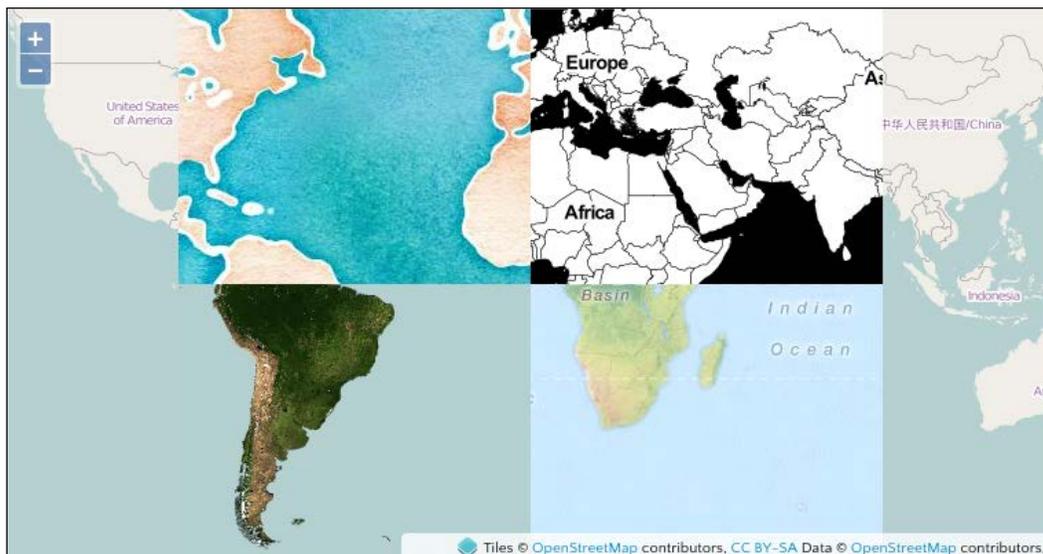
So, let's start with the official OpenLayers example from <http://openlayers.org/en/v3.0.0/examples/simple.html> using **Page inspector**.

Open the file and at the end of the URL you get from your browser add `?renderer=dom`

1. Click on the **Page Inspector** icon (or right-click on image and click **Inspect** in the menu) and hover over the images. .
2. Then, on one of the `img` tags, right-click on **Edit attributes**, as illustrated in the following screenshot:



3. Next, you will see that you can change the value in our example, `http://b.tile.openstreetmap.org/2/2/1.png`, of the `src` attribute. So, replace its value with `http://tile.stamen.com/toner/2/2/1.png` and see the result. In the **Elements** panel, the `img` (for the image tag) `src` attribute contains `http://b.tile.openstreetmap.org/2/2/1.png`. If you remember, URL can be separated in two parts. The first part, `http://b.tile.openstreetmap.org/`, (called base URL), will change when the second part, `2/2/1.png`, will change according to images you hover on. Here, we only change the first part.
4. Repeat the process by changing the image you hover on and the base URL you use. The value you can use for base URL can be `http://d.tile.stamen.com/watercolor/`, `http://b.tile.opencyclemap.org/cycle/`, and `http://otile2.mqcdn.com/tiles/1.0.0/osm/`.
5. The result obtained will look like the screenshot that follows:

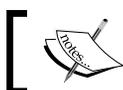


What just happened?

We saw how to modify attributes of HTML elements using the **Page Inspector** on images. You also saw the correspondence between highlight on the web page and code content in the **Elements** panel when hovering over. You also rediscovered some different OpenStreetMap backgrounds.

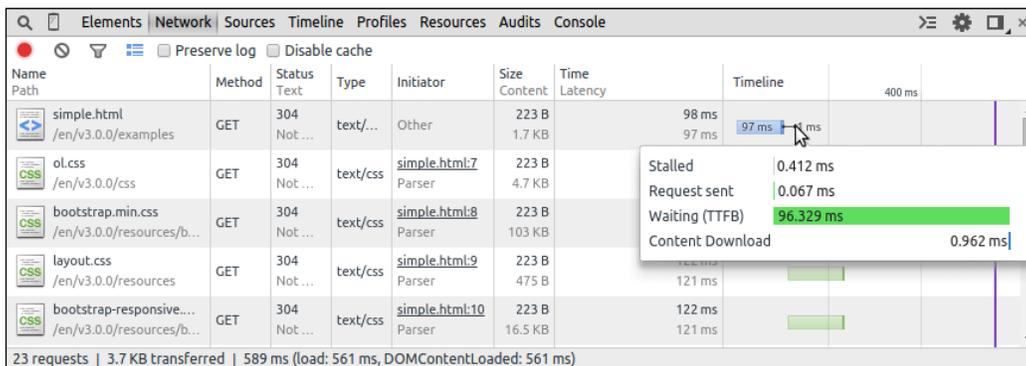
The Network panel

Chrome DevTools's **Network** panel is a tool we often use throughout this book. It basically provides a way for us to monitor a network activity by viewing all the requests and responses the web page is making. In addition to the initial page load network activity, we are also able to monitor all of the asynchronous JavaScript requests that are made by the web page. Without AJAX, we will have to refresh our entire page any time we want to do anything with our OpenLayers map. So, for example, every time you zoom in, OpenLayers makes a series of requests to the map server to get new map images, and the map server's response is a new map image that OpenLayers then displays. This request/response method is handled via AJAX; without it, we would have to refresh the entire page after every request.



See Appendix B, *More details on Closure Tools and Code Optimization Techniques*, where a small web history and a diagram covers AJAX.

The Network panel allows us to see the URL that is being requested, the `GET` or `POST` parameters, the server's status response, the type of resource requested, the size of the response, and the time it took to complete the request. Let's take a look at what the Network panel looks like for the example from the previous official example used when reviewing **Elements** panel:

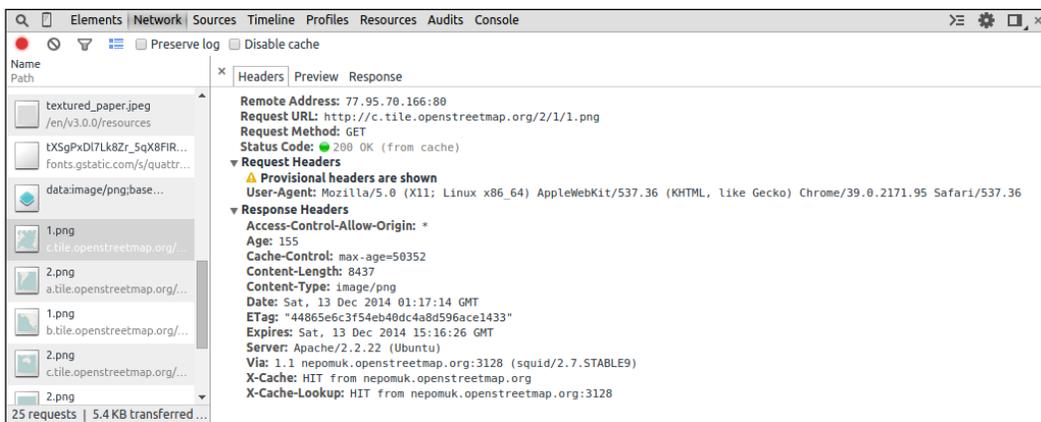


Before we talk about the requests being made, take a look at the buttons above the lists of requests—the first one is dedicated to **Record Network Log** and the second **Clear** helps you remove the list of network calls. Then, you can activate **Filter**, which displays a submenu to filter by resources types for example, **Documents**, **Stylesheets**, **Images**, but also by the type of requests such as **XHR** or **WebSockets**. The **Filter** icon also activates a full text search box. The fourth icon is **Use small resource rows**. The two checkboxes are available, **Preserve Log** will cause the list of requests to persist, or not get deleted, on page reloads, while **Disable cache** will not allow you to use cache. For better performances, some assets such as scripts or images can be kept in your browser memory to speed your browsing experience when you visit the same website again. The drawback is when you debug, you can use an outdated file.

Now, let's break down the actual request list.

The request list

The request list shows us all the requests the page makes. Each URL in the previous screenshot is a URL that OpenLayers is making a request to. By clicking on each request, we can see more information about the request, including the full request URL and the response. When we are in the **Headers** sub-tab, we get a **Request URL**, **Request Method**, and **Status Code**, and after we get all details of **Request Headers** and **Response Headers**. The **Request URL** tab gives all the parameters. The **Response** tab provides us with the server's response to our request:



Parameters

Take a look again at the list—when we look at the first image in the screenshot, the row has the name `1.png`. The method, `GET` in this case, specifies that the request type is `GET`, which basically means we are embedding variables inside the URL itself, with optional `key=value` pairs, separated by an `&` sign.

When we mouse over a URL, we can see more of it; we see the full URL, which may contain a bunch of variables in the `key=value&key=value&...` format. In our case, we only have a full URL like `http://c.tile.openstreetmap.org/2/1/1.png` when hovering.

As we saw in all OpenStreetMap examples through the book, we didn't need parameters. If you remember in *Chapter 1, Getting Started with OpenLayers*, we told you that OpenLayers consumes cartographic data; some can come from dynamic web mapping server, others from pregenerated data. Our example relies on pregenerated data so that there are no parameters added contrary, for instance, to a WMS data source.

The Sources panel

The Sources panel is very powerful. It enables you to view and edit JavaScript and CSS files loaded from the web page. You are not restricted to only view all the JavaScript code associated with the page in this panel; you can use it to do real-time code debugging. You can set watch expressions, view the stack, set breakpoints, and so on. If these terms are foreign, don't worry, we will review some of them.

For example, we want to quickly talk about enabling Pause on exceptions. With this option enabled, Chrome DevTools will stop the web page whenever a JavaScript error is encountered. This makes it very easy to quickly pinpoint where your page is blowing up at. To enable it, simply click on the **Pause on exceptions** button icon (be careful, it's not the same as an **Pause Script Execution** icon).

Keep note of this when you enable it. We've been frustrated more than once when developing because we forgot that it had been enabled. When it is enabled, the button isn't gray, as demonstrated with the icon:



Another tip in this panel, is the ability to unminify JavaScript. It's really useful to track errors. You can open a web page with a compressed JavaScript file. If you click on the icon with open/close brackets called **Pretty Print**, you will see the difference.

You are maybe wondering why we spoke so much about this panel. When you start to make complex web mapping applications, this panel is the best way to analyze how an application works. When you're developing or reusing an already existing code, you can already guess the behavior of the code, but you can't confirm it. The key feature of the debugger is to make this confirmation. Let's see an example of how you can use it.

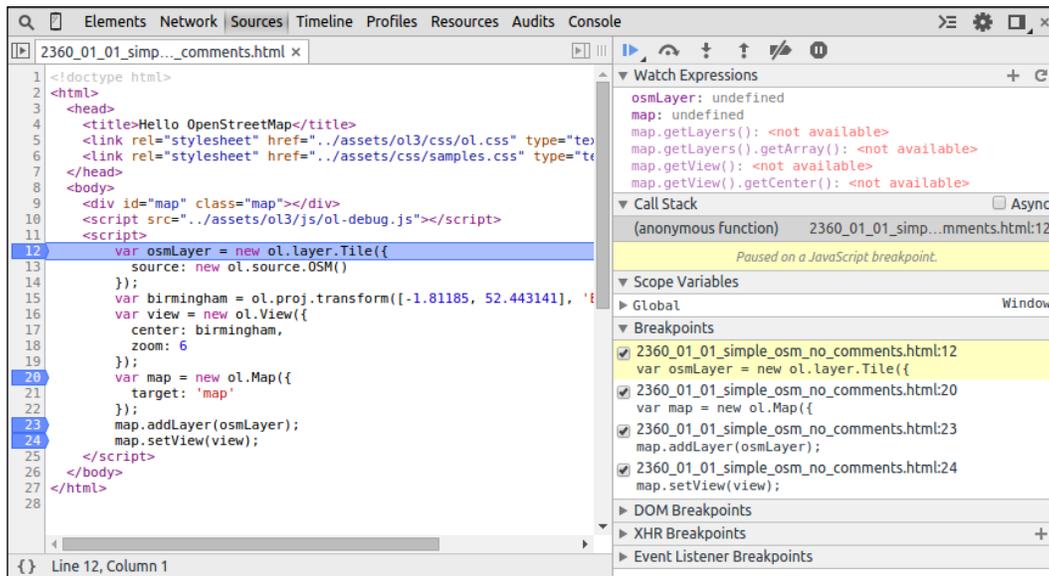
Time for action – using breakpoints to explore your code

Breakpoints help you understand available variables and their values, one at a time in your code, and see when the code is executed. Let's see how.

As we didn't have space to cover such a large topic, we chose to let you discover the basic parts using the official tutorial. So head to it and review it at <https://developers.google.com/chrome-developer-tools/docs/javascript-debugging>. Now after this review, open the example for *Chapter 1, Getting Started with OpenLayers*, with Chrome Developer Tools opened with the **Sources** panel. Change the `ol.js` reference to `ol-debug.js` (more readable).

Set breakpoints in the HTML page at `var osmLayer`, `var map`, `map.addLayer`, and `map.setView`. Check the following steps:

1. Define in the **Watch Expressions** part on the right the following variables and functions calls: `osmLayer`, `map`, `map.getLayers()`, `map.getLayers().getArray()`, `map.getView()` and `map.getView().getCenter()`.
2. Reload your page to see your page loading stopped at the first breakpoint `var osmLayer`.
3. You should have content similar to the following screenshot:



4. Use the **Resume script execution** to see at each step the value in the **Watch Expressions** part. The result should be along the steps like the following illustration:



What just happened?

When we began by introducing the library in *Chapter 1, Getting Started with OpenLayers*, we described every step to create a basic map. With this example, we are able to follow the flow of your code with Chrome Developer Tools. First, all the variables we defined in the **Watch Expressions** were empty, as seen in the screenshot at step 3.

With the declaration of `var osmLayer`, the part of figure **After var osmLayer...** showed us an `ol.layer.Tile` object was created.

Then, we created a `map` in the **After var map...** part. The result is that `map` variable was assigned an instance of `ol.Map`. With this `ol.Map` creation, `ol.Collection` was created for layers, but there were no layers: `map.getLayers().getArray()` as a length equal to 0. Moreover, a view was also added in the map but didn't have a center in this step; `map.getView()` stopped to be empty and was replaced with an `ol.View` instance.

Then, by adding the layer in the **After map.addLayer** part, we saw that the map had a layer added: the previous `map.getLayers().getArray()` was using `osmLayer`: its length is 1.

At the end, the same process happened for the map view. The `Map` class with the `map.setView` method gained the view parameters, and so, `map.getView().getCenter()` returned an array with coordinates.

This detailed description was a good way to show that we can find how the code works by following the code execution, instead of blindly searching where things happen or only deducing by reading code. When you have enough coding experience, the solution to only follow the code without using a debugger can be better to get a full code overview, but as a beginner, it's not the best solution and you should focus only on small code parts.

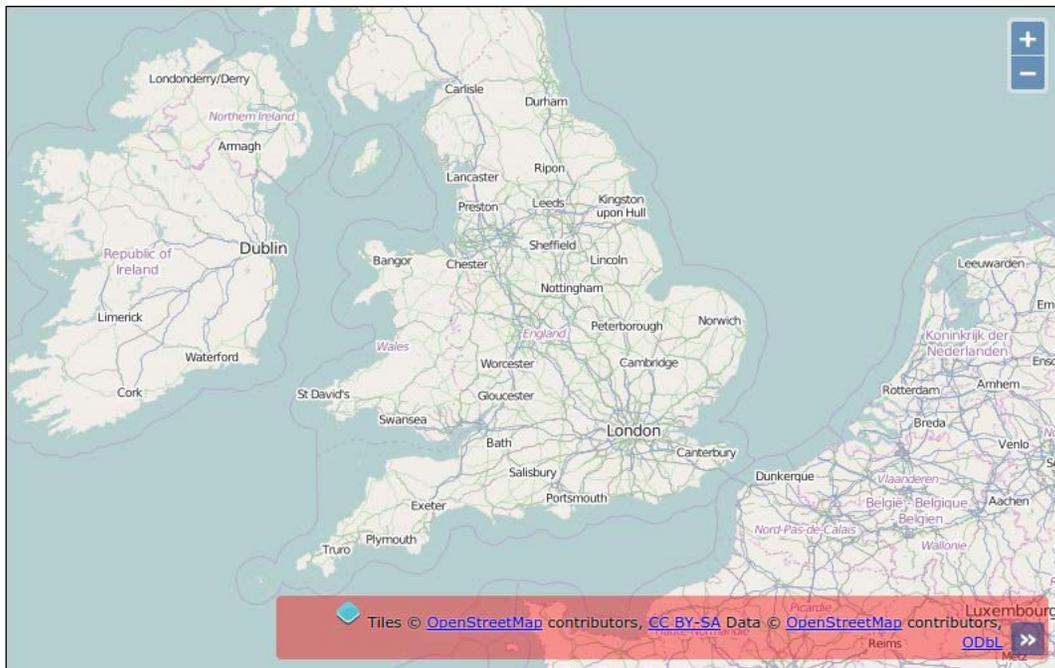
We hope with this demonstration, you appreciated discovering one of the main web debuggers features.

After this JavaScript escape, let's return to the CSS topic. Remember we said that we can also edit the CSS content in the **Sources** panel. Contrary to the **Elements** panel, we have the option to edit any CSS document associated with the page, not just the style of a selected element. We don't need to not talk much about this panel. We'll give you an accelerated overview for using it in OpenLayers.

Time for action – playing with zoom button and map copyrights

What we are customizing are the controls introduced in *Chapter 9, Taking Control of Controls*. It's time to try it: practicing things on your own will improve your comprehension. For this, we will reuse the OpenStreetMap example from *Chapter 1, Getting Started with OpenLayers*, and customize the position for zoom buttons and map copyrights.

1. In the **Sources** panel, open the `ol.css` file and use the **Format** button to make it more readable as this file is a `.css` minified file on one line.
2. Find the `.ol-zoom` class in the `ol.css` file.
3. Replace the `left : 0.5em;` parameter with `right : 0.5em;` to make changes to zoom buttons.
4. Now, it's time to change copyrights. So, like in the previous case, look for the CSS class, `.ol-attribution:not(.ol-collapsed)`.
5. Change the property background, `rgba(255,255,255,0.8);`, to `rgba(255,0,0,.4);`.



What just happened?

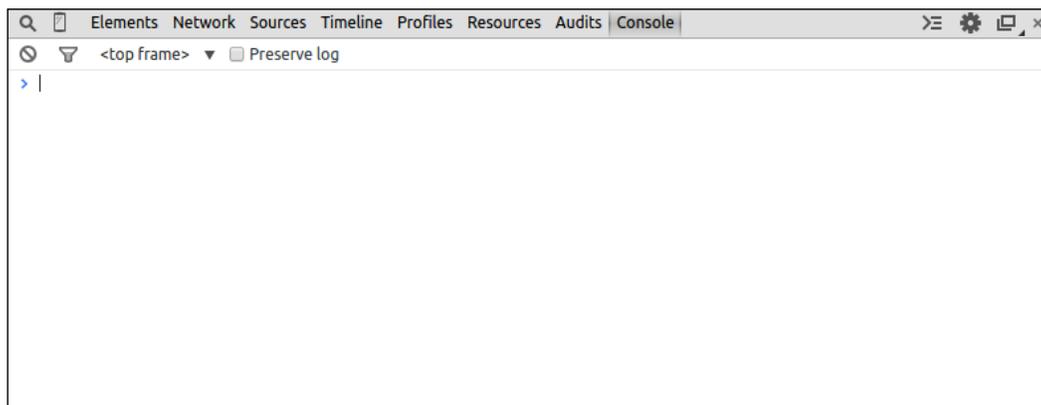
In the previous example, you played with HTML content. Here, the focus was to cover how you can change the style on the fly. We set the position of the zoom control to the top right and we also changed the background for attribution when you open the attributions collapsible block (credits to maps data and tiles) to red with an opacity change. We encourage you to perform more tests on your own to assimilate the way the panel works.

If you are a web designer working on the code or a web developer requiring to make some designs, we advise you to play a lot with this powerful panel. It can greatly speed up your development time when you master it. If you are always editing CSS in your browser, you should consider looking into the **Workspace** functionality we've already talked about.

The Console panel

The Chrome DevTools **Console** panel is where we'll spend most of our time. It acts as a powerful JavaScript command line, or interpreter, which means we can type in JavaScript code and execute it right away—no need to save or edit any files. We can also inspect values when we are stopped at a breakpoint in the **Sources** panel and want to inspect the context at this time.

Another thing that makes this panel so useful is that we can interact directly with the DOM (Document Object Model)—any HTML element on the web page, including any existing JavaScript code the page contains. So, this means we're able to interact with our OpenLayers map on the fly, issuing command and testing code to instantly see what works and what doesn't. As you can imagine, this saves a ton of time!

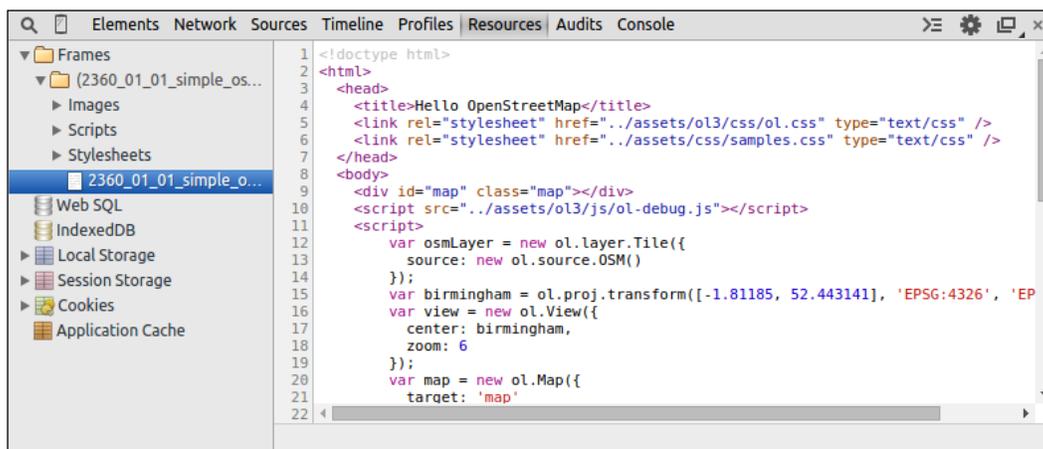


You can choose and type in the console on one line or multi-lines. To use multi-lines, type *Shift + Enter* to return without executing code.

When you need to discover the structure of an object, the Console panel is a very valuable tool, especially when you want to take a peek at JavaScript components. Assuming we are looking at a page that includes OpenLayers, we can quickly see all of OpenLayers's classes, functions, and so on. It is not a replacement for the API docs, but serves as a good, quick way to view such information.

The Resources panel

It looks like the screenshot that follows:



With it, you have a classification of all types of resources. You get all resources depending on frames such as the images, CSS, and HTML files. It is a good way to know what your web page loads.

You also can see all persistent storage. Persistent storage are Web SQL, IndexedDB, Local Storage, Session Storage, and Cookies. Although they might not mean much to you, they provide features, not directly related to OpenLayers, can be useful as they are HTML5 features. We invite you to discover their purpose by visiting <http://html5demos.com>.

With this various storage, you can keep information for customizing users' experiences. For example, you can use them to customize the language for a web application, store the zoom level for a displayed map, and so on.

To complete and end this panel description, the last thing we need to inspect is the **Application Cache**. It is the most useful function for our book in *Chapter 10, OpenLayers Goes Mobile*. It helps you inspect the data cached using the MANIFEST file.

Timeline, Profiles, and the Audits panel

These three panels are not really useful for beginners. They target advanced developers mainly for performances purposes:

- ◆ The **Timeline** panel enables you to record how the page content is processed to display the final image you see in the browser.
- ◆ The **Profile** panel is mainly to evaluate computer resources consumed by the web page such as the memory consumed by JavaScript, the CSS selectors efficiency, and the overall memory allocation.
- ◆ The **Audits** panel, like the name indicates, is an audit to give you information for improving performances at the network level or CSS levels for example.

If you want more information about these panels, visit the official documentation of Chrome DevTools at <https://developers.google.com/chrome-developer-tools/>.

Panel conclusion

Each panel serves a certain purpose and all of Google Chrome DevTools' panels are extremely useful, but throughout this book, we will be mainly focusing on the following panels:

- ◆ The **Console** panel (Command-line JavaScript)
- ◆ The **Elements** panel
- ◆ The **Sources** panel
- ◆ The **Network** panel

These four panels are the ones that we should use the most throughout this book. We can occasionally come back to the other panels, but we don't need to spend a whole lot of time with them. However, before we conclude this chapter, let's get a bit more familiar with the **Console** panel, since we will need it in most of our chapters.

Using the Console panel

We talked a bit about what the console panel is—essentially, a JavaScript command line. We can execute any JavaScript code we want, and interact with any page element. There are two primary components to the **Console** panel—the **console log area** and the **input area**.

The console log area will display information about any errors, along with displaying any code that is entered. The input area allows us to either enter a single line of code or multiple lines of code.

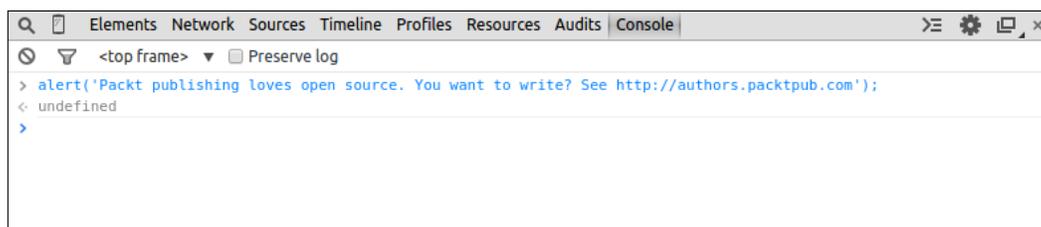
Before we start using the console with our maps, let's get familiar with the console by executing some JavaScript code.

Time for action – executing code in the Console

We will do some basic JavaScript coding via the Chrome DevTools console; specifically, just calling a built-in the `alert()` function to display an alert.

1. Open up Chrome. It doesn't matter at this point which website (if any) you go to, since we will be writing a standalone code.
2. Open up Chrome DevTools by going through the menu. Go to the **Console** panel.
3. Now, at the bottom of your screen, you'll see an area where you can enter code, designated by `>`. Clicking anywhere after this will allow you to enter the code.
4. Type in the following code, and then hit *Enter*:

```
alert('Packt publishing loves open source. You want to write? See http://authors.packtpub.com');
```
5. You should see an `alert` box pop-up with the text **'Packt publishing loves open source. You want to write? See <http://authors.packtpub.com>'** (or whatever string you passed into the `alert` function). After the code is executed, it will appear in the log above the input line:



What just happened?

We've just executed some JavaScript code without having to edit and save any files. Although we did a simple alert, we are really not limited by what we can do. Anything that we can save in a JavaScript file, we can also enter in the Console.

You'll also notice that the same code that we typed in appeared in the log area. We'll also get an error message if any errors occur in the code—go ahead and try it! Instead of typing `alert('My alert');`, type something like `fakealert('Boom');`. This will give you a reference error, since nowhere is the `fakealert()` function defined—`alert()`; on the contrary, it is a built-in function, so we can call it from any page.

That's pretty much all there is to it! The rest just builds on these principles. Let's go ahead and do just one more thing, something that is slightly more involved, before jumping into manipulating an OpenLayers page.

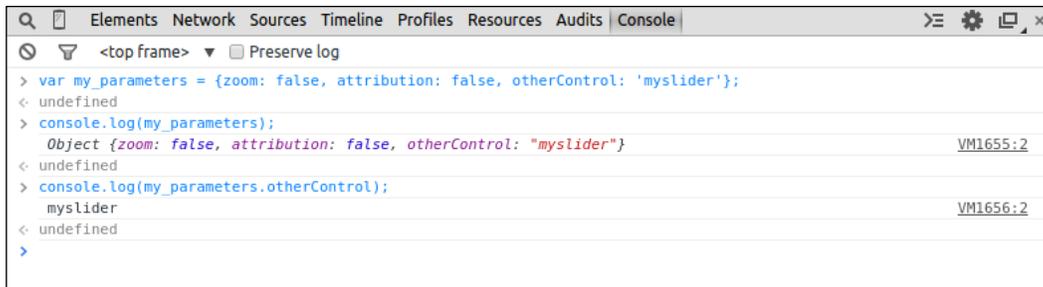
Time for action – creating object literals

We will introduce object literals and get acclimated with how to manipulate them now, so that we can better work with the OpenLayers code:

1. Open up Chrome and the DevTools **Console** panel—again, it doesn't matter right now what page you're on.
2. Type in the following code, and then execute it by pressing *Enter*:

```
var my_parameters = {zoom: false, attribution: false,
otherControl: 'myslider'};
console.log(my_parameters);
```
3. The preceding code should display, in the console log area, something similar to `{zoom: false, attribution: false; otherControl: 'mySlider'}`. In this case, the object is not complex but when the object is more complex, you will see an arrow before the object, and if you click on it, it will show all the information about the object you just created.
4. Click on the Console panel to get back to it. In the input box, add the following code to the existing code and execute it:

```
console.log(my_parameters.otherControl);
```
5. You should see a line of output in the console area containing the string `mySlider`:



```
Q Elements Network Sources Timeline Profiles Resources Audits Console
<top frame> Preserve log
> var my_parameters = {zoom: false, attribution: false, otherControl: 'myslider'};
< undefined
> console.log(my_parameters);
  Object {zoom: false, attribution: false, otherControl: "myslider"} VM1655:2
< undefined
> console.log(my_parameters.otherControl);
  myslider VM1656:2
< undefined
>
```

What just happened?

We just created what is called in JavaScript an anonymous object, or object literal. We previously discussed that objects are created from classes, in *Appendix A, Object-oriented Programming – Introduction and Concepts* and in JavaScript, we need to use the `new` keyword to instantiate an object from a function. However, here, you can see that there is no `new` keyword!

Object literals

The key concept here is that we are just creating a single object that does not derive from a class. Since object literals (anonymous objects) do not derive from a class, it is, essentially, an empty object. It contains only what we explicitly defined. The value associated with a key can be almost anything—a string, integer, function, array, or even another object literal.

We encountered object literals in *Chapter 1, Getting Started with OpenLayers*—they were the `{key:value}` pairs used to define the parameters and options of our layer and objects. The only difference is that we did not assign a variable to them; we simply passed them in when we created our layer object.

Object literals are extremely useful for a variety of tasks, and it is a great way to package information in an easy-to-use form. They are in the form of `{key:value, key2:value2}`. We can access any property of an object literal by using dot notation, in the form of `my_object_literal.key`. The key, like before, is the key part of the `key:value` pair. In the preceding code, we call `console.log(my_parameters.otherControl)`; and the value of the key `opacity` is displayed in the console's log area. You will also encounter an alternative notation and brackets notation, to retrieve the same information. This form is quite useful because you can concatenate values keys in your object.

Using `console.log(my_parameters['other' + 'Cont' + 'rol'])`; will do the same as the previous `console.log` call. It allows to loop on objects with a key that can change whereas the dot notation does not allow this.

 `console.log()`: The Chrome DevTools function `console.log()` is a function that will, essentially, display what you pass into it in the console log. You can pass in variables, strings, objects, anything, and it will display in the log. It comes in handy often, so getting familiar with it is a good idea.

We use object literals frequently when making our maps—so if they don't make much sense yet, don't worry. The basic idea to grasp, and the primary way we will use them, is that they are essentially `key:value` pairs. Before we end this chapter, let's do a quick example where we interact with an OpenLayers map using the **Console** panel.

Time for action – interacting with a map

We'll use the map we created in *Chapter 1, Getting Started with OpenLayers*, to do this example, interacting with our OpenLayers map by calling various functions of the map.

1. Edit the example map from *Chapter 1, Getting Started with OpenLayers*, to change the reference to JavaScript from `../assets/ol3/js/ol.js` to `../assets/ol3/js/ol-debug.js` and open the file in Chrome. Enable Chrome DevTools and go to the **Console** panel. If you like, you can take a look at the **Network** panel and view the network activity to see the requests your page is making.

2. Go to the **Console** panel, input the following code, and then execute it:

```
console.log(map);
```

3. You should see the map object information come up in the console log. Click on it, and take a moment to look over the various attributes it has. Near the bottom, you can see a list of all the functions that belong to it (which are also referred to as methods).

Take note of the function names, as we'll be using them.

4. Go back to the **Console** panel, type in, and execute the following code:

```
map.getView().setCenter([0, 0]);  
map.getView().calculateExtent(map.getSize());
```

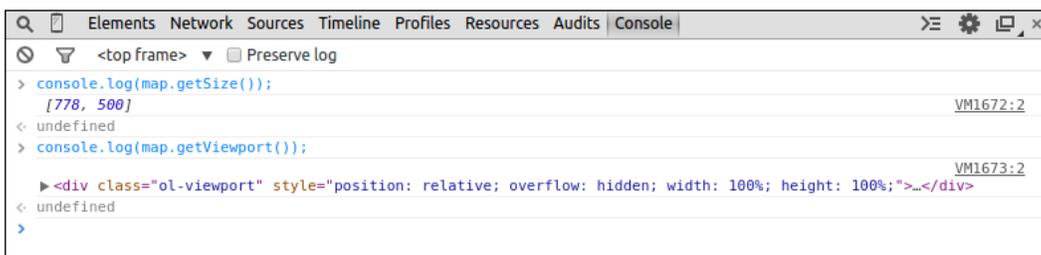
5. Take note of the extent. Clear out the code you typed in, then type in the following and execute it:

```
map.getView().setResolution(2000);  
map.getView().calculateExtent(map.getSize())
```

6. Now, let's take a look at some properties of the map object. We can access the map properties using the dot notation, which we discussed earlier. Clear any code you've typed so far, input and execute the following code:

```
console.log(map.getSize());  
console.log(map.getViewport());
```

7. You will see the following screenshot:



8. Refer back to the functions of the map object (by running `console.log(map)`; then clicking on the output in the log area). Try playing around with different functions and attributes the map object has. To access the functions, you just need to type in `map.function()`;
9. You can also access the properties of the map by typing `map.key`, where `key` would be something like `keyHandler_` (so the full code would be `map.keyHandler_`). Be aware that values with underscore at the end are private when using the compressed `ol.js` file (it's a naming convention in the library code).

```

> console.log(map);
VM1716:2
▼ ol.Map {eventTargetListeners_: goog.events.ListenerMap, actualEventTarget_: ol.Map, parentEventTarget_: null, revision_: 0, closure_uid_477460346: 3...}
  ► accessors_: Object
  ► actualEventTarget_: ol.Map
  ► animationDelay_: goog.async.AnimationDelay
  ► beforeChangeListeners_: Object
    closure_uid_477460346: 3
  ► controls_: ol.Collection
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  ► frameState_: Object
  ► interactions_: ol.Collection
  ► keyHandler_: goog.events.KeyHandler

```

What just happened?

We just executed some functions of our map and accessed some properties of it. All we have to do is call our object, `map`, followed by a period, then a function or property it owns. Using this dot notation (for example, `map.getSize()`), we can access any property or function of the map object.

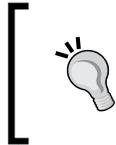
We also saw how the Console panel comes in handy, and took a look at functions that we can call, which the map object owns. Any function listed there can be called via `map.functionname()`, but some functions require parameters to be passed in or they will not work. However, where can we go to figure out more information about the functions and what they require?

Have a go hero – experimenting with functions

Try to call different functions that you see listed in the **Console** tab when typing in the window. Many functions will not work unless you pass certain arguments into them, but don't be afraid of errors! Poke around the various functions and properties and try to interact with them using the **Console** tab like in the preceding example.

The API documentation

The API documentation for the Map class, which our map object derives from (and thus, inherits all the functions and properties of the class) provides more detailed explanations of the properties, functions, and what we can do with them. They can be found at <http://openlayers.org/en/v3.0.0/apidoc/>. Even though Chrome DevTools is a great resource to quickly interact with code and learn from it, the API docs present an extra level of information that Chrome DevTools cannot necessarily provide. Do not hesitate to visit them at <http://openlayers.org/en/v3.0.0/examples/>.



Chrome DevTools is evolving rapidly and many new capabilities are being added all the time. Make sure you read the official documentation at <https://developer.chrome.com/devtools/index> and check back periodically to see what's new.

Improving Chrome and Developer Tools with extensions

Although it's more related to programming than web mapping, it's recommended to increase your abilities at using web debuggers.

Chrome DevTools by default offers the main functions to develop and debug with OpenLayers, but to be more efficient, it's really required to use extensions. Extensions are additions to Chrome browser or to the Developer Tools to add or augment default software functions. You can find most of them at <http://www.google.com/intl/en/chrome/webstore/extensions.html>.

We'll review some of them.

JSONView

Usually you're consuming web services providing **JSON (JavaScript Object Notation)** when you're doing mashups. To illustrate why the add-on is useful, we will use a geocoder service, such as Nominatim, to retrieve position for a postal code. A geocoder is a tool to match addresses with geographic coordinates.

For example, typing <http://nominatim.openstreetmap.org/search?q=35+Livery+Street+Birmingham&format=json&limit=1> in Chrome will send you the following screenshot:

```
[{"place_id":"11211228","licence":"Data \u00a9 OpenStreetMap contributors, ODbL 1.0. http://www.openstreetmap.org/copyright","osm_type":"node","osm_id":"1109093358","boundingbox":["52.483815","52.483915","-1.9007587","-1.9006587"],"lat":"52.483865","lon":"-1.9007087","display_name":"Rustic, 35, Livery Street, Jewellery Quarter, Birmingham, Warwickshire, West Midlands, England, B3, United Kingdom","class":"amenity","type":"fast_food","importance":0.421,"icon":"http://nominatim.openstreetmap.org/images/mapicons/food_fastfood.p.20.png"}]
```

With the extension, you will directly get an indented content, collapsible.

```
[
  - {
    place_id: "11211228",
    licence: "Data © OpenStreetMap contributors, ODbL 1.0.
    http://www.openstreetmap.org/copyright",
    osm_type: "node",
    osm_id: "1109093358",
    - boundingbox: [
      "52.483815",
      "52.483915",
      "-1.9007587",
      "-1.9006587"
    ],
    lat: "52.483865",
    lon: "-1.9007087",
    display_name: "Rustic, 35, Livery Street, Jewellery Quarter, Birmingham, Warwickshire,
    West Midlands, England, B3, United Kingdom",
    class: "amenity",
    type: "fast_food",
    importance: 0.421,
    icon: "http://nominatim.openstreetmap.org/images/mapicons/food_fastfood.p.20.png"
  }
]
```

So what is the difference? When it's required to correctly reuse data, we must understand received data and with this plugin, the return content is human readable! Furthermore, OpenLayers can consume GeoJSON, a subset JSON notation dedicated to maps data.

Download it at <https://chrome.google.com/webstore/detail/jsonview/chklaanhfefbnpoihckbnefhakgolnmc>.

Dealing with color with ColorZilla

When you are making a custom UI, you always have to try different colors.

You can also retrieve a color you like from another website or an image. In this situation, you will not want to always go back and forth between a graphic tool such as Gimp or Photoshop and your browser. So in this case, you can install ColorZilla. How is this related to OpenLayers? When you want to make customize controls elements, this is an invaluable tool. Go to <http://www.colorzilla.com/chrome/> to retrieve it. It's also a plugin available for Firefox.

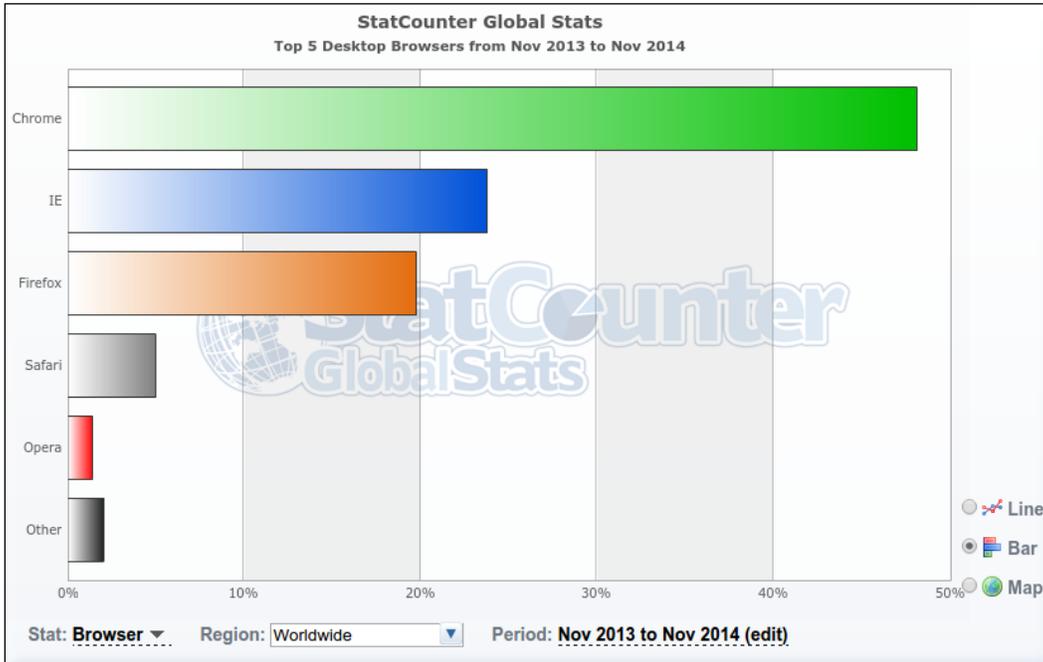


If you really want to improve your skills for using Chrome Developer Tools, you should visit **Code School** tutorial at <https://www.codeschool.com/courses/discover-devtools>. Use also the videos available in the official documentation at <https://developers.google.com/chrome-developer-tools/docs/videos>.

Visit the **Secrets of the Browser Developer Tools** website, <http://devtoolsecrets.com>. It covers all browsers!

Debugging in other browsers

During all this chapter, we introduced you to Chrome DevTools. It's one of the most powerful tools for debugging JavaScript applications, but it is important to see the reality of the web market. Just look on this graphic below from **StatCounter GlobalStats**, <http://gs.statcounter.com>, that provide statistics from more than 3 million websites.



As you see, there exists more than one web browser, and Internet Explorer with Firefox together represents a bit less than 50 percent of the market. It means that your web mapping application must be compliant to those other browsers. Moreover, you have to deal with different versions for the same browser family.

Although OpenLayers itself works really well with all browsers, your own code will not always do it.

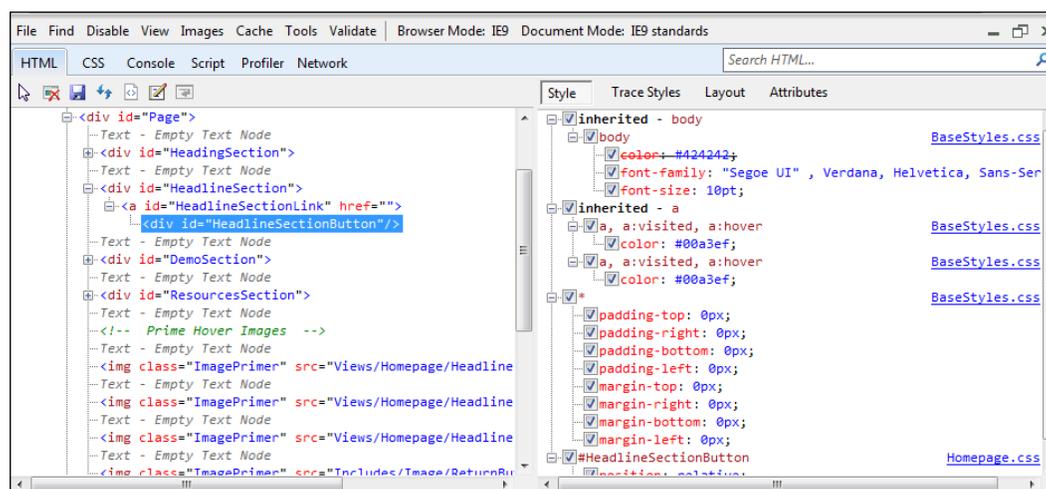
Because of this, we'll review some tools to debug in Internet Explorer and Mozilla Firefox. We will describe equivalence between Chrome DevTools panels and browsers-specific debuggers.

Debugging in Microsoft Internet Explorer

Before Internet Explorer 8, there wasn't any debugger built-in. The previous version of OpenLayers library (the 2.x series) was covering old IE versions such as IE 6, 7. OpenLayers 3 supports IE 9+.

Although the IE debugger is considered less powerful than other browsers debuggers, it is valuable tool in particular because of the step-by-step debug.

The following screenshot of IE 9 debugger shows that most panels are similar to Chrome Developer Tools:



The **HTML** panel is like the **Elements** panel, and the **CSS** and **Scripts** panels do the same job that the **Sources** panel in Chrome DevTools does.

The **Console** and **Network** panels are quite similar to the ones in Chrome Developer Tools.

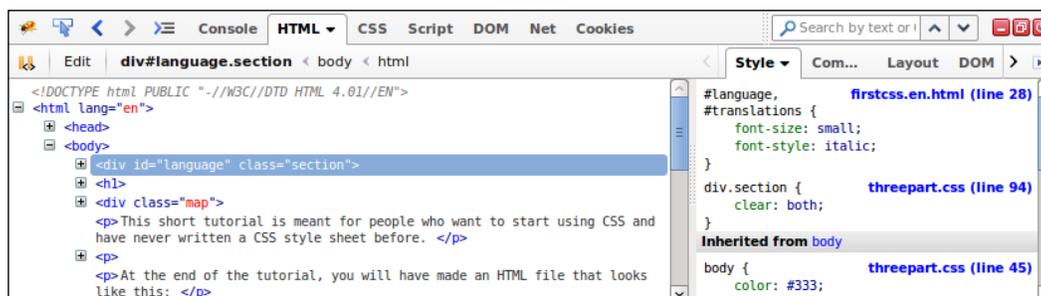
In addition, for better performance, for example, to evaluate and improve your JavaScript execution time, a profiler can be found in the **Profiles** panel but doesn't provide as much functions as its Chrome equivalent.

With IE, each version of the browser debugger gains panels. So, it would be better to review versions differences using the official Microsoft developer website at <http://msdn.microsoft.com/en-us/library/ie/>.

Debugging in Mozilla Firefox

Like for IE, this part will be dedicated to describe equivalence between Chrome DevTools and Firebug, an extension to Firefox. Although Mozilla Firefox has a built-in debugger included nowadays, Firebug remains the best tool on Mozilla to debug web maps and sites at the time of this writing.

We advise that you install it by visiting the official site at <https://getfirebug.com/>.



Now, it's time to make the comparison again.

In this case, the **Console** panel with the **DOM** panel in Firebug provides the same functionality that Chrome Developer Tools **Console** panel gives.

The **HTML** panel is equivalent to the **Elements** panel.

The **CSS** and **Script** panels combined together give you **Sources** panel functions.

The **Timeline**, **Profiles**, and **Audits** panels are specific to Chrome Developer Tools.

Most of the extensions for Firebug are listed at https://getfirebug.com/wiki/index.php/Firebug_Extensions.

Those extensions help to close the gap between default Chrome Developer and Firefox with only FireBug.

You can also find Mozilla Firefox add-on that do not always depend on FireBug. The official place to get them is <https://addons.mozilla.org>.

If you need one extension, you will have to install Acebug: <https://addons.mozilla.org/en-us/firefox/addon/acebug/>.

When you are learning and in particular doing JavaScript test directly in the browser, it behaves like an advanced text editor. Its main goal is to bring new features to Firebug's multi-lines command.

This add-on does the following:

- ◆ Add a new Firebug panel, **Resources**, to see list of files
- ◆ Auto-complete with *Ctrl + Space*. Beautify selected code with *Ctrl + Shift + B*
- ◆ Auto-indent and outdent using *Tab* and *Tab + Shift*
- ◆ Validate JavaScript, such as incomplete brackets
- ◆ Load and save JavaScript files

Moreover, the **Resources** panel that you get with AceBug in Firebug combined with **Cookies** panel provides similar experience to the **Resources** panel in Chrome DevTools.



More and more efforts have been done on the built-in Firefox Developers Tools, it starts widening the gap with Firebug debugging functions. Sometimes, it exposes more advanced capabilities than Firebug. You can take a look at its main dedicated page at <https://developer.mozilla.org/en-US/docs/Tools>.

Have a go hero – repeat after me

Learning process goes through repetitions. So, go back to the previous **Console** panel examples of the chapter and retry them in Mozilla Firefox. Take your time to see differences with Chrome Developer Tools behaviors. After those tests, go to your first OpenLayers example and type `o1` in the **Console** panel and click on it to browse like if you were in the Chrome Developer Tools **Console** tab. We also recommend that you play with autocompletion. Don't hesitate to experiment until you feel confident.

Pop quiz

Q1. What panel(s) will you use if you wanted to execute JavaScript code?

1. The **Network** panel.
2. The **Console** panel.
3. The **Timeline** panel.
4. The **Sources** panel.

Q2. You want to make some changes in CSS styles; what panel(s) can be used?

1. The **Elements** panel.
2. The **Resources** panel.
3. The **Network** panel.
4. The **Sources** panel.
5. The **Timeline** panel.

Q3. Using the sample from *Chapter 1, Getting Started with OpenLayers*, when you inspect the map object with `console.log`, what methods are available?

1. `map.getView()`.
2. `map.getLayers()`.
3. `map.getLayer()`.
4. `map.getInteraction()`.

Summary

In this appendix, we learned more about how OpenLayers works but before anything, we learned more on how to use Chrome DevTools.

We then took a look at the panels that Chrome DevTools provides and what they are used for. Afterwards, we spent time with the **Console** panel—something you'll be making extensive use of throughout this book (and when you're developing your own web maps). Then, we reviewed how to improve default Chrome DevTools. Finally, we covered basically main other web debuggers with cross-browsers support in mind.

This appendix aimed to provide some fundamental knowledge of web development tools for getting into both OpenLayers and general web development. Web development tools, such as Chrome DevTools, are one of the biggest assets in our toolkit. They speed up development time, help us identify bugs, interact with our code better, and much more.

D

Pop Quiz Answers

Chapter 3, Charting the Map Class

Pop quiz

Q1	2
Q2	1
Q3	2
Q4	3

Chapter 5, Using Vector Layers

Pop quiz

Q1	1 and 3
----	---------

Chapter 7, Wrapping Our Heads Around Projections

Pop quiz

Q1	1,2 and 3
Q2	1
Q3	1

Chapter 8, Interacting with Your Map

Pop quiz

Q1	1,2,3, and 5
Q2	3
Q3	1 and 4
Q4	1,3 and 4

Chapter 9, Taking Control of Controls

Pop quiz

Q1	3
Q2	1
Q3	2

Chapter 10, OpenLayers Goes Mobile

Pop quiz

Q1	1
Q2	3
Q3	2

Appendix B, More details on Closure Tools and Code Optimization Techniques

Pop quiz

Q1	4 and 5
----	---------

Appendix C, Squashing Bugs with Web Debuggers

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OpenLayers 3 Beginner's Guide

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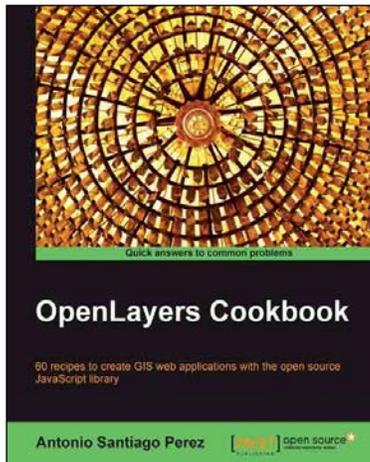
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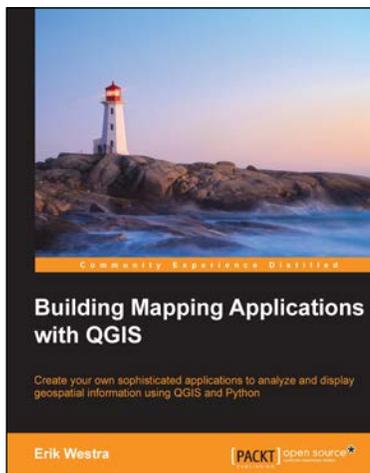


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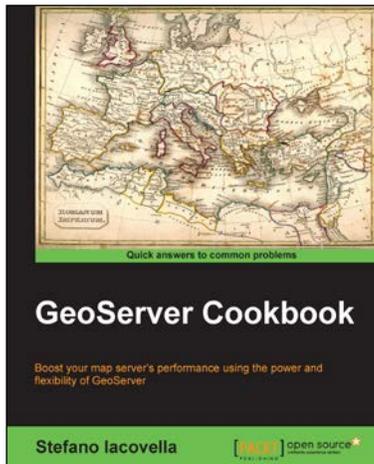
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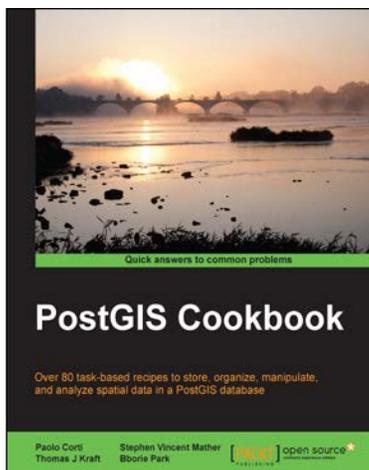


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