MERN Quick Start Guide

Build web applications with MongoDB, Express.js, React, and Node

Packt

www.packt.com

By Eddy Wilson Iriarte Koroliova

MERN Quick Start Guide

Build web applications with MongoDB, Express.js, React, and Node

Eddy Wilson Iriarte Koroliova

Packt

BIRMINGHAM - MUMBAI

MERN Quick Start Guide

Every effort has been made in the preparation of this book to ensure the accuracy of the information presented. However, the information contained in this book is sold without warranty, either express or implied. Neither the author, nor Packt Publishing or its dealers and distributors, will be held liable for any damages caused or alleged to have been caused directly or indirectly by this book.

Packt Publishing has endeavored to provide trademark information about all of the companies and products mentioned in this book by the appropriate use of capitals. However, Packt Publishing cannot guarantee the accuracy of this information.

Commissioning Editor: Ashwin Nair
Acquisition Editor: Nigel Fernandes
Content Development Editor: Roshan Kumar
Technical Editor: Shweta Jadhav
Copy Editor: Safis Editing
Project Coordinator: Hardik Bhinde
Proofreader: Safis Editing
Indexer: Rekha Nair
Graphics: Jason Monteiro
Production Coordinator: Shantanu Zagade First published: May 2018

Production reference: 1310518

Published by Packt Publishing Ltd.
Livery Place
35 Livery Street
Birmingham
B3 2PB, UK.

ISBN 978-1-78728-108-0

`www.packtpub.com`

PacktPub.com

Did you know that Packt offers eBook versions of every book published, with PDF and ePub files available? You can upgrade to the eBook version at `www.PacktPub.com` and as a print book customer, you are entitled to a discount on the eBook copy. Get in touch with us at `service@packtpub.com` for more details.

At `www.PacktPub.com`, you can also read a collection of free technical articles, sign up for a range of free newsletters, and receive exclusive discounts and offers on Packt books and eBooks.

Contributors

About the author

Eddy Wilson Iriarte Koroliova has worked and led the development of a SaaS web application for the financial sector in 2012 with the LAMP stack for 4 years. Since 2014, he has been working as a senior full-stack developer and JavaScript specialist with the MERN stack, for the development of enterprise web applications for different sectors.

Eddy travels frequently and mostly works remotely. He speaks Spanish, English, and Russian, and he is currently learning Chinese, which has allowed him to work in different team environments and communicate better with clients and co-workers.

Special thanks to my partner in life, Huang Jingxuan, for always being there and for supporting me not only while writing this book but also during the different stages of my life and development of my career.
A big thank you to my family for their moral and financial support while starting my career as a developer.

About the reviewer

Chance is passionate about the intersection of technology, collaboration, and education.
He is the founder of Chingu, a global collaboration platform for tech-learners, which has brought together thousands of developers, designers, and data scientists from 140 countries to learn and build together.

I'd like to thank Eddy Wilson for writing this book, Simon Van den Broeck for his edit contributions, and the Chingu community!

What this book covers

`Chapter 1`, *Introduction to MERN Stack*, provides an introduction to the MERN stack and the MVC architectural pattern. It covers installation of NodeJS and MongoDB as well as installing NPM packages and an example of usage. These constitute the base for all the book's recipes.

`Chapter 2`, *Building a Web Server with ExpressJS*, covers core concepts about the HTTP protocol, the “http” NodeJS module, and how it is all connected with ExpressJS. It explores all features of ExpressJS for building Web Server applications from route handlers and middleware to secure a Web Server application and debugging.

`Chapter 3`, *Building a RESTful API*, explains core concepts about what is REST, URLs, and CRUD operations. These concepts are the base for the whole chapter. It also explores how to make CRUD operations in ExpressJS and with Mongoose as well as where and how ExpressJS and Mongoose fit in the MVC architectural pattern. It covers the creation of Mongoose schemas and models as well as different types of Mongoose middleware and validation of data.

`Chapter 4`, *Real-time Communication with Socket.IO and ExpressJS*, gives a brief introduction to NodeJS events and how bi-directional communication with WebSockets works. It also goes through using SocketIO and ExpressJS to build Web Applications that deliver data in real time.

`Chapter 5`, *Managing State with Redux*, covers what Redux is and the three core principles. It also covers the very basic idea of Redux from how Array.prototype.reduce works, to how reducers are defined and how to write middleware functions as well as advanced concepts such as writing store enhancers, time traveling, and asynchronous data flow.

`Chapter 6`, *Building Web Applications with React*, explains what React is, what JSX syntax is, and where in the MVC architectural pattern it fits. It explores all core concepts of React in the form of easy-to-follow and build recipes. The recipes cover topics about composition, life cycle methods, controlled and uncontrolled components, error boundary components, and others such as type checking with PropTypes and Portals.

Packt is searching for authors like you

If you're interested in becoming an author for Packt, please visit `authors.packtpub.com` and apply today. We have worked with thousands of developers and tech professionals, just like you, to help them share their insight with the global tech community. You can make a general application, apply for a specific hot topic that we are recruiting an author for, or submit your own idea.

Table of Contents

Preface

The MERN stack can be seen as a collection of tools that share a common denominator that is the language, JavaScript. The book explores, in the form of recipes, how to build web client and server applications using the MERN stack following the MVC architectural pattern.

The model and controller of the MVC architectural pattern are covered by the chapters about building RESTful APIs with ExpressJS and Mongoose. The chapters cover core concepts about the HTTP protocol, type of methods, status codes, URLs, REST, and CRUD operations. Afterward, it moves to topics specific to ExpressJS, such as request handlers, middleware, and security, as well as specific topics about Mongoose, such as schemas, models, and custom validation.

The view of the MVC architectural patterns is covered by the chapter about ReactJS. ReactJS is a UI library that is component-based with a declarative API. The book's aim to provide the essential knowledge for building ReactJS web applications and components. Complementary to ReactJS, the book contains an entire chapter about Redux that explains from the very core concepts and principles to advanced features such as store enhancers, time travelling, and asynchronous data flow.

Additionally, this book covers real-time communication with ExpressJS and SocketIO to deliver and exchange data in real time.

By the end of the book, you will know the core concepts and essentials for building full-stack web applications with the MVC architectural pattern.

To get the most out of this book

This book is for developers who are interested in getting started with the MERN stack for developing web applications. In order to be able to understand the chapters, you should have already a general knowledge and understanding of the JavaScript language.

What you need for this book

In order to be able to work on the recipes, you need the following:

- An IDE or code editor of your preference. Visual Studio Code (vscode) was used when writing the recipes' codes, so I suggest you to give it a try
- An Operating System (O.S) that is able to run NodeJS and MongoDB, preferably one of the following:
    - macOS X Yosemite/El Capitan/Sierra
    - Linux
    - Windows 7/8/10 (.NET framework 4.5 is required if installing VSCode in Windows 7)
- Preferably, at least 1 GB RAM and 1.6 GHz processor or faster

Download the example code files

You can download the example code files for this book from your account at `www.packtpub.com`. If you purchased this book elsewhere, you can visit `www.packtpub.com/support` and register to have the files emailed directly to you.

You can download the code files by following these steps:

1. Log in or register at `www.packtpub.com`.
2. Select the SUPPORT tab.
3. Click on Code Downloads & Errata.
4. Enter the name of the book in the Search box and follow the onscreen instructions.

Once the file is downloaded, please make sure that you unzip or extract the folder using the latest version of:

- WinRAR/7-Zip for Windows
- Zipeg/iZip/UnRarX for Mac
- 7-Zip/PeaZip for Linux

The code bundle for the book is also hosted on GitHub at `https://github.com/PacktPublishing/MERN-Quick-Start-Guide`. In case there's an update to the code, it will be updated on the existing GitHub repository.

We also have other code bundles from our rich catalog of books and videos available at `https://github.com/PacktPublishing/`. Check them out!

Download the color images

We also provide a PDF file that has color images of the screenshots/diagrams used in this book. You can download it here: `https://www.packtpub.com/sites/default/files/downloads/MERNQuickStartGuide_ColorImages.pdf`.

Code in Action

Visit the following link to check out videos of the code being run:
`https://goo.gl/ymdYBT`

Conventions used

There are a number of text conventions used throughout this book.

`CodeInText`: Indicates code words in text, database table names, folder names, filenames, file extensions, pathnames, dummy URLs, user input, and Twitter handles. Here is an example: "Mount the downloaded `WebStorm-10*.dmg` disk image file as another disk in your system."

A block of code is set as follows:

```
{
        "dependencies": {
          "express": "4.16.3",
          "node-fetch": "2.1.1",
          "uuid": "3.2.1"
        }
      }
```

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

```
npm install
```

Bold: Indicates a new term, an important word, or words that you see onscreen. For example, words in menus or dialog boxes appear in the text like this. Here is an example: "Select System info from the Administration panel."

Warnings or important notes appear like this.

Tips and tricks appear like this.

Sections

In this book, you will find several headings that appear frequently (*Getting ready*, *How to do it...*, *Let's test it...*, *How it works...*, *There's more...*, and *See also*).

To give clear instructions on how to complete a recipe, use these sections as follows:

Getting ready

This section tells you what to expect in the recipe and describes how to set up any software or any preliminary settings required for the recipe.

How to do it...

This section contains the steps required to follow the recipe.

Let's test it...

This section consists of detailed steps on how to test the code given in *How to do it...* section.

How it works...

This section usually consists of a detailed explanation of what happened in the previous section.

There's more...

This section consists of additional information about the recipe in order to make you more knowledgeable about the recipe.

See also

This section provides helpful links to other useful information for the recipe.

Get in touch

Feedback from our readers is always welcome.

General feedback: Email `feedback@packtpub.com` and mention the book title in the subject of your message. If you have questions about any aspect of this book, please email us at `questions@packtpub.com`.

Errata: Although we have taken every care to ensure the accuracy of our content, mistakes do happen. If you have found a mistake in this book, we would be grateful if you would report this to us. Please visit `www.packtpub.com/submit-errata`, selecting your book, clicking on the Errata Submission Form link, and entering the details.

Piracy: If you come across any illegal copies of our works in any form on the internet, we would be grateful if you would provide us with the location address or website name. Please contact us at `copyright@packtpub.com` with a link to the material.

If you are interested in becoming an author: If there is a topic that you have expertise in and you are interested in either writing or contributing to a book, please visit `authors.packtpub.com`.

Reviews

Please leave a review. Once you have read and used this book, why not leave a review on the site that you purchased it from? Potential readers can then see and use your unbiased opinion to make purchase decisions, we at Packt can understand what you think about our products, and our authors can see your feedback on their book. Thank you!

For more information about Packt, please visit `packtpub.com`.

Introduction to the MERN Stack

In this chapter, we will cover the following topics:

- The MVC architectural pattern
- Installing and configuring MongoDB
- Installing Node.js
- Installing NPM packages

Technical requirements

You will be required to have an IDE, Visual Studio Code, Node.js and MongoDB. You will also need to install Git, in order use the Git repository of this book.

The code files of this chapter can be found on GitHub:
`https://github.com/PacktPublishing/MERN-Quick-Start-Guide/tree/master/Chapter01`

Check out the following video to see the code in action:
`https://goo.gl/1zwc6F`

Introduction

The MERN stack is a solution composed of four main components:

- **MongoDB**: A database that uses a document-oriented data model.
- **ExpressJS**: A web application framework for building web applications and APIs.
- **ReactJS**: A declarative, component-based, and isomorphic JavaScript library for building user interfaces.
- **Node.js**: A cross-platform JavaScript runtime environment built on Chrome's V8 JavaScript engine allows developers to build diverse tools, servers, and applications.

These fundamental components that comprise the MERN stack are open source, and are thus maintained and developed by a great community of developers. What ties these components together is a common language, JavaScript.

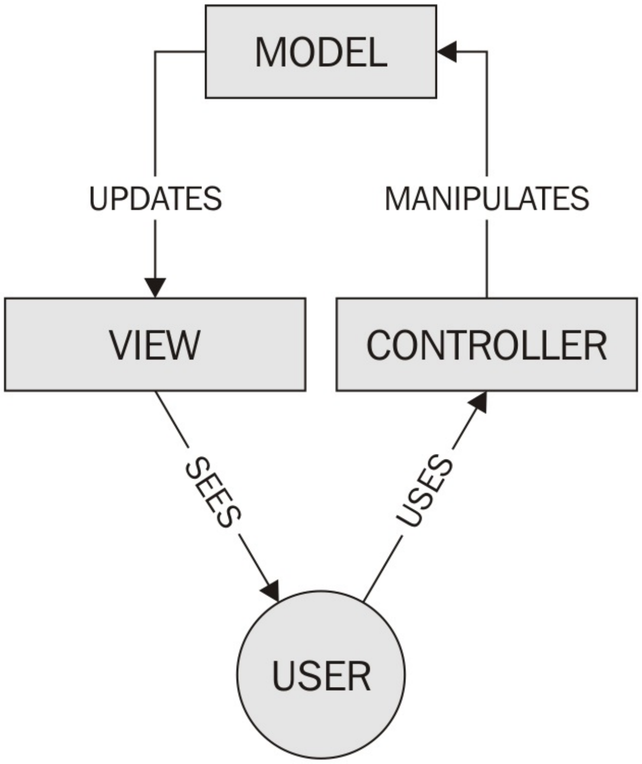
The recipes in this chapter will mainly focus on setting up a development environment to work with a MERN stack.

You are free to use the code editor or IDE of your choice. However, I would suggest you give Visual Studio Code a try if you have trouble deciding which IDE to use.

The MVC architectural pattern

Most modern web applications implement the MVC architectural pattern. It consists of three interconnected parts that separate the internal representation of information in a web application:

- **Model**: Manages the business logic of an application that determines how data should be stored, created, and modified
- **View**: Any visual representation of the data or information
- **Controller**: Interprets user-generated events and transforms them into commands for the model and view to update accordingly:



The **Separation of Concern** (**SoC**) design pattern separates frontend from backend code. Following the MVC architectural pattern, developers are able to adhere to the SoC design pattern, resulting in a consistent and manageable application structure.

The recipes in the following chapters implement this architectural pattern to separate the frontend and the backend.

Installing and configuring MongoDB

The official MongoDB website provides up-to-date packages containing binaries for installing MongoDB on Linux, OS X, and Windows.

Getting ready

Visit the official website of MongoDB at `https://www.mongodb.com/download-center`, select Community Server, and then select your preferred operating system version of the software and download it.

Installing MongoDB and configuring it may require additional steps.

How to do it...

Visit the documentation website of MongoDB at `https://docs.mongodb.com/master/installation/` for instructions and check the Tutorials section for your specific platform.

After installation, an instance of `mongod-`, the daemon process for `MongoDB-`, can be started in a standalone fashion:

1. Open a new Terminal
2. Create a new directory named `data`, which will contain the Mongo database
3. Type `mongod --port 27017 --dbpath` *`data`* to start a new instance and create a database
4. Open another Terminal
5. Type `mongo --port 27017` to connect a Mongo shell to the instance

There's more...

As an alternative, you can opt to use a **Database as a service** (**DBaaS**) such as MongoDB Atlas, which, at the time of writing, allows you to create a free cluster with 512 MB of storage. Another simple alternative is mLab, although there are many other options.

Installing Node.js

The official Node.js website provides two packages containing LTS and Current (containing the latest features) binaries to install Node.js on Linux, OS X, and Windows.

Getting ready

For the purpose of this book, we will install Node.js v10.1.x.

How to do it...

To download the latest version of Node.js:

1. Visit the official website at `https://nodejs.org/en/download/`
2. Select Current | Latest Features
3. Select the binary for your preferred platform or **operating system** (**OS**)
4. Download and install

If you prefer to install Node.js via package manager, visit `https://nodejs.org/en/download/package-manager/` and select your preferred platform or OS.

Installing npm packages

The installation of Node.js includes a package manager called `npm`, which is the default and most widely used package manager for installing JavaScript/Node.js libraries.

NPM packages are listed in the NPM registry at `https://registry.npmjs.org/`, where you can search for packages and even publish your own.

There are other alternatives to NPM as well, such as Yarn, which is compatible with the public NPM registry. You are free to use the package manager of your choice; however, for the purpose of this book, the package manager used in the recipes will be NPM.

```
{
    "name": "mern-cookbook", "version": "1.0.0", "description": "mern cookbook recipes", "main": "index.js", "scripts": {
    "test": "echo \"Error: no test specified\" && exit 1"
    }, "author": "Eddy Wilson", "license": "MIT"
}
```

After this, you will be able to use NPM to install new packages for your project.

```
<strong>npm --save-exact install chalk</strong>
```

```
const chalk = require('chalk') const { red, blue } = chalk console.log(red('hello'), blue('world!'))
```

```
<strong> node index.js</strong>
```

How it works...

NPM will connect to and look in the NPM registry for the package named react, and will download it and install it if it exists.

The following are some useful flags that you can use NPM with:

- `--save`: This will install and add the package name and version in the `dependencies` section of your `package.json` file. These dependencies are modules that your project will use while in production.
- `--save-dev`: This works in the same way as the `--save` flag. It will install and add the package name in the `devDependencies` section of the `package.json` file. These dependencies are modules that your project will use during development.
- `--save-exact`: This keeps the original version of the installed package. This means, if you share your project with other people, they will be able to install the exact same version of the package that you use.

While this book will provide you with a step-by-step guide to installing the necessary packages in every recipe, you are encouraged to visit the NPM documentation website at `https://docs.npmjs.com/getting-started/using-a-package.json` to learn more.

Building a Web server with ExpressJS

In this chapter, we will cover the following recipes:

- Routing in ExpressJS
- Modular route handlers
- Writing middleware functions
- Writing configurable middleware functions
- Writing router-level middleware functions
- Writing error-handler middleware functions
- Using ExpressJS' built-in middleware function to serve static assets
- Parsing the HTTP request body
- Compressing HTTP responses
- Using an HTTP request logger
- Managing and creating virtual domains
- Securing an ExpressJS web application with helmet
- Using template engines
- Debugging your ExpressJS web application

Technical requirements

You will be required to have an IDE, Visual Studio Code, Node.js and MongoDB. You will also need to install Git, in order use the Git repository of this book.

The code files of this chapter can be found on GitHub:
`https://github.com/PacktPublishing/MERN-Quick-Start-Guide/tree/master/Chapter02`

Check out the following video to see the code in action:
`https://goo.gl/xXhqWK`

Introduction

ExpressJS is the preferred de facto Node.js web application framework for building robust web applications and APIs.

In this chapter, the recipes will focus on building a fully functional web server and understanding the core fundamentals.

Routing in ExpressJS

Routing refers to how an application responds or acts when a resource is requested via an HTTP verb or HTTP method.

HTTP stands for **Hypertext Transfer Protocol** and it's the basis of data communication for the **World Wide Web** (**WWW**). All documents and data in the WWW are identified by a **Uniform Resource Locator** (**URL**).

HTTP verbs or HTTP methods are a *client-server* model. Typically, a web browser serves as a *client*, and in our case ExpressJS is the framework that allows us to create a *server* capable of understanding these requests. Every request expects a response to be sent to the client to recognize the status of the resource that it is requesting.

Request methods can be:

- **Safe**: An HTTP verb that performs read-only operations on the server. In other words, it does not alter the server state. For example: `GET`.
- **Idempotent**: An HTTP verb that has the same effect on the server when identical requests are made. For instance, sending a `PUT` request to modify a user's first name should have the same effect on the server if implemented correctly when multiple identical requests are sent. All *safe* methods are also idempotent. For example, the `GET`, `PUT`, and `DELETE` methods are idempotent.
- **Cacheable**: An HTTP response that can be cached. Not all methods or HTTP verbs can be cached. A response is cacheable only if the *status code* of the response and the method used to

make the request are both cacheable. For example, the GET method is cacheable and the following status codes: `200` (Request succeeded), `204` (No content), `206` (Partial content), `301` (Moved permanently), `404` (Not found), `405` (Method not allowed), `410` (Gone or Content permanently removed from server), and `414` (URI too long).

Getting ready

Understanding routing is one of the most important core aspects in building robust RESTful APIs.

In this recipe, we will see how ExpressJS handles or interprets HTTP requests. Before you start, create a new `package.json` file with the following content: { "dependencies": { "express": "4.16.3" } }

Then, install the dependencies by opening a Terminal and running:

```
npm install
```

ExpressJS does the whole job of understanding a client's request. The request may come from a browser, for instance. Once the request has been interpreted, ExpressJS saves all the information in two objects:

- **Request**: This contains all the data and information about the client's request. For instance, ExpressJS parses the URI and makes its parameters available on request.query.
- **Response**: This contains data and information that will be sent to the client. The response's headers can be modified as well before sending the information to the client. The `response` object has several methods available for sending the status code and data to the client. For instance: `response.status(200).send('Some Data!')`.

How to do it...

`Request` and `Response` objects are passed as arguments to the *route handlers* defined inside a `route` method.

```
const express = require('express') const app = express()

app.get('/', (request, response, nextHandler) => {

    response.status(200).send('Hello from ExpressJS') })

app.listen(

    1337, () => console.log('Web Server running on port 1337'), )

<strong> node 1-basic-route.js</strong>

<span class="URLPACKT"> http://localhost:1337/</span>
```

For more information about which HTTP methods are supported by ExpressJS, visit the official ExpressJS website at https://expressjs.com/en/guide/routing.html#route-methods.

```
const express = require('express') const app = express()

app.get('/one', (request, response, nextHandler) => {

    response.type('text/plain') response.write('Hello ') nextHandler() })

    app.get('/one', (request, response, nextHandler) => {

    response.status(200).end('World!') })

app.get('/two',

    (request, response, nextHandler) => {

    response.type('text/plain') response.write('Hello ') nextHandler() },

    (request, response, nextHandler) => {

    response.status(200).end('Moon!') }

    )

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )
```

```
<strong>node 2-route-handlers.js</strong>
```

```
<strong><span class="URLPACKT"> http://localhost:1337/one</span>
</strong><strong><span class="URLPACKT">
http://localhost:1337/two</span></strong>
```

```
const express = require('express') const app = express()
```

```
app
    .route('/home')
    .get((request, response, nextHandler) => {
    response.type('text/html') response.write('<!DOCTYPE html>') nextHandler()
    })
    .get((request, response, nextHandler) => {
    response.end(`
    <html lang="en"> <head>
    <meta charset="utf-8"> <title>WebApp powered by ExpressJS</title> </head>
    <body role="application"> <form method="post" action="/home"> <input type="text" /> <button type="submit">Send</button> </form>
    </body>
    </html>
    `)
    })
    .post((request, response, nextHandler) => {
    response.send('Got it!') })
app.listen(
    1337,
    () => console.log('Web Server running on port 1337'), )
```

<strong> node 3-chainable-routes.js</strong>

<span class="URLPACKT">http://localhost:1337/home</span>

There's more...

Route paths can be strings or regular expressions. Route paths are internally turned into regular expressions using the `path-to-regexp` NPM package `https://www.npmjs.com/package/path-to-regexp`.

`path-to-regexp`, in a way, helps you write path regular expressions in a more human-readable way. For example, consider the following code:

```
app.get(/([a-z]+)-([0-9]+)$/, (request, response, nextHandler) => {
    response.send(request.params)
})
// Output: {"0":"abc","1":"12345"} for path /abc-12345
```

This could be written as follows:

```
app.get('/:0-:1', (request, response, nextHandler) => {
    response.send(request.params)
})
// Outputs: {"0":"abc","1":"12345"} for /abc-12345
```

Or better:

```
app.get('/:id-:tag', (request, response, nextHandler) => {
    response.send(request.params)
})
// Outputs: {"id":"abc","tag":"12345"} for /abc-12345
```

Take a look at this expression: `/([a-z]+)-([0-9]+)$/`. The parentheses in the regular expression are called **capturing parentheses**; and when they find a match, they remember it. In the preceding example, for `abc-12345`, two strings are remembered, `{"0":"abc","1":"12345"}`. This is the way that ExpressJS finds a match, remembers its value, and associates it to a key:

```
app.get(':userId:action-:where', (request, response, nextHandler) => {
    response.send(request.params)
})
// Route path: 123edit-profile
// Outputs: {"userId":"123","action":"edit","where":"profile"}
```

```
const router = express.Router() router.get('/', (request, response, next) => {
    response.send('Hello there!') })
router.post('/', (request, response, next) => {
    response.send('I got your data!') })
```

Getting ready

In this recipe, we will see how to use a router to make a modular application. Before you start, create a new `package.json` file with the following content:

```
{
    "dependencies": {
        "express": "4.16.3"
    }
}
```

Then, install the dependencies by opening a terminal and running:

```
    npm install
```

```
const express = require('express') const app = express()

const miniapp = express.Router() miniapp.get('/home', (request, response, next)
=> {

    const url = request.originalUrl response

    .status(200)

    .send(`You are visiting /home from ${url}`) })

app.use('/first', miniapp) app.use('/second', miniapp)

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )
```

```
<strong> node modular-router.js</strong>
```

You are visting *home from* first/home You are visting *home from* second/home

As can be seen, a *router* was mounted to two different mount points. Routers are usually referred to as mini-applications because they can be mounted to an ExpressJS application's specific routes and not only once but also several times to different mount points, paths, or URIs.

Writing middleware functions

Middleware functions are mainly used to make changes in the `request` and `response` object. They are executed in sequence, one after another, but if a middleware functions does not pass control to the next one, the request is left hanging.

Getting ready

Middleware functions have the following signature:

```
app.use((request, response, next) => {
    next()
})
```

The signature is very similar to writing route handlers. In fact, a middleware function can be written for a specific HTTP method and a specific path route, and will look like this, for example: app.get('/', (request, response, next) => { next() })

So, if you are wondering what the difference is between route handlers, and middleware functions, the answer is simple: their purpose.

If you are writing route handlers, and the `request` objects and/or the `response` object is modified, then you are writing middleware functions.

In this recipe, you will see how to use a middleware function to restrict access to certain paths or routes that depend on a certain condition. Before you start, create a new `package.json` file with the following content: { "dependencies": { "express": "4.16.3" } }

Then, install the dependencies by opening a terminal and running:

```
npm install
```

```
const express = require('express') const app = express()

app.use((request, response, next) => {

    request.allowed = Reflect.has(request.query, 'allowme') next()

    })

app.get('/', (request, response, next) => {

    if (request.allowed) {

    response.send('Hello secret world!') } else {

    response.send('You are not allowed to enter') }

    })

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )

<strong> node middleware-functions.js</strong>

<strong><span class="URLPACKT"> </span>
</strong>http://localhost:1337/<br/> http://localhost:1337/?allowme
```

How it works...

Just like with route handlers, middleware functions need to pass control to the next handler; otherwise, our application will have been hanging because no data was sent to the client, and the connection was not closed either.

If new properties are added to the `request` or `response` objects inside a middleware function, the next handler will have access to those new properties. As in our previously written code, the `allowed property` in the `request` object is available to the next handler.

```
const fn = (options) => (response, request, next) => {

  next()

                                        }
```

Usually an object is used as an `options` parameters. However, there is nothing stopping you from doing it in your own way.

Getting ready

In this recipe, you will write a configurable logger middleware function. Before you start, create a new `package.json` file with the following content:

```
{
    "dependencies": {
        "express": "4.16.3"
    }
}
```

Then, install the dependencies by opening a terminal and running:

```
    npm install
```

```
const logger = (options) => (request, response, next) => {
 if (typeof options === 'object'
 && options !== null && options.enable) {
 console.log(
 'Status Code:', response.statusCode, 'URL:', request.originalUrl, )
                              }
 next()
                              }
 module.exports = logger
```

3. Save the file

```
const express = require('express') const loggerMiddleware =
require('./middleware-logger') const app = express()

app.use(loggerMiddleware({

    enable: true, }))

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )
```

<strong> node middleware-logger-test.js</strong>

<span class="URLPACKT"> http://localhost:1337*hello?world*<span><strong>
<br/></strong>

<strong> Status Code: 200 URL: *hello?world*<strong>

There's more...

If you want to experiment, start your configurable middleware test application with the `enable` property set to `false`. No logs should be displayed.

Usually, you would want to disable logging in production, since this operation could hit performance.

An alternative to disabling all logging is to use other libraries to do this task instead of using `console`. There are libraries that allow you to set different levels of logging as well, for instance:

- **Debug module**: `https://www.npmjs.com/package/debug`
- **Winston**: `https://www.npmjs.com/package/winston`

Logging is useful for several reasons. The main reasons are:

- It checks whether your services are running properly, for example, checking whether your application is connected to MongoDB.
- It discovers errors and bugs.
- It helps you to understand better how your application is working. For instance, if you have a modular application, you can see how it integrates when included in other applications.

Writing router-level middleware functions

Router-level middleware functions are only executed inside a router. They are usually used when applying a middleware to a mount point only or to a specific path.

```
{
  "dependencies": {
  "express": "4.16.3"
}
}
```

<strong>npm install</strong>

```
const express = require('express') const app = express() const router = express.Router()

router.use((request, response, next) => {

    console.log('URL:', request.originalUrl) next() })

app.use('/router', router)

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )
```

<strong> node router-level.js</strong>

<strong><span class="URLPACKT"> http://localhost:1337*router*example</span><br/></strong>

<strong> URL: *router*example</strong>

<span class="URLPACKT"> http://localhost:1337/example</span><strong><br/></strong>

11. No logs should be displayed in terminal

```
router.use((request, response, next) => {
    next('route') })
const express = require('express') const app = express()
const router = express.Router()
router.use((request, response, next) => {
    if (!request.query.id) {
    next('router') // Next, out of Router } else {
    next() // Next, in Router }
    })
router.get('/', (request, response, next) => {
    const id = request.query.id response.send(`You specified a user ID => ${id}`) })
app.get('/', router, (request, response, next) => {
    response
    .status(400) .send('A user ID needs to be specified') })
app.listen(
    1337,
    () => console.log('Web Server running on port 1337'), )
<strong> node router-level-control.js</strong>
<strong><span class="URLPACKT"> </span></strong> http://localhost:1337/
    http://localhost:1337/?id=7331<strong><br/></strong>
```

How it works...

When navigating to the first URL (`http://localhost:1337/`), the following message is shown: A user ID needs to be specified

This is because the middleware function in the router checks if the `id` was provided in the query, and because it is not, it passes control to the next handler outside of the router with `next('router')`.

On the other hand, when navigating to the second URL (`http://localhost:1337/?id=7331`), the following message is shown: You specified a user ID => 7331

That happens because, as an `id` was provided in the query, the middleware function in the router will pass control to the next handler inside the router with `next()`.

Writing error-handler middleware functions

ExpressJS already includes by default a built-in error handler which gets executed at the end of all middleware and route handlers.

There are ways that the built-in error handler can be triggered. One is implicit when an error occurs inside a route handler. For example:

```
app.get('/', (request, response, next) => {
    throw new Error('Oh no!, something went wrong!')
})
```

And another way of triggering the built-in error handler is explicit when passing an `error` as an argument to `next(error)`. For instance:

```
app.get('/', (request, response, next) => {
    try {
        throw new Error('Oh no!, something went wrong!')
    } catch (error) {
        next(error)
    }
})
```

The stack trace is displayed on the client side. If `NODE_ENV` *is set to production, then the stack trace is not included.*

A custom error handler middleware function can be written as well and it looks pretty much the same as route handlers do with the exception that an error handler function middleware expects to receive four arguments:

```
app.use((error, request, response, next) => {
    next(error)
})
```

Take into account that `next(error)`is optional. That means, if specified, `next(error)` will pass control over to the next error handler. If no other error handler was defined, then the control will pass to the built-in error handler.

Getting ready

In this recipe, we will see how to create a custom error handler. Before you start, create a new `package.json` file with the following content:

```
{
    "dependencies": {
        "express": "4.16.3"
    }
}
```

Then, install the dependencies by opening a terminal and running:

```
    npm install
```

```
const express = require('express')

   const app = express()

app.get('/', (request, response, next) => {

   try {

   throw new Error('Oh no!, something went wrong!')

   } catch (err) {

   next(err)

                                         }

   })

app.use((error, request, response, next) => {

   response.end(error.message)

   })

app.listen(

   1337,

   () => console.log('Web Server running on port 1337'),

   )
```

<strong> node custom-error-handler.js</strong>

<span class="URLPACKT"> http://localhost:1337/</span><strong><br/>
</strong>

Using ExpressJS' built-in middleware function for serving static assets

Prior to the 4.x version of ExpressJS, it has depended on ConnectJS which is an HTTP server framework `https://github.com/senchalabs/connect`. In fact, most middleware written for ConnectJS is also supported in ExpressJS.

As from the 4.x version of ExpressJS, it no longer depends on ConnectJS, and all previously built-in middleware functions were moved to separate modules `https://expressjs.com/en/resources/middleware.html`.

ExpressJS 4.x and newer versions include only two built-in middleware functions. The first one has already been seen: the built-in error handler middleware function. The second one is the `express.static` middleware function that is responsible for serving static assets.

The `express.static` middleware function is based on `serve-static` module `https://expressjs.com/en/resources/middleware/serve-static.html`.

The main difference between `express.static` and `serve-static` is that the second one can be used outside of ExpressJS.

```
                                        {
  "dependencies": {
  "express": "4.16.3"
                                        }
                                        }
```

```
<strong>npm install</strong>
```

```
<!DOCTYPE html> <html lang="en"> <head>

   <meta charset="utf-8"> <title>Simple Web Application</title> </head>

   <body>

   <section role="application"> <h1>Welcome Home!</h1> </section> </body>

   </html>
```

```
const express = require('express') const path = require('path') const app = express()

const publicDir = path.join(__dirname, './public') app.use('/', express.static(publicDir))

app.listen(

   1337,

   () => console.log('Web Server running on port 1337'), )
```

<strong> node serve-static-assets.js</strong>

<span class="URLPACKT">http://localhost:1337/index.html</span><strong><br/></strong>

How it works...

Our `index.html` file will be shown because we specified `"/"` as the root directory where to look for assets.

Try changing the path from `"/"` to `"/public"`. Then, you will be able to see that the `index.html` file, and other files that you want to include in the `/public` directory, will be accessible under `http://localhost:1337/public/[fileName]`.

```
<!DOCTYPE html>

   <html lang="en"> <head>

   <meta charset="utf-8"> <title>Simple Web Application</title> </head>

   <body>

   <section role="application"> <h1>Welcome Home!</h1> </section>

   </body>

   </html>

<!DOCTYPE html>

   <html lang="en"> <head>

   <meta charset="utf-8"> <title>Simple Web Application</title> </head>

   <body>

   <section role="application"> Welcome to Second Page!

   </section>

   </body>

   </html>

const express = require('express') const path = require('path') const app = express()

const staticRouter = express.Router()

const assets = {

   first: path.join(__dirname, './public'), second: path.join(__dirname, './another-public') }
```

```
    staticRouter

    .use(express.static(assets.first)) .use(express.static(assets.second))

app.use('/', staticRouter)

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )
```

<strong> node router-serve-static.js</strong>

<strong><span class="URLPACKT"> </span></strong> http://localhost:1337/index.html http://localhost:1337/second.html<strong><br/></strong>

11. Two different files in different locations were served under one path

If two or more files with the same name exist under different directories, only the first one found will be displayed on the client-side.

Parsing the HTTP request body

`body-parser` is a middleware function that parses the incoming request body and makes it available in the `request` object as `request.body` https://expressjs.com/en/resources/middleware/body-parser.html.

This module allows an application to parse the incoming request as:

- JSON
- Text
- Raw (buffer original incoming data)
- URL encoded form

The module supports automatic decompression of gzip and deflates encodings when the incoming request is compressed.

```
{
"dependencies": {
"body-parser": "1.18.2", "express": "4.16.3"
}
}
```

```
<strong>npm install</strong>
```

```
const express = require('express') const bodyParser = require('body-parser') const
app = express()

app.use(bodyParser.urlencoded({ extended: true })) app.use(bodyParser.text())

app.get('/', (request, response, next) => {

   response.send(`

   <!DOCTYPE html> <html lang="en"> <head>

   <meta charset="utf-8"> <title>WebApp powered by ExpressJS</title>
</head>

   <body>

   <div role="application"> <form method="post" action="/setdata"> <input
name="urlencoded" type="text" /> <button type="submit">Send</button>
</form>

   <form method="post" action="setdata" <br> enctype="text/plain"> <input
name="txtencoded" type="text" /> <button type="submit">Send</button>
</form>

   </div>

   </body>

   </html>

   `)

   })

app.post('/setdata', (request, response, next) => {

   console.log(request.body) response.end()

   })
```

```
app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )

<strong> node parse-form.js</strong>

<span class="URLPACKT"> http://localhost:1337/</span><strong><br/></strong>

<span class="URLPACKT"> http://localhost:1337/</span><strong><br/></strong>
```

12. Fill the second input box with any data and submit the form:
13. Check the output in the terminal

```
{ 'urlencoded': 'Example' }

txtencoded=Example
```

Two parsers are used above:

1. The first one `bodyParser.urlencoded()` parses incoming requests for `multipart/form-data` encoding type. The result is available as an **Object** in `request.body`
2. The second one `bodyParser.text()` parses incoming requests for `text/plain` encoding type. The result is available as a **String** in `request.body`

Compressing HTTP responses

compression is a middleware function that compresses the response body that will be send to the client. This module uses the `zlib` module `https://nodejs.org/api/zlib.html` that supports the following content-encoding mechanisms:

- gzip
- deflate

The `Accept-Encoding` HTTP header is used to determine which content-encoding mechanism is supported on the client-side (for example web browser) while the `Content-Encoding` HTTP header is used to tell the client which content encoding mechanism was applied to the response body.

`compression` is a configurable middleware function. It accepts an `options` object as the first argument to define a specific behavior for the middleware and also to pass `zlib` options as well.

```
                                        {
  "dependencies": {
  "compression": "1.7.2", "express": "4.16.3"
                                        }
                                        }
```

```
<strong>npm install</strong>
```

```
const express = require('express') const compression = require('compression') const app = express()

app.use(compression({ level: 9, threshold: 0 }))

app.get('/', (request, response, next) => {

    response.send(`

    <!DOCTYPE html> <html lang="en"> <head>

    <meta charset="utf-8"> <title>WebApp powered by ExpressJS</title> </head>

    <body>

    <section role="application"> <h1>Hello! this page is compressed!</h1> </section> </body>

    </html>

    `)

    console.log(request.acceptsEncodings()) })

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )
```

6. Save the file
7. Open a terminal and run:

    ```
    node compress-site.js
    ```

8. In your browser, navigate to:

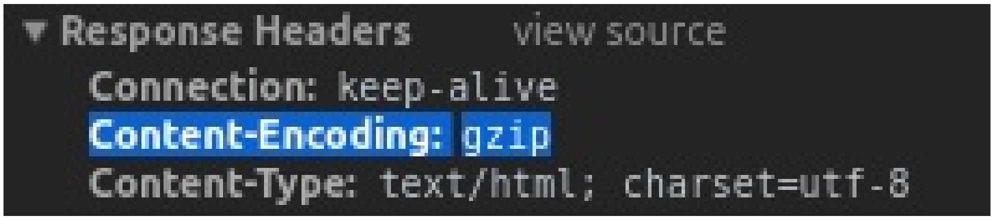
    ```
    http://localhost:1337/
    ```

How it works...

The output of the Terminal will show the content encoding mechanism that the client (for example web browser) supports. It may look something like this: **['gzip', 'deflate', 'sdch', 'br', 'identity']**

The content encoding mechanism sent by the client is used by `compression` internally to know if compression is supported. If compression is not supported, then the response body is not compressed.

If opening Chrome Dev Tools or similar and analyzing the request made, the `Content-Encoding` header that was sent by the server indicates the kind of content encoding mechanism used by `compression`.



```
▼ Response Headers      view source
    Connection: keep-alive
    Content-Encoding: gzip
    Content-Type: text/html; charset=utf-8
```

Chrome Dev Tools | Network Tab displaying Response Headers

The `compression` library sets the `Content-Encoding` header to the encoding mechanism used for compressing the response body.

> *The `threshold` option is set by default to 1 KB which means that if the response size is below the number of bytes specified, then it is not compressed. Set it to 0 or `false` to compress the response even when the size is below 1 KB*

Using an HTTP request logger

As previously seen, writing a request logger is simple. However, writing our own could take precious time. Luckily, there are several other alternatives out there. For example, a very popular HTTP request logger widely used is morgan `https://expressjs.com/en/resources/middleware/morgan.html`.

morgan is a configurable middleware function that takes two arguments `format` and `options` which are used to specify the format in which the logs are displayed and what kind of information needs to be displayed.

There are several predefined formats:

- `tiny`: Minimal output
- `short`: Same as tiny, including remote IP address
- `common`: Standard Apache log output
- `combined`: Standard Apache combined log output
- `dev`: Displays the same information as the tiny format does. However, the response statuses are colored.

Getting ready

Create a new `package.json` file with the following content:

```
{
    "dependencies": {
        "express": "4.16.3",
        "morgan": "1.9.0"
    }
}
```

Then, install the dependencies by opening a terminal and running:

```
npm install
```

```
const express = require('express') const morgan = require('morgan') const app = express()

app.use(morgan('dev'))

app.get('*', (request, response, next) => {

    response.send('Hello Morgan!') })

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )

<strong> node morgan-logger.js</strong>

<span class="URLPACKT">http://localhost:1337/</span> <span class="URLPACKT">http://localhost:1337/example</span><strong><br/></strong>
```

Managing and creating virtual domains

Managing virtual domains is really easy with ExpressJS. Imagine that you have two or more subdomains, and you want to serve two different web applications. However, you do not want to create a different web server application for each subdomain. In this kind of situation, ExpressJS allows developers to manage virtual domains within a single web server application using **vhost** `https://expressjs.com/en/resources/middleware/vhost.html`.

vhost is a configurable middleware function that accepts two arguments. The first one is the `hostname`. The second argument is the request handler which will be called when the `hostname` matches.

The `hostname` follows the same rules as route paths do. They can be either a string or a regular expression.

Getting ready

Create a new `package.json` file with the following content:

```
{
    "dependencies": {
        "express": "4.16.3",
        "vhost": "3.0.2"
    }
}
```

Then, install the dependencies by opening a terminal and running:

```
npm install
```

```
const express = require('express') const vhost = require('vhost') const app = express()

const app1 = express.Router() const app2 = express.Router()

app1.get('/', (request, response, next) => {

    response.send('This is the main application.') })

app2.get('/', (request, response, next) => {

    response.send('This is a second application.') })

app.use(vhost('localhost', app1)) app.use(vhost('second.localhost', app2))

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )
```

```
node virtual-domains.js
```

```
<span class="URLPACKT">http://localhost:1337/</span> <span class="URLPACKT">http://second.localhost:1337/</span><strong><br/></strong>
```

```
const express = require('express') const vhost = require('vhost') const app = express()

const users = express.Router() users.get('/', (request, response, next) => {

    const username = request .vhost[0]

    .split('-') .map(name => (

    name[0].toUpperCase() +

    name.slice(1) ))

    .join(' ') response.send(`Hello, ${username}`) })

app.use(vhost('*.localhost', users))

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )
```

```
node user-subdomains.js
```

```
<span class="URLPACKT"> http://john-smith.localhost:1337/</span> <span class="URLPACKT">http://jx-huang.localhost:1337/</span> <span class="URLPACKT">http://batman.localhost:1337/</span><strong><br/></strong>
```

Securing an ExpressJS web application with Helmet

Helmet allows to protect web server applications against common attacks, such as **cross-site scripting (XSS)**, insecure requests, and clickjacking.

Helmet is a collection of 12 middleware functions that allow you to set specific HTTP headers:

1. `Content Security Policy (CSP)`: This is an effective way to whitelist what kind of external resources are allowed in your web application, such as JavaScript, CSS, and images, for instance.
2. `Certificate Transparency`: This is a way of providing more transparency for certificates issued for a specific domain or specific domains `https://sites.google.com/a/chromium.org/dev/Home/chromium-security/certificate-transparency`.
3. `DNS Prefetch Control`: This tells the browser if it should perform domain name resolution (DNS) on resources that are not yet loaded, such as links.
4. `Frameguard`: This helps to prevent **clickjacking** by telling the browser not to allow your web application to be put inside an `iframe`.
5. `Hide Powered-By`: This simply hides the `X-Powered-By` header indicates not to display what technology powers the server. ExpressJS sets this header to `"Express"` by default.
6. `HTTP Public Key Pinning`: This helps to prevent **man-in-the-middle-**

attacks by pinning your web application's public keys to the `Public-Key-Pins`header.

7. `HTTP Strict Transport Security`: This tells the browser to strictly stick to the HTTPs version of your web application.
8. `IE No Open`: This prevents Internet Explorer from executing untrusted downloads, or HTML files, on the context of your site, thus preventing the injection of malicious scripts.
9. `No Cache`: This tells the browser to disable browser caching.
10. `Don't Sniff Mimetype`: This forces the browser to disable mime sniffing or guessing the content type of a served file.

11. `Referrer Policy`: The referrer headers provide the server with data regarding where the request was originated. It allows developers to disable it, or set a stricter policy for setting a `referrer` header.
12. `XSS Filter`: This prevents reflected cross-site scripting (XSS) attacks by setting the `X-XSS-Protection` header.

```
{
    "dependencies": {
    "body-parser": "1.18.2", "express": "4.16.3", "helmet": "3.12.0", "uuid":
"3.2.1"
}
}
```

<strong>npm install</strong>

```
const express = require('express') const helmet = require('helmet') const bodyParser = require('body-parser') const uuid = require('uuid/v1') const app = express()

const suid = uuid()

app.use(bodyParser.json({

   type: ['json', 'application/csp-report'], }))

app.use(helmet.contentSecurityPolicy({

   directives: {

   // By default do not allow unless whitelisted defaultSrc: [`'none'`], // Only allow scripts with this nonce scriptSrc: [`'nonce-${suid}'`], reportUri: '/csp-violation', }

   }))

app.post('/csp-violation', (request, response, next) => {

   const { body } = request if (body) {

   console.log('CSP Report Violation:') console.dir(body, { colors: true, depth: 5 }) }

   response.status(204).send() })

app.use(helmet.dnsPrefetchControl({ allow: false }))

app.use(helmet.frameguard({ action: 'deny' }))

app.use(helmet.hidePoweredBy({

   setTo: 'Django/1.2.1 SVN-13336', }))

app.use(helmet.ieNoOpen())

app.use(helmet.noSniff())
app.use(helmet.referrerPolicy({ policy: 'same-origin' }))
app.use(helmet.xssFilter())
app.get('/', (request, response, next) => {
   response.send(`
   <!DOCTYPE html> <html lang="en"> <head>
   <meta charset="utf-8"> <title>Web App</title> </head>
   <body>
   <span id="txtlog"></span> <img alt="Evil Picture" src="http://evil.com/pic.jpg"> <script>
   alert('This does not get executed!') </script>
   <script src="http://evil.com/evilstuff.js"></script> <script nonce="${suid}"> document.getElementById('txtlog') .innerText = 'Hello World!'
   </script>
   </body>
   </html>
   `)
   })
app.listen(
   1337,
   () => console.log('Web Server running on port 1337'), )
```

```
node secure-helmet.js
```

http://localhost:1337/

```
CSP Report Violation: {

    "csp-report": {

    "document-uri": "http://localhost:1337/", "referrer": "",

    "violated-directive": "img-src", "effective-directive": "img-src", "original-policy": "default-src 'none'; script-src <br/> '[nonce]'; report-uri /csp-violation", "disposition": "enforce", "blocked-uri": "http://evil.com/pic.jpg", "line-number": 9,

    "source-file": "http://localhost:1337/", "status-code": 200

                                        }

                                        }

    CSP Report Violation: {

    "csp-report": {

    "document-uri": "http://localhost:1337/", "referrer": "",

    "violated-directive": "script-src", "effective-directive": "script-src", "original-policy": "default-src 'none'; script-src <br/> '[nonce]'; report-uri /csp-violation", "disposition": "enforce", "blocked-uri": "inline", "line-number": 9,

    "status-code": 200

                                        }

                                        }

    CSP Report Violation: {

    "csp-report": {

    "document-uri": "http://localhost:1337/", "referrer": "",

    "violated-directive": "script-src", "effective-directive": "script-src", "original-
```

policy": "default-src 'none'; script-src <br/> '[nonce]'; report-uri /csp-violation", "disposition": "enforce", "blocked-uri": "http://evil.com/evilstuff.js", "status-code": 200

}

}

Using template engines

Template engines allow you to generate HTML code in a more convenient way. Templates or views can be written in any format, interpreted by a template engine that will replace variables with other values, and finally transform to HTML.

A big list of template engines that work out of the box with ExpressJS, is available in the official website at `https://github.com/expressjs/express/wiki#template-engines`.

```
app.engine('...', (path, options, callback) => { ... }); app.set('views', './');
app.set('view engine', '...');
```

```
                                        {

  "dependencies": {

  "express": "4.16.3"

                                        }

                                        }
```

```
<strong>npm install</strong>
```

```
<!DOCTYPE html> <html lang="en"> <head>

  <meta charset="utf-8"> <title>Using Template Engines</title> </head>

  <body>

  <section role="application"> <h1>%title%</h1> <p>%description%</p>
</section> </body>

  </html>

const express = require('express') const fs = require('fs') const app = express()

app.engine('tpl', (filepath, options, callback) => {

  fs.readFile(filepath, (err, data) => {

  if (err) {

  return callback(err) }

  const content = data .toString()

  .replace(/%[a-z]+%/gi, (match) => {

  const variable = match.replace(/%/g, ") if (Reflect.has(options, variable)) {

  return options[variable]

                                        }

  return match

  })

  return callback(null, content) })

  })

app.set('views', './views')
app.set('view engine', 'tpl')

app.get('/', (request, response, next) => {

  response.render('home', {

  title: 'Hello',

  description: 'World!', })

  })

app.listen(

  1337,

  () => console.log('Web Server running on port 1337'), )
```

<strong>node my-template-engine.js</strong>

<span class="URLPACKT"> http://localhost:1337/</span><strong><br/></strong>

The template engine we just have wrote doesn't escape HTML characters. That means, you should be careful if replacing those properties with data gotten from the client because it may be vulnerable to XSS attacks. You may want to use a template engine from the official ExpressJS website that is safer.

Debugging your ExpressJS web application

Debugging information on ExpressJS about all of the cycle of a web application is something simple. ExpressJS uses the **debug** NPM module internally to log information. Unlike `console.log`, **debug** logs can easily be disabled on production mode.

Getting ready

In this recipe, you will see how to debug your ExpressJS web application. Before you start, create a new `package.json` file with the following content:

```
{
    "dependencies": {
        "debug": "3.1.0",
        "express": "4.16.3"
    }
}
```

Then, install the dependencies by opening a terminal and running:

```
npm install
```

```
const express = require('express') const app = express()

app.get('*', (request, response, next) => {

  response.send('Hello there!') })

app.listen(

  1337, () => console.log('Web Server running on port 1337'), )

<strong> set DEBUG=express:* node debugging.js</strong>
```

8. On Linux or MacOS:

   ```
   DEBUG=express:* node debugging.js
   ```

9. In your web browser, navigate to:

   ```
   http://localhost:1337/
   ```

10. Observe your terminal's output for logs

How it works...

The `DEBUG` environment variable is used to tell the **debug** module which parts of the ExpressJS application to debug. In our previously written code, `express:*` tells the debug module to log everything related to the express application.

We could use `DEBUG=express:router` to displays logs related to the Router or routing of ExpressJS.

```
const express = require('express') const app = express()
    const debug = require('debug')('myapp') app.get('*', (request, response, next) => {
    debug('Request:', request.originalUrl) response.send('Hello there!') })
    app.listen(
    1337,
    () => console.log('Web Server running on port 1337'), )
```

```
<strong>set DEBUG=myapp node myapp.js</strong>
```

```
<strong> DEBUG=myapp node myapp.js</strong>
```

```
Web Server running on port 1337
    myapp Request: / +0ms
```

```
<strong>set DEBUG=myapp,express:* node myapp.js</strong>
```

```
<strong>DEBUG=myapp,express:* node myapp.js</strong>
```

Building a RESTful API

In this chapter, we will cover the following recipes:

- CRUD operations using ExpressJS' route methods
- CRUD operations with Mongoose
- Using Mongoose query builders
- Defining document instance methods
- Defining static model methods
- Writing middleware functions for Mongoose
- Writing custom validators for Mongoose's schemas
- Building a RESTful API to manage users with ExpressJS and Mongoose

Technical requirements

You will be required to have an IDE, Visual Studio Code, Node.js and MongoDB. You will also need to install Git, in order use the Git repository of this book.

The code files of this chapter can be found on GitHub:
`https://github.com/PacktPublishing/MERN-Quick-Start-Guide/tree/master/Chapter03`

Check out the following video to see the code in action:
`https://goo.gl/73dE6u`

Introduction

Representation State Transfer (**REST**) is an architectural style that the web was built on. More specifically, the HTTP 1.1 protocol standards were built using the REST principles. REST provides a representation of a resource. **URLs** (**Uniform Resource Locator**) are used to define the location of a resource and tell the browser where it is located.

A RESTful API is a web service API that adheres to this architectural style.

The most commonly used HTTP verbs or methods are: `POST`, `GET`, `PUT`, and `DELETE`. These methods are the basis for persistent storage and are known as **CRUD** operations (**Create, Read, Update, and Delete**).

In this chapter, the recipes will be focused on building a RESTful API using the REST architectural style with ExpressJS and Mongoose.

```
/* Add a new user */

   app.post('/users', (request, response, next) => { }) /* Get user */

   app.get('users:id', (request, response, next) => { }) /* Update a user */

   app.put('users:id', (request, response, next) => { }) /* Delete a user */

   app.delete('users:id', (request, response, next) => { })
```

It's good to think of every URL as a noun and because of that a verb can act on it. In fact, HTTP methods are also known as HTTP verbs. If we think about them as verbs, when a request is made to our RESTful API, they can be understood as:

- Post a user
- Get a user
- Update a user
- Delete a user.

In the **MVC** (**model-view-controller**) architectural pattern, controllers are in charge of transforming input to something a model or view can understand. In other words, they transform input into actions or commands and sends them to the model or view to update accordingly.

ExpressJS' route methods usually act as controllers. They just get input from a client such as a request from the browser, and then converts the input to actions. These actions are then sent to the model, which is the business logic of your application, such as a mongoose model, or to a view (a ReactJS client application) to update.

```
                                        {
  "dependencies": {
  "express": "4.16.3", "node-fetch": "2.1.1", "uuid": "3.2.1"
                                        }
                                        }
```

<strong> npm install</strong>

```
const express = require('express') const uuid = require('uuid') const app = express()

let data = [

  { id: uuid(), name: 'Bob' }, { id: uuid(), name: 'Alice' }, ]

const usr = {

  create(name) {

  const user = { id: uuid(), name }

  data.push(user) return user

  },

  read(id) {

  if (id === 'all') return data return data.find(user => user.id === id) },

  update(id, name) {

  const user = data.find(usr => usr.id === id) if (!user) return { status: 'User not found' }

  user.name = name return user

  },

  delete(id) {

  data = data.filter(user => user.id !== id) return { status: 'deleted', id }

                                }

                                }

app.post('users:name', (req, res) => {
  res.status(201).json(usr.create(req.params.name)) })
app.get('users:id', (req, res) => {
  res.status(200).json(usr.read(req.params.id)) })
app.put('users:id=:name', (req, res) => {
  res.status(200).json(usr.update(
  req.params.id, req.params.name, ))
  })
app.delete('users:id', (req, res) => {
  res.status(200).json(usr.delete(req.params.id)) })
app.listen(
  1337,
  () => console.log('Web Server running on port 1337'), )
<strong> node restfulapi.js</strong>
```

```
const fetch = require('node-fetch') const r = async (url, method) => (

    await fetch(`http://localhost:1337${url}`, { method }) .then(r => r.json())

    )

    const log = (...obj) => (

    obj.forEach(o => console.dir(o, { colors: true })) )

    async function test() {

    const users = await r('usersall', 'get') const { id } = users[0]

    const getById = await r(`users${id}`, 'get') const updateById = await
r(`users${id}=John`, 'put') const deleteById = await r(`users${id}`, 'delete')
const addUsr = await r(`usersSmith`, 'post') const getAll = await r('usersall',
'get') log('[GET] users:', users)

    log(`[GET] a user with id="${id}":`, getById) log(`[PUT] a user with
id="${id}":`, updateById) log(`[POST] a new user:`, addUsr) log(`[DELETE] a
user with id="${id}":`, deleteById) log(`[GET] users:`, getAll) }

    test()

<strong>node test-restfulapi.js</strong>
```

<strong>r(`/users/Smith`, 'post')</strong>

CRUD operations with Mongoose

One of many reasons why developers opt to use Mongoose instead of the official MongoDB driver for Node.js is that it allows you to create data structures with ease by using schemas and also because of the built-in validation. MongoDB is a document-oriented database, meaning that the structure of the documents varies.

In the MVC architectural pattern, Mongoose is often used for creating models that shape or define data structures.

This is how a typical Mongoose schema would be defined and then compiled into a model:

```
const PersonSchema = new Schema({
          firstName: String,
          lastName: String,
      })
      const Person = connection.model('Person', PersonSchema)
```

Model names should be in singular since Mongoose will make them plural and lowercase them when saving the collection to the database. For instance, if the model is named "User", it will be saved as a collection named "users" in MongoDB. Mongoose includes an internal dictionary to pluralize common names. That means if your model's name is a common name, such as "Person", it will be saved in MongoDB as a collection named "people".

Mongoose allows the following types to define a schema's path or document structure:

- String
- Number

- Boolean
- Array
- Date
- Buffer
- Mixed
- Objectid
- Decimal128

A schema type can be declared by using directly the global constructor function for `String`, `Number`, `Boolean`, `Buffer`, and `Date`:

```
const { Schema} = require('mongoose')
      const PersonSchema = new Schema({
          name: String,
          age: Number,
          isSingle: Boolean,
          birthday: Date,
          description: Buffer,
      })
```

These schema types are also available under an object called `SchemaTypes` in the exported `mongoose` object:

```
const { Schema, SchemaTypes } = require('mongoose')
      const PersonSchema = new Schema({
          name: SchemaTypes.String,
          age: SchemaTypes.Number,
          isSingle: SchemaTypes.Boolean,
          birthday: SchemaTypes.Date,
          description: SchemaTypes.Buffer,
      })
```

Schema types can be declared using an object as a property that gives you more control over the specific schema type. Take the following code, for example:

```
const { Schema } = require('mongoose')
      const PersonSchema = new Schema({
          name: { type: String, required: true, default: 'Unknown' },
          age: { type: Number, min: 18, max: 80, required: true },
          isSingle: { type: Boolean },
          birthday: { type: Date, required: true },
          description: { type: Buffer },
      })
```

Schema types can also be arrays. For instance, if we want a field to define what are the things the user likes in an array of strings, you could use this code:

```
const PersonSchema = new Schema({
          name: String,
          age: Number,
          likes: [String],
      })
```

To learn more about schema types, visit the official Mongoose documentation website: `http://mongoosejs.com/docs/schematypes.html`.

```
                                        {
  "dependencies": {
  "mongoose": "5.0.11"
                                        }
                                        }
```

<strong> npm install</strong>

```
const mongoose = require('mongoose') const { connection, Schema } = mongoose mongoose.connect(
    'mongodb://localhost:27017/test'
    ).catch(console.error)
const UserSchema = new Schema({
    firstName: String, lastName: String, likes: [String], })
const User = mongoose.model('User', UserSchema)
const addUser = (firstName, lastName) => new User({
    firstName,
    lastName,
    }).save()
const getUser = (id) => User.findById(id)
const removeUser = (id) => User.remove({ id })
connection.once('connected', async () => {
    try {
    // Create
    const newUser = await addUser('John', 'Smith') // Read
    const user = await getUser(newUser.id) // Update
    user.firstName = 'Jonny'
    user.lastName = 'Smithy'
    user.likes = [
    'cooking',

    'watching movies', 'ice cream',

                                 ]

    await user.save() console.log(JSON.stringify(user, null, 4)) // Delete

    await removeUser(user.id) } catch (error) {

    console.dir(error.message, { colors: true }) } finally {

    await connection.close() }

    })
```

<strong>node mongoose-models.js</strong>

```
                              {

 "likes": [

 "cooking",

 "watching movies", "ice cream"

 ],

 "_id": "[some id]", "firstName": "Jonny", "lastName": "Smithy", "__v": 1

                              }
```

See also

- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing NPM Packages*
- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing MongoDB*

```
const user = await User.findOne({

   firstName: 'Jonh', age: { $lte: 30 }, }, (error, document) => {

   if (error) return console.log(error) console.log(document) })

const user = User.findOne({

   firstName: 'Jonh', age: { $lte: 30 }, })

   user.exec((error, document) => {

   if (error) return console.log(error) console.log(document) })

try {

   const user = await User.findOne({

   firstName: 'Jonh', age: { $lte: 30 }, })

   console.log(user) } catch (error) {

   console.log(error) }

try {

   const user = await User.findOne() .where('firstName', 'John') .where('age').lte(30) console.log(user) } catch (error) {

   console.log(error) }
```

```
{
  "dependencies": {
  "mongoose": "5.0.11"
}
}
```

<strong> npm install</strong>

```
const mongoose = require('mongoose') const { connection, Schema } = mongoose mongoose.connect(

    'mongodb://localhost:27017/test'

    ).catch(console.error)

const UserSchema = new Schema({

    firstName: String, lastName: String,

    age: Number,

    })

const User = mongoose.model('User', UserSchema)

connection.once('connected', async () => {

    try {

    const user = await new User({

    firstName: 'John', lastName: 'Snow',

    age: 30,

    }).save()

    const findUser = await User.findOne() .where('firstName').equals('John') .where('age').lte(30) .select('lastName age') console.log(JSON.stringify(findUser, null, 4)) await user.remove() } catch (error) {

    console.dir(error.message, { colors: true }) } finally {

    await connection.close() }

    })

<strong>node chaining-queries.js</strong>
```

See also

- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing NPM Packages*
- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing MongoDB*

Defining document instance methods

Documents have their own built-in instance methods such as `save` and `remove`. However, we can write our own instance methods as well.

Documents are instances of models. They can be explicitly created: const instance = new Model()

Or they can be the result of a query:

```
Model.findOne([conditions]).then((instance) => {})
```

Document instance methods are defined in the schema. All schemas have a method called `method` which allows you to define custom instance methods.

```
{
  "dependencies": {
  "mongoose": "5.0.11"
}
}
```

```
<strong>npm install</strong>
```

```
const mongooconst mongoose = require('mongoose') const { connection,
Schema } = mongoose mongoose.connect(

   'mongodb://localhost:27017/test'

   ).catch(console.error)

const UserSchema = new Schema({

   firstName: String,

   lastName: String,

   likes: [String],

   })

UserSchema.method('setFullName', function setFullName(v) {

   const fullName = String(v).split(' ') this.lastName = fullName[0] || "

   this.firstName = fullName[1] || "

   })

UserSchema.method('getFullName', function getFullName() {

   return `${this.lastName} ${this.firstName}`

   })

UserSchema.method('loves', function loves(stuff) {

   this.likes.push(stuff) })

UserSchema.method('dislikes', function dislikes(stuff) {

   this.likes = this.likes.filter(str => str !== stuff) })

const User = mongoose.model('User', UserSchema)
```

```
connection.once('connected', async () => {

   try {

   // Create

   const user = new User() user.setFullName('Huang Jingxuan')
user.loves('kitties') user.loves('strawberries') user.loves('snakes')

   await user.save()

   // Update

   const person = await User.findOne() .where('firstName', 'Jingxuan')
.where('likes').in(['snakes', 'kitties']) person.dislikes('snakes') await person.save()

   // Display

   console.log(person.getFullName()) console.log(JSON.stringify(person, null,
4)) // Remove

   await user.remove()

   } catch (error) {

   console.dir(error.message, { colors: true }) } finally {

   await connection.close() }

   })
```

```
<strong>node document-methods.js</strong>
```

There's more...

Document instance methods can also be defined using the `methods`, schema property. For instance:

```
UserSchema.methods.setFullName = function setFullName(v) {
    const fullName = String(v).split(' ')
    this.lastName = fullName[0] || ''
    this.firstName = fullName[1] || ''
}
```

See also

- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing NPM Packages*
- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing MongoDB*

Defining static model methods

Models have built-in static methods such as `find`, `findOne`, and `findOneAndRemove`. Mongoose allow us to define custom static model methods as well. Static model methods are defined in the schema in the same way as document instance methods are.

Schemas have a property called `statics` which is an object. All the methods defined inside the `statics` object are passed to the model. Static model methods can also be defined by calling the `static` schema method.

```
                                {

  "dependencies": {

  "mongoose": "5.0.11"

                                }

                                }
```

<strong>npm install</strong>

```
const mongoose = require('mongoose') const { connection, Schema } =
mongoose mongoose.connect(

    'mongodb://localhost:27017/test'

    ).catch(console.error)

const UsrSchm = new Schema({

    firstName: String,

    lastName: String,

    likes: [String],

    })

UsrSchm.static('getByFullName', function getByFullName(v) {

    const fullName = String(v).split(' ') const lastName = fullName[0] || "

    const firstName = fullName[1] || "

    return this.findOne() .where('firstName').equals(firstName)
.where('lastName').equals(lastName) })

const User = mongoose.model('User', UsrSchm)

connection.once('connected', async () => {

    try {

    // Create

    const user = new User({

    firstName: 'Jingxuan', lastName: 'Huang',

    likes: ['kitties', 'strawberries'], })
    await user.save()

    // Read

    const person = await User.getByFullName(

    'Huang Jingxuan'

    )

    console.log(JSON.stringify(person, null, 4)) await person.remove() await connection.close() } catch (error) {

    console.log(error.message) }

    })
```

```
<strong>node static-methods.js</strong>
```

There's more...

Static model methods can also be defined using the `statics` schema property. For instance:

```
UsrSchm.statics.getByFullName = function getByFullName(v) {
    const fullName = String(v).split(' ')
    const lastName = fullName[0] || ''
    const firstName = fullName[1] || ''
    return this.findOne()
        .where('firstName').equals(firstName)
        .where('lastName').equals(lastName)
}
```

See also

- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing NPM Packages*
- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing MongoDB*

Writing middleware functions for Mongoose

Middleware functions in Mongoose are also called `hooks`. There are two types of hooks `pre hooks` and `post hooks`.

The difference, between `pre hooks` and post hooks, is pretty simple. `pre hooks` are called before a method is called, and `post hooks` are called after. For example:

```
const UserSchema = new Schema({
          firstName: String,
          lastName: String,
          fullName: String,
      })
      UserSchema.pre('save', async function preSave() {
          this.fullName = `${this.lastName} ${this.firstName}`
      })
      UserSchema.post('save', async function postSave(doc) {
          console.log(`New user created: ${doc.fullName}`)
      })
      const User = mongoose.model('User', UserSchema)
```

And later on, once the connection is made to the database, within an `async` function:

```
const user = new User({
          firstName: 'John',
          lastName: 'Smith',
      })
      await user.save()
```

Once the `save` method is called, the `pre hook` is executed first. After the document is saved, the `post hook` is then executed. In the previous example, it will display in the Terminal output the following text:

```
New user created: Smith John
```

There are four different types of middleware functions in Mongoose: document middleware, model middleware, aggregate middleware, and query middleware. All of them are defined on the schema level. The difference is, when the hooks are executed, the context of`this` refers to the document, model, the aggregation object, or the query object.

All types of middleware support pre and post hooks

```
{
  "dependencies": {
  "mongoose": "5.0.11"
}
}
```

<strong> npm install</strong>

How to do it...

In document middleware functions, the context of `this` refers to the document. A document has the following built-in methods and you can define `hooks` for them:

- `init`: This is called internally, immediately after a document is returned from MongoDB. Mongoose uses setters for marking the document as modified or which fields of the document were modified. `init` initializes the document without setters.
- `validate`: This executes built-in and custom set validation rules for the document.
- `save`: This saves the document in the database.
- `remove`: This removes the document from the database.

```
const mongoose = require('mongoose') const { connection, Schema } = mongoose mongoose.connect(
    'mongodb://localhost:27017/test'
    ).catch(console.error)
const UserSchema = new Schema({
    firstName: { type: String, required: true }, lastName: { type: String, required: true }, })
UserSchema.pre('init', async function preInit() {
    console.log('A document is going to be initialized.') })
    UserSchema.post('init', async function postInit() {
    console.log('A document was initialized.') })
UserSchema.pre('validate', async function preValidate() {
    console.log('A document is going to be validated.') })
    UserSchema.post('validate', async function postValidate() {
    console.log('All validation rules were executed.') })
UserSchema.pre('save', async function preSave() {
    console.log('Preparing to save the document') })
    UserSchema.post('save', async function postSave() {
    console.log(`A doc was saved id=${this.id}`) })
UserSchema.pre('remove', async function preRemove() {
    console.log(`Doc with id=${this.id} will be removed`) })
    UserSchema.post('remove', async function postRemove() {

    console.log(`Doc with id=${this.id} was removed`) })

const User = mongoose.model('User', UserSchema)

connection.once('connected', async () => {

    try {

    const user = new User({

    firstName: 'John',

    lastName: 'Smith',

    })

    await user.save()

    await User.findById(user.id) await user.remove()

    await connection.close()

    } catch (error) {

    await connection.close()

    console.dir(error.message, { colors: true }) }

    })
```

```
<strong> node document-middleware.js</strong>

A document is going to be validated.

    All validation rules were executed.

    Preparing to save the document A doc was saved id=[ID]

    A document is going to be initialized.
    A document was initialized.

    Doc with id=[ID] will be removed Doc with id=[ID] was removed
```

```
UserSchema.pre('save', async function preSave() {

    this.firstName = this.firstName.toUpperCase() this.lastName = this.lastName.toUpperCase() })
```

```
UserSchema.pre('save', async function preSave() {

    throw new Error('Doc was prevented from being saved.') })
```

Query middleware functions are defined exactly as document middleware functions are. However, the context of `this` doesn't not refer to the document but instead to the query object. Query middleware functions are only supported in the following model and query functions:

- `count`: Counts the number of document that match a specific query condition
- `find`: Returns an array of documents that match a specific query condition
- `findOne`: Return a document that matches a specific query condition
- `findOneAndRemove`: Similar to `findOne`. However, after a document is found, it is removed
- `findOneAndUpdate`: Similar to `findOne` but once a document matching a specific query condition is found, the document can also be updated
- `update`: Update one or more documents that match a certain query condition

```
const mongoose = require('mongoose') const { connection, Schema } = mongoose mongoose.connect(

    'mongodb://localhost:27017/test'

    ).catch(console.error)

const UserSchema = new Schema({

    firstName: { type: String, required: true }, lastName: { type: String, required: true }, })

UserSchema.pre('count', async function preCount() {

    console.log(

    `Preparing to count document with this criteria: ${JSON.stringify(this._conditions)}`

    )

    })

    UserSchema.post('count', async function postCount(count) {

    console.log(`Counted ${count} documents that coincide`) })

    UserSchema.pre('find', async function preFind() {

    console.log(

    `Preparing to find all documents with criteria: ${JSON.stringify(this._conditions)}`

    )

    })

    UserSchema.post('find', async function postFind(docs) {
```

```
    console.log(`Found ${docs.length} documents`) })
    UserSchema.pre('findOne', async function prefOne() {
    console.log(
    `Preparing to find one document with criteria: ${JSON.stringify(this._conditions)}`
    )
    })
    UserSchema.post('findOne', async function postfOne(doc) {
    console.log(`Found 1 document:`, JSON.stringify(doc)) })
    UserSchema.pre('update', async function preUpdate() {
    console.log(
    `Preparing to update all documents with criteria: ${JSON.stringify(this._conditions)}`
    )
    })
    UserSchema.post('update', async function postUpdate(r) {
    console.log(`${r.result.ok} document(s) were updated`) })
const User = mongoose.model('User', UserSchema)
connection.once('connected', async () => {
    try {
    const user = new User({
    firstName: 'John',
    lastName: 'Smith',

    })

    await user.save()

    await User

    .where('firstName').equals('John') .update({ lastName: 'Anderson' }) await User

    .findOne()

    .select(['lastName'])

    .where('firstName').equals('John') await User

    .find()

    .where('firstName').equals('John') await User

    .where('firstName').equals('Neo') .count()

    await user.remove()

    } catch (error) {

    console.dir(error, { colors: true }) } finally {

    await connection.close() }

    })
```

```
<strong> node query-middleware.js</strong>

Preparing to update all documents with criteria: {"firstName":"John"}

    1 document(s) were updated Preparing to find one document with criteria: {"firstName":"John"}

    Found 1 document: {"_id":"[ID]","lastName":"Anderson"}
```

```
Preparing to find all documents with criteria: {"firstName":"John"}

Found 1 documents

Preparing to count document with this criteria: {"firstName":"Neo"}

Counted 0 documents that coincide
```

Finally, there is only one model instance method that supports hooks:

- `insertMany`: This validates an array of documents and saves them in the database only if all the documents in the array passed validation

As you probably guessed, a model middleware function is also defined in the same way as query middleware methods and document middleware methods are.

```
const mongoose = require('mongoose') const { connection, Schema } = mongoose mongoose.connect(

    'mongodb://localhost:27017/test'

    ).catch(console.error)

const UserSchema = new Schema({

    firstName: { type: String, required: true }, lastName: { type: String, required: true }, })

UserSchema.pre('insertMany', async function prMany() {

    console.log('Preparing docs...') })

    UserSchema.post('insertMany', async function psMany(docs) {

    console.log('The following docs were created:n', docs) })

const User = mongoose.model('User', UserSchema)

connection.once('connected', async () => {

    try {

    await User.insertMany([

    { firstName: 'Leo', lastName: 'Smith' }, { firstName: 'Neo', lastName: 'Jackson' }, ])

    } catch (error) {

    console.dir(error, { colors: true }) } finally {

    await connection.close() }

    })
```

```
<strong> node query-middleware.js</strong>
```

```
Preparing docs...

    The following documents were created: [ { firstName: 'Leo', lastName:
'Smith', _id: [id] }, { firstName: 'Neo', lastName: 'Jackson', _id: [id] } ]
```

There's more...

It's useful to mark the fields as required to avoid having "null" values being saved in the database. An alternative is to set default values for the fields that are not explicitly defined in the creation time of the document. For instance:

```
const UserSchema = new Schema({
          name: {
              type: string,
              required: true,
              default: 'unknown',
          }
      })
```

When a new document is created, if no path or property `name` is assigned, then it will assign the default value defined in the schema type option `default`.

> *The schema type `default` option can also be a function. The value returned by calling this function is assigned as the default value.*

Sub-documents or arrays can also be created by just adding brackets when defining the schema type. For instance:

```
const WishBoxSchema = new Schema({
          wishes: {
              type: [String],
              required: true,
              default: [
                  'To be a snowman',
                  'To be a string',
                  'To be an example',
              ],
          },
      })
```

When a new document is created, it will expect an array of strings in the `wishes` property or path. If no array is provided, then the default values will be used to create the document.

See also

- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing NPM Packages*
- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing MongoDB*

```
path: { type: String, required: true }
   path: { type: String, required: [true, 'Custom error message'] }
   path: { type: String, required: () => true }
gender: {
   type: SchemaTypes.String,
   enum: ['male', 'female', 'other'],
                                                  }
website: {
   type: SchemaTypes.String,
   match: ^www,
                                                  }
name: {
   type: SchemaTypes.String,
   minlength: 5,
   maxlength: 20,
                                                  }
age: {
   type: String,
   min: 18,
   max: 100,
                                       }
nickname: {
   type: String,
   validate: {
   validator: function validator(value) {
   return ^[a-zA-Z-]$.test(value)
   },
   message: '{VALUE} is not a valid nickname.',
   },
                                       }
```

```
                                                {
   "dependencies": {
   "mongoose": "5.0.11"
                                                }
                                                }
```

```
<strong> npm install</strong>
```

```
const mongoose = require('mongoose') const { connection, Schema } = mongoose mongoose.connect(
    'mongodb://localhost:27017/test'
    ).catch(console.error)
const UserSchema = new Schema({
    username: {
    type: String,
    minlength: 6,
    maxlength: 20,
    required: [true, 'user is required'], validate: {
    message: '{VALUE} is not a valid username', validator: (val) => ^[a-zA-Z]+$.test(val), },
    },
    })
const User = mongoose.model('User', UserSchema)
connection.once('connected', async () => {
    try {
    const user = new User() let errors = null // username field is not defined errors = user.validateSync() console.dir(errors.errors['username'].message) // username contains less than 6 characters user.username = 'Smith'
    errors = user.validateSync() console.dir(errors.errors['username'].message) // RegExp matching user.username = 'Smith_9876'
    errors = user.validateSync() console.dir(errors.errors['username'].message) }
catch (error) {
    console.dir(error, { colors: true }) } finally {
    await connection.close() }
    })
```

```
<strong> node custom-validation.js</strong>
'user is required'
    'Path `username` (`Smith`) is shorter than the minimum allowed <br/> length (6).'
    'Smith_9876 is not a valid username'
```

See also

- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing NPM Packages*
- `Chapter 1`, *Introduction to the MERN Stack*, section *Installing MongoDB*

Building a RESTful API to manage users with ExpressJS and Mongoose

In this recipe, you will build a RESTful API that will allow the creation of new users, log in, display user information, and delete a user's profile. Furthermore, you will learn how to build a NodeJS REPL with a client API that you can use to interact with your server's RESTful API.

A **REPL** (**Read-Eval-Print Loop**) is like an interactive shell where you can execute commands one after another. For instance, the Node.js REPL can be opened by running this command in your terminal: **node -i**

Here, the `-i` flag stands for interactive. Now, you can execute the JavaScript code that gets evaluated piece by piece in a new context.

```
{
  "dependencies": {
  "body-parser": "1.18.2", "connect-mongo": "2.0.1", "express": "4.16.3", "express-session": "1.15.6", "mongoose": "5.0.11", "node-fetch": "2.1.2"
}
}
```

<strong>npm install</strong>

```
const mongoose = require('mongoose') const express = require('express') const
session = require('express-session') const bodyParser = require('body-parser')
const MongoStore = require('connect-mongo')(session) const api =
require('./api/controller') const app = express()

    const db = mongoose.connect(

    'mongodb://localhost:27017/test'

    ).then(conn => conn).catch(console.error)

app.use(bodyParser.json())

app.use((request, response, next) => {<br/> Promise.resolve(db).then(<br/>
(connection, err) => (<br/> typeof connection !== 'undefined'<br/> ? next()<br/>
: next(new Error('MongoError'))<br/> )<br/> )<br/> })

app.use(session({

    secret: 'MERN Cookbook Secrets', resave: false,

    saveUninitialized: true, store: new MongoStore({

    collection: 'sessions', mongooseConnection: mongoose.connection, }),

    }))

app.use('/users', api)

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )

const { connection, Schema } = require('mongoose') const crypto =
require('crypto')

const UserSchema = new Schema({
    username: {

    type: String,

    minlength: 4,

    maxlength: 20,

    required: [true, 'username field is required.'], validate: {

    validator: function (value) {

    return /^[a-zA-Z]+$/.test(value) },

    message: '{VALUE} is not a valid username.', },

    },

    password: String,

    })

UserSchema.static('login', async function(usr, pwd) {

    const hash = crypto.createHash('sha256') .update(String(pwd))

    const user = await this.findOne() .where('username').equals(usr)
.where('password').equals(hash.digest('hex')) if (!user) throw new
Error('Incorrect credentials.') delete user.password

    return user

    })

UserSchema.static('signup', async function(usr, pwd) {

    if (pwd.length < 6) {

    throw new Error('Pwd must have more than 6 chars') }

    const hash = crypto.createHash('sha256').update(pwd) const exist = await
```

```
this.findOne() .where('username')

    .equals(usr)

    if (exist) throw new Error('Username already exists.') const user = this.create({

    username: usr,

    password: hash.digest('hex'), })

    return user

    })

UserSchema.method('changePass', async function(pwd) {

    if (pwd.length < 6) {

    throw new Error('Pwd must have more than 6 chars') }

    const hash = crypto.createHash('sha256').update(pwd) this.password = hash.digest('hex') return this.save()

    })

module.exports = connection.model('User', UserSchema)

const express = require('express') const User = require('./model') const api = express.Router()

const isLogged = ({ session }, res, next) => {

    if (!session.user) res.status(403).json({

    status: 'You are not logged in!', })

    else next()

}
```

```
    const isNotLogged = ({ session }, res, next) => {

    if (session.user) res.status(403).json({

    status: 'You are logged in already!', })

    else next()

                                              }

api.post('/login', isNotLogged, async (req, res) => {

    try {

    const { session, body } = req const { username, password } = body const user = await User.login(username, password) session.user = {

    id: user.id,

    username: user.username, }

    session.save(() => {

    res.status(200).json({ status: 'Welcome!'}) })

    } catch (error) {

    res.status(403).json({ error: error.message }) }

    })

api.post('/logout', isLogged, (req, res) => {

    req.session.destroy()

    res.status(200).send({ status: 'Bye bye!' }) })

api.post('/signup', async (req, res) => {

    try {
```

```
    const { session, body } = req const { username, password } = body const user = await User.signup(username, password) res.status(201).json({ status: 'Created!'}) } catch (error) {

    res.status(403).json({ error: error.message }) }

    })

api.get('/profile', isLogged, (req, res) => {

    const { user } = req.session res.status(200).json({ user }) })

api.put('/changepass', isLogged, async (req, res) => {

    try {

    const { session, body } = req const { password } = body const { _id } = session.user const user = await User.findOne({ _id }) if (user) {

    await user.changePass(password) res.status(200).json({ status: 'Pwd changed' }) } else {

    res.status(403).json({ status: user }) }

    } catch (error) {

    res.status(403).json({ error: error.message }) }

    })

api.delete('/delete', isLogged, async (req, res) => {

    try {

    const { _id } = req.session.user const user = await User.findOne({ _id }) await user.remove()

    req.session.destroy((err) => {

    if (err) throw new Error(err) res.status(200).json({ status: 'Deleted!'}) })
```

```
  } catch (error) {
  res.status(403).json({ error: error.message }) }
  })
module.exports = api
```

11. Save the file

```
const repl = require('repl') const util = require('util') const vm = require('vm')
const fetch = require('node-fetch') const { Headers } = fetch

let cookie = null

const query = (path, ops) => {

    return fetch(`http://localhost:1337/users/${path}`, {

    method: ops.method, body: ops.body,

    credentials: 'include', body: JSON.stringify(ops.body), headers: new Headers({

    ...(ops.headers || {}), cookie,

    Accept: 'application/json', 'Content-Type': 'application/json', }),

    }).then(async (r) => {

    cookie = r.headers.get('set-cookie') || cookie return {

    data: await r.json(), status: r.status,

                                                            }

    }).catch(error => error) }

const signup = (username, password) => query('/signup', {

    method: 'POST',

    body: { username, password }, })

const login = (username, password) => query('/login', {

    method: 'POST',

    body: { username, password }, })
```

```
const logout = () => query('/logout', {
    method: 'POST',
    })
const getProfile = () => query('/profile', {
    method: 'GET',
    })
const changePassword = (password) => query('/changepass', {
    method: 'PUT',
    body: { password }, })
const deleteProfile = () => query('/delete', {
    method: 'DELETE',
    })
const replServer = repl.start({
    prompt: '> ',
    ignoreUndefined: true, async eval(cmd, context, filename, callback) {
    const script = new vm.Script(cmd) const is_raw = process.stdin.isRaw process.stdin.setRawMode(false) try {
    const res = await Promise.resolve(
    script.runInContext(context, {
    displayErrors: false, breakOnSigint: true, })
    )
```

```
                                                }

    callback(null, res) } catch (error) {

    callback(error)

    } finally {

    process.stdin.setRawMode(is_raw) }

    },

    writer(output) {

    return util.inspect(output, {

    breakLength: process.stdout.columns, colors: true,

    compact: false,

    })

                                                }

    })

replServer.context.api = {

    signup,

    login,

    logout,

    getProfile,

    changePassword,

    deleteProfile,

                                                }
```

```
<strong>node server.js</strong>
```

```
<strong>node client-repl.js</strong>

api.signup('John', 'zxcvbnm') api.login('John', 'zxcvbnm') api.getProfile()

  api.changePassword('newPwd') api.logout()

  api.login('John', 'incorrectPwd')
```

How it works...

Your RESTful API server will accept requests for the following paths:

- `POST/users/login`: If a username does not exist in the `users` collection in MongoDB, an error message is sent to the client. Otherwise, it returns a welcome message.
- `POST/users/logout`: This destroys the session ID.
- `POST/users/signup`: This creates a new username with the defined password. However, an error will be sent to the client if the username or password does not pass the validation. It will also send an error message to the client when the username already exists.
- `GET/users/profile`: If the user is logged in, the user information is sent to the client. Otherwise, an error message is sent to the client.
- `PUT/users/changepass/`: This will change the current logged-in user's password. However, if the user is not logged-in, an error message is sent to the client.
- `DELETE/users/delete`: This will remove a logged-in user's profile from the collection `users` in MongoDB. The session will be destroyed and a confirmation message is sent to the client. If the user is not logged-in, an error message is sent to the client

See also

- `Chapter 1`, *Introduction to MERN Stack*, section *Installing NPM Packages*
- `Chapter 1`, *Introduction to MERN Stack*, section *Installing MongoDB*

Real-Time Communication with Socket.IO and ExpressJS

In this chapter, we will cover the following recipes:

- Understanding NodeJS events
- Understanding Socket.IO events
- Working with Socket.IO namespaces
- Defining and joining to Socket.IO rooms
- Writing middleware for Socket.IO
- Integrating Socket.IO with ExpressJS
- Using ExpressJS middleware in Socket.IO

Technical requirements

You will be required to have an IDE, Visual Studio Code, Node.js and MongoDB. You will also need to install Git, in order use the Git repository of this book.

The code files of this chapter can be found on GitHub: `https://github.com/PacktPublishing/MERN-Quick-Start-Guide/tree/master/Chapter04`

Check out the following video to see the code in action: `https://goo.gl/xfyDBn`

Introduction

Modern web applications usually require real-time communication where data is continuously flowing from client to server and vice versa with (almost) no delay.

The HTML5 WebSocket Protocol was created to fulfill this requirement. WebSocket uses a single TCP connection that is kept open even when the server or client is not sending any data. That means, while a connection between the client and the server exists, data can be sent at any time without having to open a new connection to the server.

Real-time communication has several applications from building chat applications to multi-user games, where the response time is really important.

In this chapter, we will focus on learning how to build a real-time web application using Socket.IO (`https://socket.io`) and understanding the Node.js event-driven architecture.

Socket.IO is one of the most used libraries for implementing real-time communication. Socket.IO uses WebSocket whenever possible but falls-back to other methods when WebSocket is not supported on a specific web browser. Because you probably want to make your application accessible from any web browser, having to work directly with WebSocket may not seem like a good idea.

Understanding Node.js events

Node.js has an event-driven architecture. Most of Node.js' core API is built around `EventEmitter`. This is a Node.js module that allows `listeners` to subscribe to certain named events that can be triggered later by an **emitter**.

You can define your own event emitter easily by just including the events Node.js module and creating a new instance of `EventEmitter`:

```
const EventEmitter = require('events')
const emitter = new EventEmitter()
emitter.on('welcome', () => {
    console.log('Welcome!')
})
```

Then, you can trigger the `welcome` event by using the `emit` method:

```
emitter.emit('welcome')
```

It is actually, pretty simple. One of the advantages is that you can subscribe multiple listeners to the same event, and they will get triggered when the `emit` method is used:

```
emitter.on('welcome', () => {
    console.log('Welcome')
})
emitter.on('welcome', () => {
    console.log('There!')
})
emitter.emit('welcome')
```

The `EventEmitter` API provides several helpful methods that give you more control to handle events. Check the official Node.js documentation to see all information about the API: `https://nodejs.org/api/events.html`.

Getting ready

In this recipe, you will create a class that will extend `EventEmitter`, and which will contain its own instance methods to trigger listeners attached to a specific event. First, create a new project by opening a Terminal and running the following line:

```
npm init
```

```
const EventEmitter = require('events')
const NS_PER_SEC = 1e9
  const NS_PER_MS = 1e6
class Timer extends EventEmitter {
  start() {
  this.startTime = process.hrtime()
  this.emit('start')
                                }
  stop() {
  const diff = process.hrtime(this.startTime)
  this.emit(
  'stop',
  (diff[0] * NS_PER_SEC + diff[1]) / NS_PER_MS,
  )
                                }
                                }
const tasks = new Timer()
tasks.on('start', () => {
  let res = 1
  for (let i = 1; i < 100000; i++) {
```

```
  res *= i
                                }
  tasks.stop()
  })
tasks.on('stop', (time) => {
  console.log(`Task completed in ${time}ms`)
  })
tasks.start()
```

```
<strong> node timer.js</strong>
```

How it works...

When the `start` method is executed, it keeps the starting time using `process.hrtime`, which returns the current high-resolution real time in an array of two items, where the first item is a number that represents seconds while the second item is another number that represents nanoseconds. Then, it triggers all event listeners attached to the `start` event.

On the other side, when the `stop` method is executed, it uses the result of previously calling `process.hrtime` as an argument to the same function, which returns the difference in time. This is useful to measure the time from when the `start` method was called until the time when the `stop` method was called.

There's more...

A common mistake is to assume that events are called asynchronously. It is true that defined events can be called at any time. However, they are still executed synchronously. Take the following example:

```
const EventEmitter = require('events')
const events = new EventEmitter()
events.on('print', () => console.log('1'))
events.on('print', () => console.log('2'))
events.on('print', () => console.log('3'))
events.emit('print')
```

The outputs for the preceding code will be shown as follows:

```
1
2
3
```

If you have a loop running inside one of your events, the next event won't get called until the previous one finishes executing.

Events can be made asynchronous by simply adding an `async` function as an event listener. By doing so, every function will still be called in order from the first `listener` defined to the last. However, the emitter won't wait for the first `listener` to finish its execution to call the next listener. That means you cannot guarantee that the output will always be in the same order, for instance:

```
events.on('print', () => console.log('1'))
events.on('print', async () => console.log(
    await Promise.resolve('2'))
)
events.on('print', () => console.log('3'))
events.emit('print')
```

The outputs for the preceding code will be shown as follows:

```
1
3
2
```

Asynchronous functions allow us to write non-blocking applications. If implemented correctly, you won't run into problems like this above.

`EventEmitter` instances have a method called `listeners` which when executed, providing an event name as an argument, returns an array of the attached listeners for that specific event. We can use this method in a way to allow `async` functions to be executed in the order they were attached, for instance:

```
const EventEmitter = require('events')
class MyEvents extends EventEmitter {
    start() {
        return this.listeners('logme').reduce(
            (promise, nextEvt) => promise.then(nextEvt),
            Promise.resolve(),
        )
    }
}
const event = new MyEvents()
event.on('logme', () => console.log(1))
event.on('logme', async () => console.log(
    await Promise.resolve(2)
))
event.on('logme', () => console.log(3))
event.start()
```

This will execute and display output in the order they were attached:

```
1
2
3
```

Understanding Socket.IO events

Socket.IO is an event-driven module or library, and, as you probably guessed, is based on `EventEmitter`. Everything in Socket.IO works with events. An event is triggered when a new connection is made to the Socket.IO server and an event can be emitted to send data to the client.

The Socket.IO server API differs from the Socket.IO client API. However, both work with events to send data from client to server and vice versa.

```
io.on('connection', (socket) => {

    console.log('A new client is connected') })

    // Which is the same as:<br/> io.of('/').on('connection', (socket) => {

    console.log('A new client is connected') })

socket.on('disconnecting', (reason) => {

    console.log('Disconnecting because', reason) })

socket.on('disconnect', (reason) => {

    console.log('Disconnected because', reason) })

socket.on('error', (error) => {

    console.log('Oh no!', error.message) })
```

- `[eventName]`: A user-defined event that will get fired when the client emits an event with the same name. The client can emit an event providing data in the arguments. On the server, the event will be fired and it will receive the data sent by the client

```
clientSocket.on('connect', () => {
    console.log('Successfully connected to server') })
clientSocket.on('connect_error', (error) => {
    console.log('Connection error:', error) })
clientSocket.on('connect_timeout', (timeout) => {
    console.log('Connect attempt timed out after', timeout) })
clientSocket.on('disconnect', (reason) => {
    console.log('Disconnected because', reason) })
clientSocket.on('reconnect', (n) => {
    console.log('Reconnected after', n, 'attempt(s)') })
clientSocket.on('reconnect_attempt', (n) => {
    console.log('Trying to reconnect again', n, 'time(s)') })
clientSocket.on('reconnect_error', (error) => {
    console.log('Oh no, couldn't reconnect!', error) })
clientSocket.on('reconnect_failed', (n) => {
    console.log('Couldn'nt reconnected after', n, 'times') })
clientSocket.on('ping', () => {
    console.log('Checking if server is alive') })
clientSocket.on('pong', (latency) => {
    console.log('Server responded after', latency, 'ms') })
```

```
clientSocket.on('error', (error) => {

    console.log('Oh no!', error.message)

    })
```

- `[eventName]`: A user-defined event that gets fired when the event is emitted in the server. The arguments provided by the server will be received by the client.

```
                                      {
  "dependencies": {
  "socket.io": "2.1.0"
                                      }
                                      }
```

<strong>npm install</strong>

```
const io = require('socket.io')()

io.path('/socket.io')

const root = io.of('/')

root.on('connection', socket => {

    let counter = 0

    socket.on('time', () => {

    const currentTime = new Date().toTimeString() counter += 1

    socket.emit('got time?', currentTime, counter) })

    })

io.listen(1337)

const io = require('socket.io-client')

const clientSocket = io('http://localhost:1337', {

    path: '/socket.io', })

clientSocket.on('connect', () => {

    for (let i = 1; i <= 5; i++) {

    clientSocket.emit('time') }

    })

clientSocket.on('got time?', (time, counter) => {

    console.log(counter, time) })
```

```
<strong>node simple-io-server.js</strong>
```

```
<strong>node simple-io-client.js</strong>
```

How it works...

Everything works with events. Socket.IO allows events to be defined in the server side that the client can emit. On the other side, it also allows to define events in the client side that the server can emit.

When a user-defined event is emitted by the server side, the data is sent to the client. The Socket.IO client checks whether there is a listener for that event first. Then, if there is a listener, it will get triggered. The same thing happens the other way around when a user-defined event is emitted by the client side:

1. An event listener `time` was added in our Socket.IO server's **socket object** which can be emitted by the client side
2. An event listener `"got time?"` was added in our Socket.IO Client which can be emitted by the server side

3. On connection, the client emits the `time` event first
4. Afterwards, the `time` event is fired on the server side which will emit the `"got time?"` event providing two arguments, the current server's `time` and a `counter` that specifies how many times a request was made
5. Then, the `"got time?"` event is fired on the client side receiving two arguments that were provided by the server, the `time` and a `counter`

Working with Socket.IO namespaces

Namespaces are a way of separating the business logic of your application while reusing the same TCP connection or minimizing the need for creating new TCP connections for to implement real-time communication between the server and the client.

Namespaces look pretty similar to ExpressJS' route paths:

```
home
users
usersprofile
```

However, as mentioned in previous recipes, these are not related to URLs. By default, a single TCP connection is created at this URL `http[s]://host:port/socket.io`

Reusing the same event names is a good practice when using namespaces. For example, let's suppose that we have a Socket.IO server that we use to emit a `setWelcomeMsg` event when the client emits a `getWelcomeMsg` event: io.of('*en').on('connection', (socket) => { socket.on('getWelcomeMsg', () => { socket.emit('setWelcomeMsg', 'Hello World!') }) })*
io.of('es').on('connection', (socket) => { socket.on('getWelcomeMsg', () => { socket.emit('setWelcomeMsg', 'Hola Mundo!') }) })

As you can see, we defined a listener for the event `getWelcomeMsg` in two different namespaces:

- If the client is connected to the English or `/en` namespace, when the `setWelcomeMsg` event is fired, the client will receive `"Hello World!"`

- On the other hand, if the client is connected to the Spanish or `/es` namespace, when the `setWelcomeMsg` event is fired, the client will receive `"Hola Mundo!"`

```
                                        {
  "dependencies": {
  "socket.io": "2.1.0"
                                        }
                                        }
```

<strong>npm install</strong>

```
const http = require('http') const fs = require('fs') const path = require('path')
const io = require('socket.io')()

const app = http.createServer((req, res) => {
    if (req.url === '/') {
    fs.readFile(
    path.resolve(__dirname, 'nsp-client.html'), (err, data) => {
    if (err) {
    res.writeHead(500) return void res.end() }
    res.writeHead(200) res.end(data)
                                            }
    )
    } else {
    res.writeHead(403) res.end()
                                            }
    })
io.path('/socket.io')
io.of('/en').on('connection', (socket) => {
    socket.on('getData', () => {
    socket.emit('data', {
    title: 'English Page', msg: 'Welcome to my Website', })
    })
    })

io.of('/es').on('connection', (socket) => {

    socket.on('getData', () => {

    socket.emit('data', {

    title: 'Página en Español', msg: 'Bienvenido a mi sitio Web', })

    })

    })

io.attach(app.listen(1337, () => {

    console.log(

    'HTTP Server and Socket.IO running on port 1337'

    )

    }))

<!DOCTYPE html> <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Socket.IO Client</title> </head>

    <body>

    <!-- code here --> </body>

    </html>

<h1 id="title"></h1> <section id="msg"></section> <button
id="toggleLang">Get Content in Spanish</button> <script
src="http://localhost:1337/socket.io/socket.io.js"> <br/> </script> <script
src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script>

<script type="text/babel"> // code here!
```

```
    </script>

const title = document.getElementById('title') const msg =
document.getElementById('msg') const btn =
document.getElementById('toggleLang')

const manager = new io.Manager(

    'http://localhost:1337', { path: '/socket.io' }, )

const socket = manager.socket('/en')

manager.socket('/en') manager.socket('/es')

socket.on('connect', () => {

    socket.emit('getData') })

socket.on('data', (data) => {

    title.textContent = data.title msg.textContent = data.msg })

btn.addEventListener('click', (event) => {

    socket.nsp = socket.nsp === '/en'

    ? '/es'

    : '/en'

    btn.textContent = socket.nsp === '/en'

    ? 'Get Content in Spanish'

    : 'Get Content in English'

    socket.close()

    socket.open()

    })
```

<strong> node nsp-server.js</strong>

<strong> http://localhost:1337/</strong>

Let's test it...

To see your previous work in action, follow these steps:

1. Once you navigate to `http://localhost:1337/` in your web browser, click on the `"Get Content in Spanish"` button to switch to the Spanish namespace
2. Click on the `"Get Content in English"` button to switch back to the English namespace

How it works...

This is what happens on the server side:

1. We defined two namespaces, `"/en"` and `"/es"`, then added a new event listener, `getData`, to the **socket object.**
2. When the `getData` event is fired in any of the two defined namespaces, it will emit a data event and send an object, that contains a title and a message property, to the client

On the client side, inside the script tag in our HTML document:

1. Initially, a new socket is created for the namespace `"/en"`:

```
const socket = manager.socket('/en')
```

2. At the same time, we created two new **sockets** for the namespaces `"/en"` and `"/es"`. They will act as reserved connections:

```
manager.socket('/en')
      manager.socket('/es')
```

3. After, an event listener connect was added that sends a request to the server on connection
4. Then, another event listener data was added that is fired when data is received from the server

5. Inside the event listener that handles onclick events for our button, we change the nsp property to switch to a different namespace. However, for this to happen, we had to disconnect the **socket** first, and call the open method to make a new connection again using the new namespace

Let's see one of the confusing parts about reserved connections. When you create one or more **sockets** in the same namespace, the first connection is reused, for example:

```
const first = manager.socket('/home')
const second = manager.socket('/home') // <- reuses first connection
```

On the client side, if there were no reserved connections, then switching to a namespace that was not used before would result in a new connection being created.
If you are curious, remove these two lines from the `nsp-client.html` file:

```
manager.socket('/en')
manager.socket('/es')
```

Afterwards, restart or run the Socket.IO server again. You will notice that there is a slow response when switching to a different namespace because a new connection is created instead of being reused.

There is an alternative way of achieving the same goal. We could have created two sockets that point to two different namespaces, `"/en"` and `"/es"`. Then, we could have added two event listeners connect and data to each socket. However, because the first and second socket would contain the same event names and receive data in the same format from the server, we would have gotten repeated code. Imagine the case if we had to do the same for five different namespaces that have the same event names and receive data in the same format, there would be too many repeated lines of code. This is where switching namespaces and reusing the same socket object is helpful. However, there may be cases were two or more different namespaces have different event names for different kinds of event, in that case, it is better to add event listeners for each of the namespaces separately. For example:

```
const englishNamespace = manager.socket('/en')
const spanishNamespace = manager.socket('/es')
// They listen to different events
englishNamespace.on('showMessage', (data) => {})
spanishNamespace.on('mostrarMensaje', (data) => {})
```

There's more...

On the client side, you have probably noticed one thing that we didn't use before, `io.Manager`.

io.Manager

This allows us predefine or configure how new connections will be created. The options defined in a `Manager`, as the URL, will be passed to the socket on initiation.

In our HTML file, inside a `script` tag, we created a new instance of `io.Manager` and passed two arguments; the server URL and an options object including a `path` property which indicates where new connections will be made: const manager = new io.Manager('http://localhost:1337', { path: '/socket.io' },)

To find out more about the `io.Manager` API visit the official documentation Website offer for Socket.IO `https://socket.io/docs/client-api/#manager`.

Later, we used the `socket` method to initialize and create a new Socket for the provided namespace:

```
const socket = manager.socket('/en')
```

This way, it is easier to work with several namespaces at the same time without having to configure each one of them with the same options.

Defining and joining Socket.IO rooms

Within namespaces, you can define rooms or channels that a socket can join and leave.

By default, a room is created with a random un-guessable ID for the connected **socket**: io.on('connection', (socket) => { console.log(socket.id) // Outputs socket ID })

On connection, when emitting an event, for example:

```
io.on('connection', (socket) => {
    socket.emit('say', 'hello')
})
```

What happens underneath is similar to this:

```
io.on('connection', (socket) => {
    socket.join(socket.id, (err) => {
        if (err) {
            return socket.emit('error', err)
        }
        io.to(socket.id).emit('say', 'hello')
    })
})
```

The `join` method was used to include the socket inside a room. In this case, the socket ID is the joint room, and the only client connected to that room is the socket itself.

Because a socket ID represents a unique connection with a client and, by default, a room with the same ID is created; all data sent by the server to that room will be received only by that client. However, if several clients or socket IDs join a room with the same name and the server sends data; all clients could be able to receive it.

```
                                        {
  "dependencies": {
  "socket.io": "2.1.0"
                                        }
                                        }
<strong>npm install</strong>
```

```
const http = require('http') const fs = require('fs') const path = require('path')
const io = require('socket.io')() const app = http.createServer((req, res) => {
  if (req.url === '/') {
  fs.readFile(
  path.resolve(__dirname, 'rooms-client.html'), (err, data) => {
  if (err) {
  res.writeHead(500) return void res.end() }
  res.writeHead(200) res.end(data)
                                    }
  )
  } else {
  res.writeHead(403) res.end()
                                    }
  })
io.path('/socket.io')
const root = io.of('/')
const notifyClients = () => {
  root.clients((error, clients) => {
  if (error) throw error root.to('commonRoom').emit(
  'updateClientCount', clients.length,
  )
```

```
    })

                                                        }

root.on('connection', socket => {

    socket.join('commonRoom') socket.emit('welcome', `Welcome client:
${socket.id}`) socket.on('disconnect', notifyClients) notifyClients()

    })

io.attach(app.listen(1337, () => {

    console.log(

    'HTTP Server and Socket.IO running on port 1337'

    )

    }))

<!DOCTYPE html> <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Socket.IO Client</title> </head>

    <body>

    <h1 id="title"> Connected clients: <span id="n"></span> </h1>

    <p id="welcome"></p> <script
src="http://localhost:1337/socket.io/socket.io.js"><br/> </script> <script <br/>
src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script>
<script type="text/babel"> // Code here

    </script>

    </body>

    </html>

const welcome = document.getElementById('welcome') const n =
document.getElementById('n')

const manager = new io.Manager(

    '<a href="http://localhost:1337">http://localhost:1337</a>', { path: '/socket.io' }, )

const socket = manager.socket('/')

socket.on('welcome', msg => {

    welcome.textContent = msg })

socket.on('updateClientCount', clientsCount => {

    n.textContent = clientsCount })
```

<strong> node rooms-server.js</strong>

<strong> </strong>http://localhost:1337/

<strong> </strong>http://localhost:1337/

13. The number of connected clients in both tabs or windows should have increased to 2

There's more...

Sending the same message or data, to more than one client, is called broadcasting. The method we have seen broadcasts a message to all clients, including the client that generated the request.

There are other several methods to broadcast a message. For instance: socket.to('commonRoom').emit('updateClientCount', data)

Which will emit an `updateClientCount` event to all clients in `commonRoom` expect to the sender or the socket that originated the request.

For a complete list check the official documentation of Socket.IO emit cheatsheet: `https://socket.io/docs/emit-cheatsheet/`

```
namespace.use((socket, next) => { ... })
```

```
socket.use((packet, next) => { ... })
```

It works similarly to how ExpressJS middleware functions do. We can add new properties to the `socket` or `packet` objects. Then, we can call `next` to pass the control to the next middleware in the chain. If `next` is not called, then the `socket` won't be connected, or the `packet` received.

```
                                        {
  "dependencies": {
  "socket.io": "2.1.0"
                                        }
                                        }
```

```
<strong>npm install</strong>
```

```
const http = require('http') const fs = require('fs') const path = require('path')
const io = require('socket.io')() const app = http.createServer((req, res) => {

    if (req.url === '/') {

    fs.readFile(

    path.resolve(__dirname, 'middleware-cli.html'), (err, data) => {

    if (err) {

    res.writeHead(500)

    return void res.end() }

    res.writeHead(200)

    res.end(data)

                                   }

    )

    } else {

    res.writeHead(403)

    res.end()

                                   }

    })

io.path('/socket.io')

const users = [

    { username: 'huangjx', password: 'cfgybhji' }, { username: 'johnstm',
password: 'mkonjiuh' }, { username: 'jackson', password: 'qscwdvb' }, ]
```

```
const userMatch = (username, password) => (
    users.find(user => (
    user.username === username && user.password === password ))
    )
const isUserLoggedIn = (socket, next) => {
    const { session } = socket.request if (session && session.isLogged) {
    next()
                                        }
                                        }
const namespace = {
    home: io.of('/home').use(isUserLoggedIn), login: io.of('/login'), }
namespace.login.on('connection', socket => {
    socket.use((packet, next) => {
    const [evtName, data] = packet const user = data
    if (evtName === 'tryLogin'
    && user.username === 'johnstm') {
    socket.emit('loginError', {
    message: 'Banned user!', })
    } else {
    next()
                                        }
```

```
   })

   socket.on('tryLogin', userData => {

   const { username, password } = userData const request = socket.request if
(userMatch(username, password)) {

   request.session = {

   isLogged: true,

   username,

                                              }

   socket.emit('loginSuccess') } else {

   socket.emit('loginError', {

   message: 'invalid credentials', })

                                              }

   })

   })

io.attach(app.listen(1337, () => {

   console.log(

   'HTTP Server and Socket.IO running on port 1337'

   )

   }))

<!DOCTYPE html>

   <html lang="en"> <head>
```

```
    <meta charset="UTF-8"> <title>Socket.IO Client</title> <script
src="http://localhost:1337/socket.io/socket.io.js"><br/> </script> <script <br/>
src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script>
</head>

    <body>

    <h1 id="title"></h1> <form id="loginFrm" disabled> <input type="text"
name="username" placeholder="username"/> <input type="password"
name="password" <br/> placeholder="password" /> <input type="submit"
value="LogIn" /> <output name="logs"></output> </form>

    <script type="text/babel"> // Code here

    </script>

    </body>

    </html>

const title = document.getElementById('home') const error =
document.getElementsByName('logErrors')[0]

    const loginForm = document.getElementById('loginForm')

const manager = new io.Manager(

    'http://localhost:1337', { path: '/socket.io' }, )

const namespace = {

    home: manager.socket('/home'), login: manager.socket('/login'), }

namespace.home.on('connect', () => {

    title.textContent = 'Great! you are connected to /home'

    error.textContent = ''

    })
```

```
namespace.login.on('loginSuccess', () => {
    namespace.home.connect() })
namespace.login.on('loginError', (err) => {
    logs.textContent = err.message })
form.addEventListener('submit', (event) => {
    const body = new FormData(form) namespace.login.emit('tryLogin', {
    username: body.get('username'), password: body.get('password'), })
    event.preventDefault() })
```

11. Save the file

<strong> node middleware-server.js</strong>

<strong> http://localhost:1337</strong>

invalid credentials

Banned user!

Connected to /home

Integrating Socket.IO with ExpressJS

Socket.IO works well with ExpressJS. In fact, it's possible to run an ExpressJS application and a Socket.IO server using the same port or HTTP server.

```
                                        {
  "dependencies": {
  "express": "4.16.3", "socket.io": "2.1.0"
                                        }
                                        }
<strong>npm install</strong>
```

```
<!DOCTYPE html>

    <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Socket.IO Client</title> <script
src="http://localhost:1337/socket.io/socket.io.js"><br/> </script> <script <br/>
src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script>
</head>

    <body>

    <h1 id="welcome"></h1> <script type="text/babel"> const welcome =
document.getElementById('welcome') const manager = new io.Manager(

    'http://localhost:1337', { path: '/socket.io' }, )

    const root = manager.socket('/') root.on('welcome', (msg) => {

    welcome.textContent = msg })

    </script>

    </body>

    </html>

const path = require('path') const express = require('express') const io =
require('socket.io')() const app = express()

io.path('/socket.io')

app.get('/', (req, res) => {

    res.sendFile(path.resolve(

    __dirname,

    'io-express-view.html', ))

    })
```

```
io.of('/').on('connection', (socket) => {
    socket.emit('welcome', 'Hello from Server!') })
io.attach(app.listen(1337, () => {
    console.log(
    'HTTP Server and Socket.IO running on port 1337'
    )
    }))
<strong> node io-express-server.js</strong>
<strong><span class="URLPACKT"> </span></strong>http://localhost:1337/
```

How it works...

Socket.IO's `attach` method expects to receive a HTTP server as a parameter in order to attach the Socket.IO server application to it. The reason why we can attach Socket.IO to an ExpressJS server application is because the `listen` method returns the underlying HTTP server to which ExpressJS is connected.

To sum up, the `listen` method returns the underlying HTTP server. Then, it is passed as a parameter to the `attach` method. This way, we can share the same connection with ExpressJS.

There's more...

So far, we have seen that we can share the same underlying HTTP server between ExpressJS and Socket.IO. However, that is not all.

The reason why we define a Socket.IO path is actually useful when working with ExpressJS. Take the following example:

```
const express = require('express')
const io = require('socket.io')()
const app = express()
io.path('/socket.io')
 app.get('/socket.io', (req, res) => {
    res.status(200).send('Hey there!')
})
io.of('/').on('connection', socket => {
    socket.emit('someEvent', 'Data from Server!')
})
io.attach(app.listen(1337))
```

As you can see, we are using the same URL path for Socket.IO and ExpressJS. We accept new connections to the Socket.IO server on the `/socket.io` path, but we also send content for `/socket.io` using the GET route method.

Even though this preceding example won't actually break your application, make sure to never use the same URL path to serve content from ExpressJS and accept new connections for Socket.IO at the same time. For instance, changing the previous code to this:

```
io.path('/socket.io')
 app.get('socket.io:msg', (req, res) => {
    res.status(200).send(req.params.msg)
})
```

While you may expect your browser, when visiting `http://localhost:1337`*`socket.io`*`message`, to display `message`, that won't be the case and you will see the following instead:

```
{"code":0,"message":"Transport unknown"}
```

That is because Socket.IO will interpret the incoming data first and it won't understand the data you just sent. In addition, your route handler will never be executed.

Besides that, the Socket.IO server also serves, by default, its own Socket.IO Client under the defined URL path. For example, try visiting `http://localhost:1337`*`socket.io`*`socket.io.js` and you will be able to see the minimized JavaScript code of the Socket.IO client.

If you wish to server your own version of Socket.IO client or if it is included in the bundle of your application, you can disable the default behavior in your Socket.IO server application with the `serveClient` method:

```
io.serveClient(false)
```

See also

- `Chapter 2`, *Building a Web server with ExpressJS*, section *Using Express.js' built-in middleware function for serving static assets*

```
namespace.use((socket, next) => {

    const req = socket.request const res = socket.request.res next() })

const expressMiddleware = (request, response, next) => {

    next() }

root.use((socket, next) => {

    const req = socket.request const res = socket.request.res
expressMiddleware(req, res, next) })
```

However, that doesn't mean that all ExpressJS middleware functions will work out of the box. For example, if an ExpressJS middleware function uses methods only available within ExpressJS, it may fail or have an unexpected behavior.

```
{
  "dependencies": {
  "express": "4.16.3", "express-session": "1.15.6", "socket.io": "2.1.0"
}
}
```

<strong>npm install</strong>

```
<!DOCTYPE html>

    <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Socket.IO Client</title> <script
src="http://localhost:1337/socket.io/socket.io.js"> <br/> </script> <script <br/>
src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script>
</head>

    <body>

    <h1 id="title"></h1> <form id="loginForm"> <input type="text"
name="username" placeholder="username"/> <input type="password"
name="password" <br/> placeholder="password" /> <input type="submit"
value="LogIn" /> <output name="logErrors"></output> </form>

    <script type="text/babel"> // Code here

    </script>

    </body>

    </html>

const title = document.getElementById('title') const error =
document.getElementsByName('logErrors')[0]

    const loginForm = document.getElementById('loginForm')

const manager = new io.Manager(

    'http://localhost:1337', { path: '/socket.io' }, )

const namespace = {

    home: manager.socket('/home'), login: manager.socket('/login'), }

namespace.home.on('welcome', (msg) => {

    title.textContent = msg error.textContent = ''
    })

namespace.login.on('loginSuccess', () => {

    namespace.home.connect() })

namespace.login.on('loginError', err => {

    error.textContent = err.message })

loginForm.addEventListener('submit', event => {

    const body = new FormData(loginForm) namespace.login.emit('enter', {

    username: body.get('username'), password: body.get('password'), })

    event.preventDefault() })

const path = require('path') const express = require('express') const io = require('socket.io')() const expressSession = require('express-session') const app = express()

io.path('/socket.io')

const session = expressSession({

    secret: 'MERN Cookbook Secret', resave: true,

    saveUninitialized: true, })

const ioSession = (socket, next) => {

    const req = socket.request const res = socket.request.res session(req, res, (err) => {

    next(err)

    req.session.save()

    })
```

```
                                        }

const home = io.of('/home') const login = io.of('/login')

const users = [

  { username: 'huangjx', password: 'cfgybhji' }, { username: 'johnstm', password: 'mkonjiuh' }, { username: 'jackson', password: 'qscwdvb' }, ]

app.use(session)

app.get('/home', (req, res) => {

  res.sendFile(path.resolve(

  __dirname,

  'io-express-cli.html', ))

  })

home.use(ioSession)

  home.use((socket, next) => {

  const { session } = socket.request if (session.isLogged) {

  next()

                                        }

  })

home.on('connection', (socket) => {

  const { username } = socket.request.session socket.emit(

  'welcome',

  `Welcome ${username}!, you are logged in!`, )
```

```
    })

login.use(ioSession)

    login.on('connection', (socket) => {

    socket.on('enter', (data) => {

    const { username, password } = data const { session } = socket.request const
found = users.find((user) => (

    user.username === username && user.password === password ))

    if (found) {

    session.isLogged = true session.username = username
socket.emit('loginSuccess') } else {

    socket.emit('loginError', {

    message: 'Invalid Credentials', })

                                                    }

    })

    })

io.attach(app.listen(1337, () => {

    console.log(

    'HTTP Server and Socket.IO running on port 1337'

    )

    }))

<strong> node io-express-srv.js</strong>

<strong><span class="URLPACKT"> </span></strong>
```

http://localhost:1337/home

Username: johntm<br/> Password: mkonjiuh

18. If you logged in successfully, after refreshing the page, your Socket.IO client application will still be able to connect to `/home` and you will see a welcome message every time

How it works...

When the session middleware is used inside ExpressJS, after modifying the session object, the `save` method is automatically called at the end of the response. However, that is not the case when using the session middleware in Socket.IO namespaces, that is why we call the `save` method manually to save the session back to the store. In our case, the store is the memory where the sessions are kept until the server stops.

Forbidding access to certain namespaces based on specific conditions is possible thanks to Socket.IO namespace middleware. If the control is not passed to the `next` handler, then the connection is not made. That's why after the login is successful, we ask the `/home` namespace to attempt to connect again.

See also

- `Chapter 2`, *Building a Web server with ExpressJS*, section *Writing middleware functions*

Managing State with Redux

In this chapter, we will cover the following recipes:

- Defining actions and action creators
- Defining reducer functions
- Creating a Redux store
- Binding action creators to the dispatch method
- Splitting and combining reducers
- Writing Redux store enhancers
- Time traveling with Redux
- Understanding Redux middleware
- Dealing with asynchronous data flow

Technical requirements

You will be required to have an IDE, Visual Studio Code, Node.js and MongoDB. You will also need to install Git, in order use the Git repository of this book.

The code files of this chapter can be found on GitHub: `https://github.com/PacktPublishing/MERN-Quick-Start-Guide/tree/master/Chapter05`

Check out the following video to see the code in action: `https://goo.gl/mU9AjR`

Introduction

Redux is a predictable state container for JavaScript applications. It allows developers to manage the state of their applications with ease. With Redux, the state is immutable. Thus, it is possible to go back and forth to the next or previous state of your application. Redux is bound to three core principles:

- **Single source of truth**: All the state of your application must be stored in a single object tree within one single store
- **State is read-only**: You must not mutate the state tree. Only by dispatching an action can the state tree change
- **Changes are made with pure functions**: These are called reducers, which are functions that accept the previous state and an action and compute a new state. Reducers must never mutate the previous state but rather always return a new one

Reducers work in a very similar way to how the `Array.prototype.reduce` function does. The `reduce` method executes a function for every item in an array against an accumulator to reduce it to a single value. For example:

```
const a = 5
const b = 10
const c = [a, b].reduce((accumulator, value) => {
    return accumulator + value
}, 0)
```

The resulting value in variable `c` while reducing `a` and `b` against the `accumulator`, is `15` and the initial value is `0`. The reducer function here is:

```
(accumulator, value) => {
    return accumulator + value
}
```

Redux reducers are written in a similar way and they are the most important concept of Redux. For example:

```
const reducer = (prevState, action) => newState
```

In this chapter, we will focus on learning how to manage simple and complex state trees with Redux. You will learn as well how to deal with asynchronous data flows.

Defining actions and action creators

Reducers accept an `action` object that describes the action that is going to be performed and decides how to transform the state based on this `action` object.

Actions are just plain objects and they have only one required property that needs to be present, the action-type. For instance: const action = { type: 'INCREMENT_COUNTER', }

We can also provide additional properties as well. For instance:

```
const action = {
    type: 'INCREMENT_COUNTER',
    incrementBy: 2,
}
```

Actions creators are just functions that return actions, for instance:

```
const increment = (incrementBy) => ({
    type: 'INCREMENT_COUNTER',
    incrementBy,
})
```

Getting ready

In this recipe, you will see how these simple Redux concepts can be applied with `Array.prototype.reduce` to decide how data should be accumulated or reduced.

We won't need the Redux library yet for this purpose.

```
const INCREMENT_COUNTER = 'INCREMENT_COUNTER'
    const DECREMENT_COUNTER = 'DECREMENT_COUNTER'
const increment = (by) => ({
    type: INCREMENT_COUNTER, by,
    })
    const decrement = (by) => ({
    type: DECREMENT_COUNTER, by,
    })
const reduced = [
    increment(10), decrement(5), increment(3), ].reduce((accumulator, action) => {
    switch (action.type) {
    case INCREMENT_COUNTER: return accumulator + action.by case DECREMENT_COUNTER: return accumulator - action.by default:
    return accumulator }
    }, 0)
console.log(reduced)
```

<strong>node counter.js</strong>

7. Outputs: 8

How it works...

1. The first action type that the reducer encounters is `increment(10)` which will increment the accumulator by `10`. Because the initial value of the accumulator is `0`, the next current value will be `10`
2. The second action type tells the reducer function to decrement the accumulator by `5`. Thus, the accumulator's value will be `5`.
3. The last action type tells the reducer function to increment the accumulator by `3`. As a result, the accumulator's value will be `8`.

Defining reducer functions

Redux reducers are pure functions. That means, they have no side-effects. Given the same arguments, the reducer must always generate the same shape of state. Take for example the following reducer function:

```
const reducer = (prevState, action) => {
    if (action.type === 'INC') {
        return { counter: prevState.counter + 1 }
    }
    return prevState
}
```

If we execute this function providing the same arguments, the result will always be the same:

```
const a = reducer(
   { counter: 0 },
   { type: 'INC' },
) // Value is { counter: 1 }
const b = reducer(
   { counter: 0 },
   { type: 'INC' },
) // Value is { counter: 1 }
```

> *However, take into account that even though the returned values have the same shape, these are two different objects. For instance, comparing the above: `console.log(a === b)` returns false.*

Impure reducer functions prevent your application state from being predictable and make difficult to reproduce the same state. For instance:

```
const impureReducer = (prevState = {}, action) => {
    if (action.type === 'SET_TIME') {
        return { time: new Date().toString() }
    }
    return prevState
}
```

If we execute this function:

```
const a = impureReducer({}, { type: 'SET_TIME' })
setTimeout(() => {
    const b = impureReducer({}, { type: 'SET_TIME' })
    console.log(
        a, // Output may be: {time: "22:10:15 GMT+0000"}
        b, // Output may be: {time: "22:10:17 GMT+0000"}
    )
}, 2000)
```

As you can see, after executing the function for a second time after 2 seconds, we get a different result. To make it pure, you can consider re-writing the previously impure reducer as:

```
const timeReducer = (prevState = {}, action) => {
    if (action.type === 'SET_TIME') {
        return { time: action.time }
    }
    return prevState
}
```

Then, you can safely pass a time property inside your action to set the time:

```
const currentTime = new Date().toTimeString()
const a = timeReducer(
   { time: null },
   { type: 'SET_TIME', time: currentTime },
)
const b = timeReducer(
   { time: null },
   { type: 'SET_TIME', time: currentTime },
)
console.log(a.time === b.time) // true
```

This approach makes your state predictable and the state is easy to reproduce. For instance, you could re-create a scenario of how your application will act if you pass the `time` property for any time in morning or afternoon.

Getting ready

Now that you understand the concept of how reducers work, in this recipe, you will build a small application that will act differently according to the state change.

For this purpose, you won't need to install or use the Redux library yet.

```
<!DOCTYPE html>

    <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Breakfast Time</title> <script <br/>
src="https://unpkg.com/@babel/standalone/babel.min.js"> <br/> </script>
</head>

    <body>

    <h1>What you need to do:</h1> <p>

    <b>Current time:</b> <span id="display-time"></span> </p>

    <p id="display-meal"></p> <button id="emulate-night"> Let's pretend is
00:00:00

    </button>

    <button id="emulate-noon"> Let's pretend is 12:00:00

    </button>

    <script type="text/babel"> // Add JavaScript code here </script>

    </body>

    </html>

let state = {

    kindOfMeal: null,

    time: null,

                                                }

const meal = document.getElementById('display-meal') const time =
document.getElementById('display-time') const btnNight =
document.getElementById('emulate-night') const btnNoon =
document.getElementById('emulate-noon')
const SET_MEAL = 'SET_MEAL'
    const SET_TIME = 'SET_TIME'
const setMeal = (kindOfMeal) => ({
    type: SET_MEAL,
    kindOfMeal,
    })
const setTime = (time) => ({
    type: SET_TIME,
    time,
    })
const reducer = (prevState = state, action) => {
    switch (action.type) {
    case SET_MEAL:
    return Object.assign({}, prevState, {
    kindOfMeal: action.kindOfMeal, })
    case SET_TIME:
    return Object.assign({}, prevState, {
    time: action.time,
    })
    default:
```

```
    return prevState

                                                            }

                                                            }

const onStateChange = (nextState) => {

    const comparison = [

    { time: '23:00:00', info: 'Too late for dinner!' }, { time: '18:00:00', info: 'Dinner
time!' }, { time: '16:00:00', info: 'Snacks time!' }, { time: '12:00:00', info: 'Lunch
time!' }, { time: '10:00:00', info: 'Branch time!' }, { time: '05:00:00', info:
'Breakfast time!' }, { time: '00:00:00', info: 'Too early for breakfast!' }, ]

    time.textContent = nextState.time meal.textContent =
comparison.find((condition) => (

    nextState.time >= condition.time )).info

                                                            }

const dispatch = (action) => {

    state = reducer(state, action) onStateChange(state) }

btnNight.addEventListener('click', () => {

    const time = new Date('1/1/1 00:00:00')
dispatch(setTime(time.toTimeString())) })

btnNoon.addEventListener('click', () => {

    const time = new Date('1/1/1 12:00:00')
dispatch(setTime(time.toTimeString())) })

dispatch(setTime(new Date().toTimeString()))
```

15. Save the file.

Let's test it...

To see your previous work in action:

1. Open the `meal-time.html` file in your web browser. You can do so by double-clicking on the file, or right-clicking on the file and choosing Open with....
2. You should be able to see your current local time and a message stating what kind of meal you should have. For instance, if your local time is `20:42:35 GMT+0800 (CST)`, you should see `Dinner time!`
3. Click on the button `"Let's pretend is 00:00:00"` to see what your application would display if the time was `00:00a.m`.
4. The same way, click on the button `"Let's pretend is 12:00:00"` to see what your application would display if the time was `12:00p.m`.

How it works...

We can summarize our application like the following to understand how it works:

1. Action types `SET_MEAL` and `SET_TIME` were defined.
2. Two action creators were defined:

    1. `setMeal` which generates an action with the `SET_MEAL` action type and a `kindOfMeal` property with the provided argument
    2. `setTime` which generates an action with the `SET_TIME` action type and a `time` property with the provided argument

3. A reducer function was defined:

    1. For the action type `SET_MEAL`, computes a new state with a new `kindOfMeal` property
    2. For the action type `SET_TIME`, computes a new state with a new `time` property

4. We defined a function that will get called when the state tree changes. Inside the function, we updated the view according to the new state.
5. A `dispatch` function was defined that calls the reducer function providing the previous state and an action object to generate a new state.

```
createStore(reducer, preloadedState, enhancer)

const TYPE = {

  INC_COUNTER: 'INC_COUNTER', DEC_COUNTER: 'DEC_COUNTER',
}

const initialState = {

  counter: 0, }

const reducer = (state = initialState, action) => {

  switch (action.type) {

  case TYPE.INC_COUNTER: return { counter: state.counter + 1 }

  case TYPE.DEC_COUNTER: return { counter: state.counter - 1 }

  default:

  return state }

                                }

const store = createStore(reducer)
```

Calling `createStore` will expose four methods:

- `store.dispatch(action)`: Where action is an object that contains at least one property named `type` that specifies the action type
- `store.getState()`: Returns the whole state tree
- `store.subscribe(listener)`: Where listener is a callback function that will get triggered whenever the state tree changes. Several listeners can be subscribed
- `store.replaceReducer(reducer)`: Replaces the current Reducer function with a new one

```
                                   {
  "dependencies": {
  "express": "4.16.3", "redux": "4.0.0"
                                   }
                                   }
```

```
<strong>npm install</strong>
```

```
const express = require('express') const path = require('path') const app = express()

app.use('/lib', express.static(

    path.join(__dirname, 'node_modules', 'redux', 'dist') ))

app.get('/', (req, res) => {

    res.sendFile(path.join(

    __dirname,

    'meal-time-client.html', ))

    })

app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )

<!DOCTYPE html>

    <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Meal Time with Redux</title> <script <br/> src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script> <script src="libredux.js"></script> </head>

    <body>

    <h1>What you need to do:</h1> <p>

    <b>Current time:</b> <span id="display-time"></span> </p>

    <p id="display-meal"></p> <button id="emulate-night"> Let's pretend is 00:00:00
```

```
  </button>

  <button id="emulate-noon"> Let's pretend is 12:00:00

  </button>

  <script type="text/babel"> // Add JavaScript code here </script>

  </body>

  </html>

const { createStore } = Redux

const initialState = {

  kindOfMeal: null,

  time: null,

                                                 }

const meal = document.getElementById('display-meal') const time =
document.getElementById('display-time') const btnNight =
document.getElementById('emulate-night') const btnNoon =
document.getElementById('emulate-noon')

const SET_MEAL = 'SET_MEAL'

  const SET_TIME = 'SET_TIME'

const setMeal = (kindOfMeal) => ({

  type: SET_MEAL,

  kindOfMeal,

  })

  const setTime = (time) => ({
  type: SET_TIME,

  time,

  })

const reducer = (prevState = initialState, action) => {

  switch (action.type) {

  case SET_MEAL:

  return {...prevState, kindOfMeal: action.kindOfMeal, }

  case SET_TIME:

  return {...prevState, time: action.time,

                                      }

  default:

  return prevState

                                      }

                                      }

const store = createStore(reducer)

store.subscribe(() => {

  const nextState = store.getState() const comparison = [

  { time: '23:00:00', info: 'Too late for dinner!' }, { time: '18:00:00', info: 'Dinner
time!' }, { time: '16:00:00', info: 'Snacks time!' }, { time: '12:00:00', info: 'Lunch
time!' }, { time: '10:00:00', info: 'Brunch time!' }, { time: '05:00:00', info:
'Breakfast time!' }, { time: '00:00:00', info: 'Too early for breakfast!' }, ]

  time.textContent = nextState.time meal.textContent =
comparison.find((condition) => (
    nextState.time >= condition.time )).info

    })

btnNight.addEventListener('click', () => {

    const time = new Date('1/1/1 00:00:00')
store.dispatch(setTime(time.toTimeString())) })

btnNoon.addEventListener('click', () => {

    const time = new Date('1/1/1 12:00:00')
store.dispatch(setTime(time.toTimeString())) })

store.dispatch(setTime(new Date().toTimeString()))
```

15. Save the file

<strong> node meal-time-server.js</strong>

http://localhost:1337/

3. You should be able to see your current local time and a message stating what kind of meal you should have. For instance, if your local time is `20:42:35 GMT+0800 (CST)`, you should see `Dinner time!`
4. Click on the button `"Let's pretend is 00:00:00"` to see what your application would display if the time was `00:00a.m`.
5. The same way, click on the `"Let's pretend is 12:00:00"` button to see what your application would display if the time was `12:00p.m`.

```
const reducer = (prevState = initialState, action) => {
    switch (action.type) {
    case SET_MEAL: return Object.assign({}, prevState, {
    kindOfMeal: action.kindOfMeal, })
    case SET_TIME: return Object.assign({}, prevState, {
    time: action.time, })
    default: return prevState }
                                                            }
const reducer = (prevState = initialState, action) => {
    switch (action.type) {
    case SET_MEAL: return {...prevState, kindOfMeal: action.kindOfMeal, }
    case SET_TIME: return {...prevState, time: action.time, }
    default: return prevState }
                                                            }
```

This could make the code more readable.

Binding action creators to the dispatch method

Actions creators are just functions that generate action objects which can later be used to dispatch actions using the `dispatch` method. Take for example the following code:

```
const TYPES = {
    ADD_ITEM: 'ADD_ITEM',
    REMOVE_ITEM: 'REMOVE_ITEM',
}
const actions = {
    addItem: (name, description) => ({
        type: TYPES.ADD_ITEM,
        payload: { name, description },
    }),
    removeItem: (id) => ({
        type: TYPES.REMOVE_ITEM,
        payload: { id },
    })
}
module.exports = actions
```

Later, somewhere in your application, you can dispatch these actions using the `dispatch` method:

```
dispatch(actions.addItem('Little Box', 'Cats'))
dispatch(actions.removeItem(123))
```

However, as you can see, calling the `dispatch` method every time seems like a repeated and unnecessary step. You could simply wrap the action creators around the `dispatch` function itself like this:

```
const actions = {
    addItem: (name, description) => dispatch({
        type: TYPES.ADD_ITEM,
        payload: { name, description },
    }),
    removeItem: (id) => dispatch({
        type: TYPES.REMOVE_ITEM,
        payload: { id },
    })
}
module.exports = actions
```

Even though this seems like a good solution, there is a problem. It means, you would need to create the store first, then define your action creators binding them to the `dispatch` method. In addition, it would be difficult to maintain the action creators in a separate file since they depend on the `dispatch` method to be present. There is a solution provided by the Redux module, a helper method called `bindActionCreators` which accepts two arguments. The first argument is an object with keys, which represent the name of an action creator, and values, which represent a function that returns an action. The second argument is expected to be the `dispatch` function:

```
bindActionCreators(actionCreators, dispatchMethod)
```

This helper method will map all the action creators to the dispatch method. For instance, we could re-write the previous example as the following:

```
const store = createStore(reducer)
const originalActions = require('./actions')
const actions = bindActionCreators(
    originalActions,
    store.dispatch,
)
```

Then, later somewhere in your application, you can call these methods without wrapping them around the `dispatch` method:

```
actions.addItem('Little Box', 'Cats')
actions.removeItem(123)
```

As you can see, our bound action creators look more like regular functions now. In fact, by destructuring the `actions` object, you can use only the methods you need. For instance:

```
const {
    addItem,
    removeItem,
} = bindActionCreators(
    originalActions,
    store.dispatch,
)
```

Then, you can call them like this:

```
addItem('Little Box', 'Cats')
removeItem(123)
```

```
                                        {
  "dependencies": {
  "express": "4.16.3", "redux": "4.0.0"
                                        }
                                        }
```

<strong>npm install</strong>

```
const express = require('express') const path = require('path') const app =
express() app.use('/lib', express.static(

    path.join(__dirname, 'node_modules', 'redux', 'dist') ))

    app.get('/', (req, res) => {

    res.sendFile(path.join(

    __dirname,

    'bind-index.html',

    ))

    })

    app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )

<!DOCTYPE html>

    <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Binding action creators</title> <script <br/>
src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script>
<script src="libredux.js"></script> </head>

    <body>

    <h1>List:</h1> <form id="item-form"> <input id="item-input" name="item"
/> </form>

    <ul id="list"></ul> <script type="text/babel"> // Add code here

    </script>
    </body>

    </html>

const form = document.querySelector('#item-form') const input =
document.querySelector('#item-input') const list =
document.querySelector('#list')

const initialState = {

    items: [],

                                 }

const TYPE = {

    ADD_ITEM: 'ADD_ITEM', }

const actions = {

    addItem: (text) => ({

    type: TYPE.ADD_ITEM, text,

    })

                                 }

const reducer = (state = initialState, action) => {

    switch (action.type) {

    case TYPE.ADD_ITEM: return {

    items: [...state.items, action.text].splice(-5) }

    default: return state }

                                 }

const { createStore, bindActionCreators } = Redux const store =
createStore(reducer) const { addItem } = bindActionCreators(
    actions,
    store.dispatch,
    )
store.subscribe(() => {
    const { items } = store.getState() items.forEach((itemText, index) => {
    const li = (
    list.children.item(index) ||
    document.createElement('li') )
    li.textContent = itemText list.insertBefore(li, list.children.item(0)) })
    })
form.addEventListener('submit', (event) => {
    event.preventDefault() addItem(input.value) })
```

12. Save the file.

```
<strong> node bind-server.js</strong>
```

http://localhost:1337/

3. Type something in the input box and press Enter. A new item should appear in the list.
4. Try to add more than five items to the list. The last one displayed will be removed and only five items are kept on the view.

```
const initialState = {
    todoList: [],
    chatMsg: [],
                                                                }
const reducer = (state = initialState, action) => {
    switch (action.type) {
    case 'ADD_TODO': return {
    ...state,
    todoList: [
    ...state.todoList,
                                                                {
    title: action.title,
    completed: action.completed,
    },
    ],
                                                                }
    case 'ADD_CHAT_MSG': return {
    ...state,
    chatMsg: [
    ...state.chatMsg,
                                {
    from: action.id,
    message: action.message,
    },
    ],
                                }
    default:
    return state
                                }
                                }
const initialState = {
    todoList: [],
    chatMsg: [],
                                }
const todoListReducer = (state = initialState.todoList, action) => {
    switch (action.type) {
    case 'ADD_TODO': return state.concat([
                                {
    title: action.title,
    completed: action.completed,
    },
    ])
    default: return state
                                          }
                                          }
const chatMsgReducer = (state = initialState.chatMsg, action) => {
    switch (action.type) {
    case 'ADD_CHAT_MSG': return state.concat([
                                          {
    from: action.id,
    message: action.message,
    },
    ])
    default: return state
                                          }
                                          }
const reducer = (state = initialState, action) => {
    return {
    todoList: todoListReducer(state.todoList, action),
    chatMsg: chatMsgReducer(state.chatMsg, action),
                                          }
                                          }
```

```
const reducer = combineReducers({
    todoList: todoListReducer,
    chatMsg: chatMsgReducer,
})
console.log(JSON.stringify(
    reducer(initialState, { type: null }),
    null, 2,
))
{
    "todoList": [],
    "chatMsg": [],
}
console.log(JSON.stringify(
    reducer(
    initialState,
{
    type: 'ADD_TODO',
    title: 'This is an example',
    completed: false,
    },
    ),
    null, 2,
))
                                        {
    "todoList": [
                                        {
    "title": "This is an example",
    "completed": false,
    },
    ],
    "chatMsg": [],
                                        }
```

This shows that each reducer is managing only the slice of the state assigned to them.

```
                                   {
  "dependencies": {
  "express": "4.16.3", "redux": "4.0.0"
                                   }
                                   }
<strong>npm install</strong>
```

```
const express = require('express') const path = require('path') const app = express()
    app.use('/lib', express.static(
    path.join(__dirname, 'node_modules', 'redux', 'dist') ))
    app.get('/', (req, res) => {
    res.sendFile(path.join(
    __dirname,
    'todo-time.html',
    ))
    })
    app.listen(
    1337,
    () => console.log('Web Server running on port 1337'), )
<!DOCTYPE html>
    <html lang="en">
    <head>
    <meta charset="UTF-8"> <title>Lucky Todo</title> <script <br/> src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script> <script src="libredux.js"></script> </head>
    <body>
    <h1>List:</h1> <form id="item-form"> <input id="item-input" name="item" /> </form>
    <ul id="list"></ul> <script type="text/babel"> // Add code here

    </script>

    </body>

    </html>

const timeElem = document.querySelector('#current-time') const formElem =
document.querySelector('#todo-form') const listElem =
document.querySelector('#todo-list') const inputElem =
document.querySelector('#todo-input') const luckyElem =
document.querySelector('#lucky-number')

const {

    createStore,

    combineReducers,

    bindActionCreators,

    } = Redux

const TYPE = {

    SET_TIME: 'SET_TIME',

    SET_LUCKY_NUMBER: 'SET_LUCKY_NUMBER', ADD_TODO:
'ADD_TODO',

    REMOVE_TODO: 'REMOVE_TODO', TOGGLE_COMPLETED_TODO:
'TOGGLE_COMPLETED_TODO', }

const actions = {

    setTime: (time) => ({

    type: TYPE.SET_TIME,

    time,
    }),
    setLuckyNumber: (number) => ({
    type: TYPE.SET_LUCKY_NUMBER, number,
    }),
    addTodo: (id, title) => ({
    type: TYPE.ADD_TODO,
    title,
    id,
    }),
    removeTodo: (id) => ({
    type: TYPE.REMOVE_TODO, id,
    }),
    toggleTodo: (id) => ({
    type: TYPE.TOGGLE_COMPLETED_TODO, id,
    }),
                                          }
const currentTime = (state = null, action) => {
    switch (action.type) {
    case TYPE.SET_TIME: return action.time default: return state
                                          }
                                          }
```

```
const luckyNumber = (state = null, action) => {

  switch (action.type) {

  case TYPE.SET_LUCKY_NUMBER: return action.number default: return state

                                                  }

                                                  }

const todoList = (state = [], action) => {

  switch (action.type) {

  case TYPE.ADD_TODO: return state.concat([

                                                  {

  id: String(action.id),

  title: action.title,

  completed: false,

                                                  }

  ])

  case TYPE.REMOVE_TODO: return state.filter(

  todo => todo.id !== action.id )

  case TYPE.TOGGLE_COMPLETED_TODO: return state.map(

  todo => (

  todo.id === action.id

                                                ? {
```

```
   ...todo,
   completed: !todo.completed, }
   : todo
   )
   )
   default: return state
                                                }
                                                }
const reducer = combineReducers({
   currentTime,
   luckyNumber,
   todoList,
   })
const store = createStore(reducer)
const {
   setTime,
   setLuckyNumber,
   addTodo,
   removeTodo,
   toggleTodo,
   } = bindActionCreators(actions, store.dispatch)
```

```
store.subscribe(() => {
    const { currentTime } = store.getState() timeElem.textContent = currentTime
})
store.subscribe(() => {
    const { luckyNumber } = store.getState() luckyElem.textContent = `Your lucky number is: ${luckyNumber}`
    })
store.subscribe(() => {
    const { todoList } = store.getState() listElem.innerHTML = ''
    todoList.forEach(todo => {
    const li = document.createElement('li') li.textContent = todo.title li.dataset.id = todo.id li.setAttribute('draggable', true) if (todo.completed) {
    li.style = 'text-decoration: line-through'
                                                            }
    listElem.appendChild(li) })
    })
listElem.addEventListener('click', (event) => {
    <strong> </strong>toggleTodo(event.target.dataset.id) })
listElem.addEventListener('drag', (event) => {
    removeTodo(event.target.dataset.id) })
let id = 0
    formElem.addEventListener('submit', (event) => {
```

```
    event.preventDefault()

    addTodo(++id, inputElem.value) inputElem.value = ''

    })

setLuckyNumber(Math.ceil(Math.random() * 1024)) setInterval(() => {

    setTime(new Date().toTimeString()) }, 1000)
```

21. Save the file

```
<strong> node todo-time.js</strong>
```

http://localhost:1337/

3. Introduce something in the input box and press enter. A new item should appear in the list.
4. Click on one of the items that you have added to mark it as completed.
5. Click once again on one of the items marked as completed to mark it as not completed.
6. Click and drag one of the items outside of the list to remove it from the To-do list.

```
{
currentTime: String,
luckyNumber: Number,
todoList: Array.of({
id: Number,
title: String,
completed: Boolean,
}),
}
```

2. We used the `combineReducers` helper method from the Redux library to combine those three reducers into a single one
3. Then, a store was created providing the combined reducer function
4. For convenience, we subscribed three listener functions that get triggered whenever the state changes to update the HTML elements used to display the data from the state
5. We also defined three event listeners: one to detect when a user submits a form that contains an input HTML element to add a new To-do item, another to detect when the user clicks on a To-do item displayed on the screen to toggle its state from not completed to completed or vice versa, and finally one event listener to detect when the user drags an element from the list to dispatch an action to remove it from the list of To-do items

```
createStore = (reducer, preloadedState, enhancer) => Store

enhancer = (...optionalArguments) => (

createStore => (reducer, preloadedState, enhancer) => Store )
```

It may look a bit difficult to understand now, but you don't really have to worry if you don't get it at first because you will probably never need to write a store enhancer. The purpose of this recipe was simply to help you to understand their purpose in a very simple way.

```
{
  "dependencies": {
  "redux": "4.0.0"
}
}
```

<strong> npm install</strong>

```
const {
    createStore,
    combineReducers, bindActionCreators, } = require('redux')
const acceptMap = () => createStore => (
    (reducerMap, ...rest) => {
    const reducerList = {}
    for (const [key, val] of reducerMap) {
    reducerList[key] = val }
    return createStore(
    combineReducers(reducerList), ...rest,
    )
                                                            }
    )
const TYPE = {
    INC_COUNTER: 'INC_COUNTER', DEC_COUNTER: 'DEC_COUNTER',
SET_TIME: 'SET_TIME', }
const actions = {
    incrementCounter: (incBy) => ({
    type: TYPE.INC_COUNTER, incBy,
    }),
    decrementCounter: (decBy) => ({
```

```
    type: TYPE.DEC_COUNTER, decBy,

    }),

    setTime: (time) => ({

    type: TYPE.SET_TIME, time,

    }),

                                                    }

const map = new Map()

map.set('counter', (state = 0, action) => {

    switch (action.type) {

    case TYPE.INC_COUNTER: return state + action.incBy case
TYPE.DEC_COUNTER: return state - action.decBy default: return state }

    })

map.set('time', (state = null, action) => {

    switch (action.type) {

    case TYPE.SET_TIME: return action.time default: return state }

    })

const store = createStore(map, acceptMap())

const {

    incrementCounter, decrementCounter, setTime,

    } = bindActionCreators(actions, store.dispatch)

setInterval(function() {
    setTime(new Date().toTimeString()) if (this.shouldIncrement) {

    incrementCounter((Math.random() * 5) + 1 | 0) } else {

    decrementCounter((Math.random() * 5) + 1 | 0) }

    console.dir(

    store.getState(), { colors: true, compact: false }, )

    this.shouldIncrement = !this.shouldIncrement }.bind({ shouldIncrement: false }), 1000)
```

```
<strong> node map-store.js</strong>
```

```
                                     {

   "counter": Number, "time": String,

                                     }
```

How it works...

The enhancer composes the store creator into a new one. For instance, the following line:

```
const store = createStore(map, acceptMap())
```

Could be written as:

```
const store = acceptMap()(createStore)(map)
```

Which actually, in a way, wraps the original `createStore` method into another `createStore` method.

Composition can be explained as a set of functions that are called accepting the result argument of the previous function. For instance:

```
const c = (...args) => f(g(h(...args)))
```

This composes functions `f`, `g`, and `h` from right to left into a single function `c`. That means, we could write the previous line of code also like this:

```
const createStore = acceptMap()(createStore)
const store = createStore(map)
```

Here `_createStore` is the result of composing `createStore` and your store enhancer function.

Time traveling with Redux

Even though, you may probably never need to write store enhancers, there is one special that you may find very useful for debugging your Redux powered applications to time travel through the state of your application. You can enable time traveling on your application by simple installing **Redux DevTools Extension** (for Chrome and Firefox): `https://github.com/zalmoxisus/redux-devtools-extension`.

```
                                     {
  "dependencies": {
  "express": "4.16.3", "redux": "4.0.0"
                                     }
                                     }
```

<strong>npm install</strong>

Make sure to have installed the Redux DevTools Extension in your web browser.

```
const express = require('express') const path = require('path') const app =
express() app.use('/lib', express.static(

    path.join(__dirname, 'node_modules', 'redux', 'dist') ))

    app.get('/', (req, res) => {

    res.sendFile(path.join(

    __dirname,

    'time-travel.html', ))

    })

    app.listen(

    1337,

    () => console.log('Web Server running on port 1337'), )

<!DOCTYPE html> <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Time travel</title> <script <br/>
src="https://unpkg.com/@babel/standalone/babel.min.js"><br/> </script>
<script src="libredux.js"></script> </head>

    <body>

    <h1>Counter: <span id="counter"></span></h1> <script type="text/babel">
// Add JavaScript Code here </script>

    </body>

    </html>

const counterElem = document.querySelector('#counter')

const {
    createStore,

    bindActionCreators, } = Redux

const TYPE = {

    INC_COUNTER: 'INC_COUNTER', DEC_COUNTER: 'DEC_COUNTER',
}

const actions = {

    incCounter: (by) => ({ type: TYPE.INC_COUNTER, by }), decCounter: (by)
=> ({ type: TYPE.DEC_COUNTER, by }), }

const reducer = (state = { value: 5 }, action) => {

    switch (action.type) {

    case TYPE.INC_COUNTER: return { value: state.value + action.by }

    case TYPE.DEC_COUNTER: return { value: state.value - action.by }

    default:

    return state

                                        }

                                        }

const store = createStore(

    reducer,

                                        (

    window.__REDUX_DEVTOOLS_EXTENSION__ &&
window.__REDUX_DEVTOOLS_EXTENSION__() ),

    )
```

```
const {
    incCounter,
    decCounter,
    } = bindActionCreators(actions, store.dispatch)
store.subscribe(() => {
    const state = store.getState() counterElem.textContent = state.value })
for (let i = 0; i < 10; i++) {
    const incORdec = (Math.random() * 10) > 5
    if (incORdec) incCounter(2) else decCounter(1) }
```

13. Save the file

Let's test it...

To see the previous work in action:

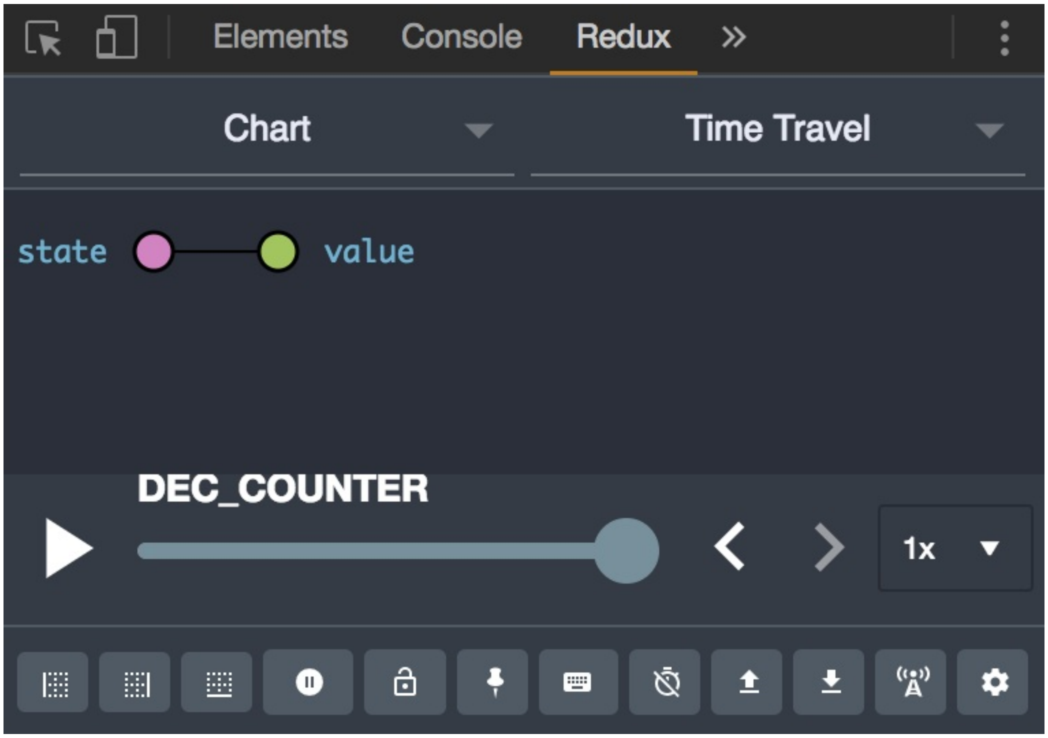
1. Open a new Terminal and run:

```
    node todo-time.js
```

2. In your Browser, visit:

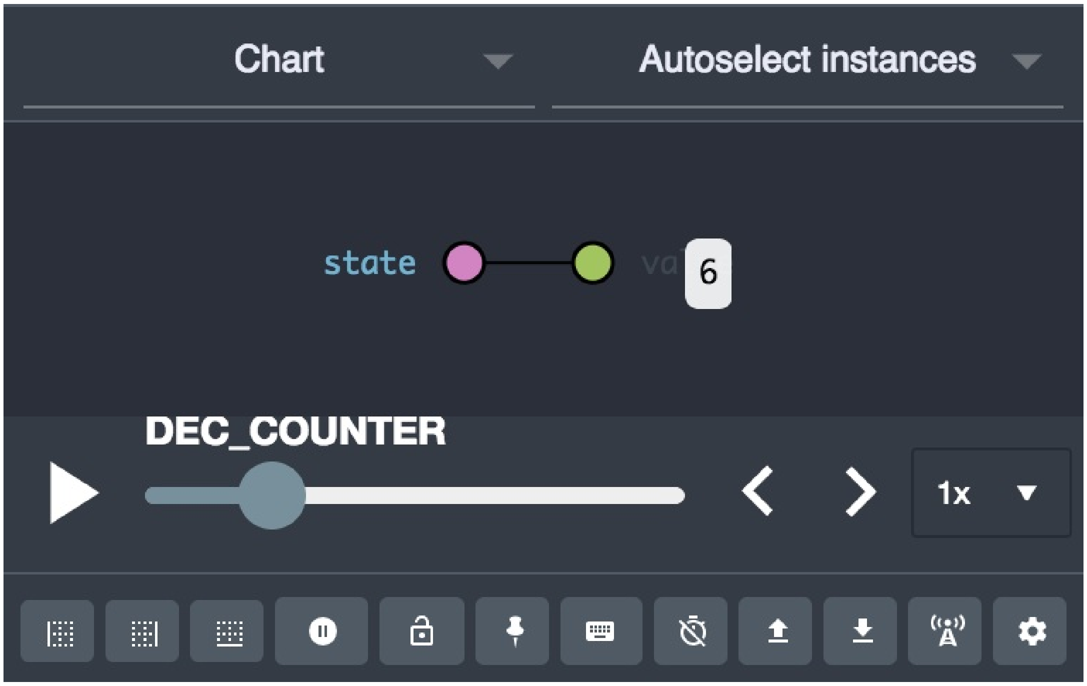
```
http://localhost:1337/
```

3. Open Developer Tools of your Browser and look for the Redux tab. You should see a tab like this:



Redux DevTools – Tab Window

4. The slider allows you to move from the last state to the very first state of your application. Try moving the slider to a different position:



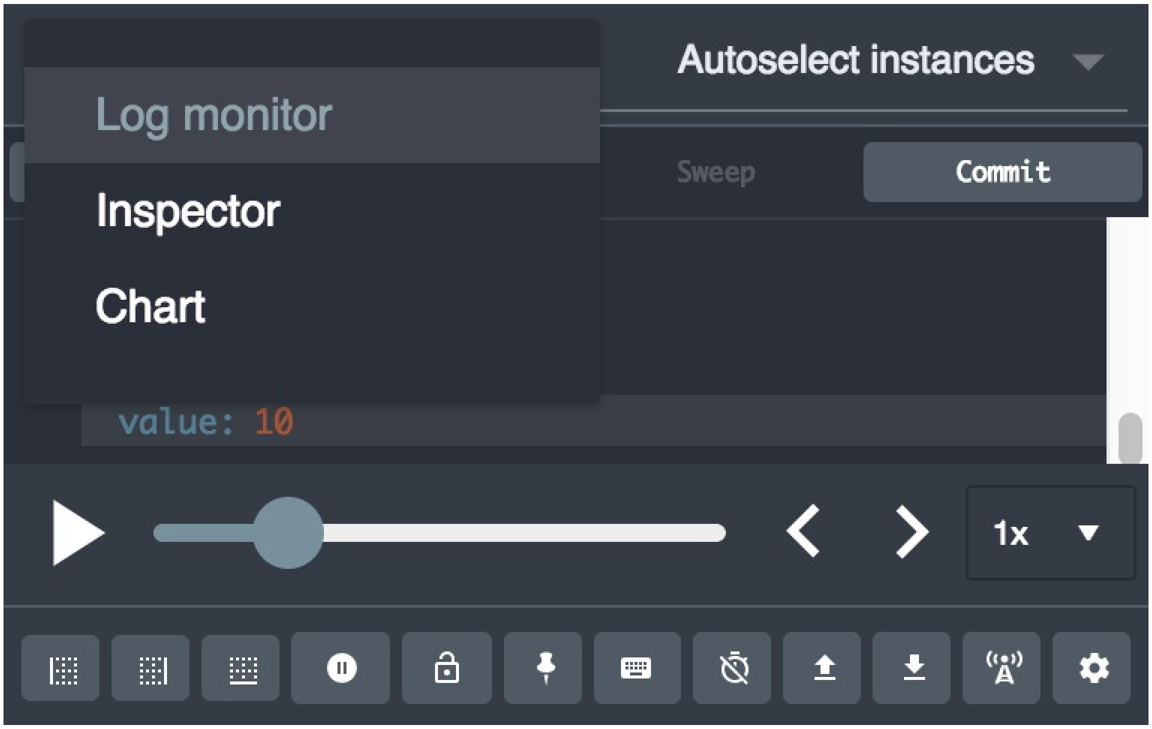
Redux DevTools – Moving Slider

5. While moving the slider, you would be able to see in your browser the counters initial value and how it changed those ten times in the for loop

There's more

Redux DevTools has some features that you will probably find amazing and helpful for debugging and managing the state of your application. In fact, if you followed the previous recipes, I suggest you go back to the projects we wrote and enable this enhancer and try to experiment with Redux DevTools.

One of many features of Redux DevTools is the Log monitor, which displays in chronological order which action was dispatched and the resulting value of transforming the state:



```
value: 10
```

Redux DevTools – Log Monitor

```
middleware = API => next => action => next(action)

middleware = ({

    getState,

    dispatch,

}) => next => action => next(action)

applyMiddleware(middleware1, middleware2)

middlewares.map((middleware) => middleware(API))

dispatch = (action) => (

    (action) => (

    (action) => store.dispatch(action) )(action)

    )(action)
```

4. Which means that a middleware function can interrupt the chain and prevent a certain action from being dispatched if the `next(action)` method is not called
5. The dispatch method from the middleware `API` object, allows you to call the dispatch method of the store with the previously applied middleware. That means, if you are not careful while using this method, you may create an infinite loop

Understanding how it works internally may not be so simple at first, but I assure you that you will get it soon.

```
                              {
  "dependencies": {
  "redux": "4.0.0"
                              }
                              }
```

<strong>npm install</strong>

```
const {

   createStore, applyMiddleware, } = require('redux')

const TYPE = {

   INCREMENT: 'INCREMENT', DECREMENT: 'DECREMENT',
SET_TIME: 'SET_TIME', }

const reducer = (

   state = null, action,

   ) => state

const typeCheckMiddleware = api => next => action => {

   if (Reflect.has(TYPE, action.type)) {

   next(action) } else {

   const err = new Error(

   `Type "${action.type}" is not a valid` +

   `action type. ` +

   `did you mean to use one of the following` +

   `valid types? ` +

   `"${Reflect.ownKeys(TYPE).join('"|"')}"n`, )

   throw err

                                                  }

                                                  }

const store = createStore(
   reducer,
   applyMiddleware(typeCheckMiddleware), )
store.dispatch({ type: 'INCREMENT' }) store.dispatch({ type: 'MISTAKE' })
```

8. Save the file.

```
<strong>node type-check-redux.js </strong>

/type-check-redux.js:25

    throw err ^

Error: Type "MISTAKE" is not a valid action type. did you mean to use one of
the following valid types? "INCREMENT"|"DECREMENT"|"SET_TIME"

    at Object.action [as dispatch] (/type-check-redux.js:18:15) at Object.
<anonymous> (/type-check-redux.js:33:7)
```

In this example, the stack trace tells us that the error happened on line `18`, which points to our middleware function. However, the next one points to line `33`, `store.dispatch({ type: 'MISTAKE' })`, which is a good thing because it can help you track exactly where certain actions are dispatched that were never defined.

How it works...

It's pretty simple, the middleware function checks the action type, of the action being dispatched, to see if it exists as a property of the `TYPE` object constant. If it exists, then the middleware passes control to the next middleware in the chain. However, in our case, there is no next middleware, so the control is passed to the original dispatch method of the store that will apply the reducer and transform the state. On the other side, if the action type was not defined, the middleware function interrupts the middleware chain by not calling the `next` function and by throwing an error.

Dealing with asynchronous data flow

By default, Redux doesn't handle asynchronous data flow. There are several libraries out there that can help you with these tasks. However, for the purpose of this chapter, we will build our own implementation using middleware functions to give the `dispatch` method the ability to dispatch and handle asynchronous data flow.

```
                                   {
  "dependencies": {
  "express": "4.16.3", "node-fetch": "2.1.2", "redux": "4.0.0"
                                   }
                                   }
```

<strong>npm install</strong>

```
const express = require('express') const app = express()

app.get('/time', (req, res) => {

    setTimeout(() => {

    res.send(new Date().toTimeString()) }, 2000)

    })

app.get('/date', (req, res) => {

    setTimeout(() => {

    res.destroy(new Error('Internal Server Error')) }, 2000)

    })

app.listen(

    1337,

    () => console.log('API server running on port 1337'), )

const fetch = require('node-fetch') const {

    createStore, applyMiddleware, combineReducers, bindActionCreators, } = require('redux')

const STATUS = {

    PENDING: 'PENDING', RESOLVED: 'RESOLVED', REJECTED: 'REJECTED', }

const TYPE = {

    FETCH_TIME: 'FETCH_TIME', FETCH_DATE: 'FETCH_DATE', }

const actions = {
    fetchTime: () => ({

    type: TYPE.FETCH_TIME, value: async () => {

    const time = await fetch(

    'http://localhost:1337/time'

    ).then((res) => res.text()) return time

                                        }

    }),

    fetchDate: () => ({

    type: TYPE.FETCH_DATE, value: async () => {

    const date = await fetch(

    'http://localhost:1337/date'

    ).then((res) => res.text()) return date

                                        }

    }),

    setTime: (time) => ({

    type: TYPE.FETCH_TIME, value: time, })

                                        }

const setValue = (prevState, action) => ({

    ...prevState, value: action.value || null, error: action.error || null, status: action.status || STATUS.RESOLVED, })

const iniState = {
    time: {
    value: null, error: null, status: STATUS.RESOLVED, },
    date: {
    value: null, error: null, status: STATUS.RESOLVED, }
                                                            }
const timeReducer = (state = iniState, action) => {
    switch (action.type) {
    case TYPE.FETCH_TIME: return {
    ...state,
    time: setValue(state.time, action) }
    case TYPE.FETCH_DATE: return {
    ...state,
    date: setValue(state.date, action) }
    default: return state }
                                                            }
const allowAsync = ({ dispatch }) => next => action => {
    if (typeof action.value === 'function') {
    dispatch({
    type: action.type, status: STATUS.PENDING, })
    const promise = Promise .resolve(action.value()) .then((value) => dispatch({
    type: action.type, status: STATUS.RESOLVED, value,
    }))
    .catch((error) => dispatch({
    type: action.type, status: STATUS.REJECTED, error: error.message, }))
    return promise }
    return next(action) }
const store = createStore(
    timeReducer, applyMiddleware(
    allowAsync,
    ),
    )
const {
    setTime,
    fetchTime,
    fetchDate,
    } = bindActionCreators(actions, store.dispatch)
store.subscribe(() => {
    console.log('x1b[1;34m%sx1b[0m', 'State has changed') console.dir(
    store.getState(), { colors: true, compact: false }, )
    })
setTime(new Date().toTimeString())
fetchTime()
```

```
fetchDate()
```

16. Save the file.

Let's test it...

To see your previous work in action:

1. Open a new terminal and run:

```
node api-server.js
```

2. Without closing the previously running NodeJS process, open another Terminal and run:

```
node async-redux.js
```

```
time: {
    value: "01:02:03 GMT+0000",
    error: null,
    status: "RESOLVED"
                                        }
time: {
    value: null,
    error: null,
    status: "PENDING"
                                        }
    // Later, once the operation is fulfilled:
    time: {
    value: "01:02:03 GMT+0000",
    error: null,
    status: "RESOLVED"
                                        }
date: {
    value: null,
    error: null,
    status: "PENDING"
}

// Later, once the operation is fulfilled:

date: {

value: null,

error: "request to http://localhost:1337/date failed, reason: <br/> socket hang up",

status: "REJECTED"

}
```

5. Take into account that because the operations are asynchronous, the output displayed in the terminal may not always be in the same order
6. Notice that the first async operation is fulfilled and the status marked as `RESOLVED` while the second async operation is fulfilled and its status marked as `REJECTED`
7. The statuses `PENDING`, `RESOLVED`, and `REJECTED` reflect the three statuses that a JavaScript Promise can be, and they are not obligatory names, simply easy to remember

There's more...

If you don't want to write your own middleware functions or store enhancers to deal with asynchronous operations, you can opt to use one of the many libraries for Redux that exist out there. Two of the most use or popular ones are these:

- Redux Thunk—`https://github.com/gaearon/redux-thunk`
- Redux Saga—`https://github.com/redux-saga/redux-saga`

Building Web Applications with React

In this chapter, we will cover the following recipes:

- Understanding React elements and React components
- Composing components
- Stateful components and life cycle methods
- Working with React.PureComponent
- React event handlers
- Conditional rendering of components
- Rendering lists with React
- Working with forms and inputs in React
- Understanding refs and how to use them
- Understanding React portals
- Catching errors with error boundary components
- Type checking properties with PropTypes

Technical requirements

You will be required to know Go programming language, also basics of web application framework. You will also need to install Git, in order use the Git repository of this book. And finally, ability to develop with an IDE on the command line.

The code files of this chapter can be found on GitHub:
`https://github.com/PacktPublishing/MERN-Quick-Start-Guide/tree/master/Chapter06`

Check out the following video to see the code in action:
`https://goo.gl/J7d7Ag`

Introduction

React is a JavaScript library for building **user interfaces** (**UI**). React is component-based, which means that each component can live separately from others and manage its own state. Complex UIs can be created by composing components.

Components are usually created using JSX syntax, which has an XML-like syntax, or using the `React.createElement` method. However, JSX is what makes React special for building web applications in a declarative way.

> *In the MVC pattern, React is usually associated with the View.*

Understanding React elements and React components

React elements can be created using JSX syntax:

```
const element = <h1>Example</h1>
```

This is transformed to:

```
const element = React.createElement('h1', null, 'Example')
```

JSX is a language extension on top of JavaScript that allows you to create complex UIs with ease. For example, consider the following:

```
const element = (
    <details>
        <summary>React Elements</summary>
        <p>JSX is cool</p>
    </details>
)
```

The previous example could be written without JSX syntax as:

```
const element = React.createElement(
    'details',
    null,
    React.createElement('summary', null, 'React Elements'),
    React.createElement('p', null, 'JSX is cool'),
  )
```

React elements can be any HTML5 tag and any JSX tag can be self-closed. For instance, the following will create a paragraph React element with an empty content within:

```
const element = <p />
```

The same way as you would do with HTML5, you can provide attributes to React elements, called properties or props in React:

```
const element = (
    <input type="text" value="Example" readOnly />
)
```

React components allow you to isolate parts of your web application as re-usable pieces of code or components. They can be defined in several ways. For instance:

- **Functional components**: These are plain JavaScript functions that accept properties as the first argument and return React elements:

```
const InputText = ({ name, children }) => (
          <input
              type="text"
              name={name}
              value={children}
              readOnly
          />
      )
```

- **Class components**: Using ES6 classes allows you to define life cycle methods and create stateful components. They render React elements from the `render` method:

```
 class InputText extends React.Component { render() {
              const { name, children } = this.props
              return (
                  <input
                      type="text"
                      name={name}
                      value={children}
```

```
                     readOnly
                 />
             )
         }
     }
```

- **Expressions**: These keep a reference to an instance of a React element or component:

```
const InstanceInputText = (
         <InputText name="username">
             Huang Jx
         </InputText>
     )
```

There are a few properties that are unique and are only part of React. For instance, the `children` property refers to the elements contained within the tag:

```
<MyComponent>
    <span>Example</span>
</MyComponent>
```

The `children` property received in `MyComponent`, in the previous example, will be an instance of a `span` React element. If multiple React elements or components are passed as children, the `children` property will be an array. However, if no children are passed, the `children` property will be `null`. The `children` property doesn't necessarily need to be a React element or component; it can also be a JavaScript function, or a JavaScript primitive:

```
<MyComponent>
    {() => {
        console.log('Example!')
        return null
    }}
</MyComponent>
```

React also considers functional components and class components that return or render a string, a valid React component. For instance:

```
const SayHi = ({ to }) => (
    `Hello ${to}`
)
const element = (
    <h1>
        <SayHi to="John" >, how are you?
    <h1>
)
```

React components' names must start with an uppercase letter. Otherwise, React will treat lowercased JSX tags as React elements

Rendering components to the DOM in React is not a complicated task. React provides several methods for rendering a React component to the DOM using the `ReactDOM` library. React uses JSX or `React.createElement` to create a tree or a representation of the DOM tree. It does so by using a virtual DOM, which allows React to transform React elements to DOM nodes and update only the nodes that have changed.

This is how you usually render your application using the `render` method from the `ReactDOM` library:

```
import * as ReactDOM from 'react-dom'
import App from './App'
ReactDOM.render(
   <App />,
   document.querySelector('[role="main"]'),
)
```

The first argument provided to the `render` method is a React component or a React element. The second argument tells you where in the DOM to render the application. In the previous example, we use the `querySelector` method from the document object to look for a DOM node with an attribute of `role` set to `"main"`.

React also allows you to render React components as an HTML string, which is useful for generating content on the server side and sending the content directly to the browser as an HTML file:

```
import * as React from 'react'
import * as ReactDOMServer from 'react-dom/server'
const OrderedList = ({ children }) => (
   <ol>
      {children.map((item, indx) => (
         <li key={indx}>{item}</li>
      ))}
   </ol>
)
console.log(
   ReactDOMServer.renderToStaticMarkup(
      <OrderedList>
         {['One', 'Two', 'Three']}
      </OrderedList>
   )
)
```

It will output the following in the console:

```
<ol>
   <li>One</li>
   <li>Two</li>
   <li>Three</li>
</ol>
```

```
{
  "scripts": {
  "start": "parcel serve -p 1337 index.html"
  },
  "devDependencies": {
  "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env": "1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler": "1.8.1", "react": "16.3.2",
  "react-dom": "16.3.2"
}
}
```

```
{
  "presets": ["env","react"], "plugins": ["transform-class-properties"]
}
```

<strong>npm install</strong>

```
import * as React from 'react'
    import * as ReactDOM from 'react-dom'
const RedText = ({ text }) => (
    <span style={{ color: 'red' }}>
    {text}
    </span>
    )
const Welcome = ({ to }) => (
    <h1>Hello, <RedText text={to}/></h1>
    )
const TodoList = (
    <ul>
    <li>Lunch at 14:00 with Jenny</li>
    <li>Shower</li>
    </ul>
    )
class Footer extends React.Component {
    render() {
    return (
    <footer>
    {new Date().toDateString()}
    </footer>
    )
                                                            }
                                                            }
ReactDOM.render(
    <div>
    <Welcome to="John" />
    {TodoList}
    <Footer />
    </div>,
    document.querySelector('[role="main"]'),
    )
<!DOCTYPE html>
    <html lang="en">
    <head>
    <meta charset="UTF-8">
    <title>MyApp</title>
    </head>
    <body>
    <div role="main"></div>
```

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

</body>

</html>
```

3. Save the file

<strong> npm start</strong>

http://localhost:1337/

3. You should be able to see the React application rendered to the DOM

Composing components

In React, all components can be isolated and complex UIs can be built by composing components which enables their re-usability.

```
                                        {

  "scripts": {

  "start": "parcel serve -p 1337 index.html"

  },

  "devDependencies": {

  "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env":
"1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler":
"1.8.1", "react": "16.3.2",

  "react-dom": "16.3.2"

                                        }

                                        }
```

```
                                        {

  "presets": ["env","react"], "plugins": ["transform-class-properties"]

                                        }
```

<strong>npm install</strong>

```
import * as React from 'react'
<strong> </strong>import * as ReactDOM from 'react-dom'
    export default ({ title }) => (
    <h1>{title}</h1> )
import * as React from 'react'
    import * as ReactDOM from 'react-dom'
    export default ({ date }) => (
    <footer>{date}</footer> )
import * as React from 'react'
    import * as ReactDOM from 'react-dom'
    export default () => (
    <p>This is a cool website designed with ReactJS</p> )
import * as React from 'react'
    import * as ReactDOM from 'react-dom'
import Header from './component/Header'
    import Footer from './component/Footer'
    import Description from './component/Description'
const App = () => (
    <React.Fragment> <Header title="Simple React App" /> <Description />
    <Footer date={new Date().toDateString()} /> </React.Fragment> )
```

```
ReactDOM.render(

    <App />,

    document.querySelector('[role="main"]'), )

<!DOCTYPE html>

    <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Composing Components</title> </head>

    <body>

    <div role="main"></div> <script src="./composing-react.js"></script>
</body>

    </html>
```

3. Save the file

```
<strong> npm start</strong>
```

http://localhost:1337/

```
<div role="app"> <h1>React App</h1> <p>This is a cool website designed with ReactJS</p> <footer>Tue May 22 2018</footer> </div>
```

How it works...

Each React component is written in a separate file. Then, we import the components in the main application file, `composing-react.js`, and use composition to generate a virtual DOM tree. Each component is re-usable because it can be used again in other parts of your application or in other components by just importing the files. Then, the `render` method from the `ReactDOM` library is used to generate a DOM representation of the virtual DOM tree.

```
const Example = () => (

    <span>One</span> <span>Two</span> ) // < will trow an error

const Example = () => (

    <React.Fragment> <span>One</span> <span>Two</span>
</React.Fragment> )
```

Stateful components and life cycle methods

React components can manage their own state and update only when the state has changed. Stateful React components are written using ES6 classes:

```
class Example extends React.Component {
   render() {
      <span>This is an example</span>
   }
}
```

React class components have a `state` instance property to access their internal state and a `props` property to access properties passed to the component:

```
class Example extends React.Component {
    state = { title: null }
    render() {
        return (
            <React.Fragment>
                <span>{this.props.title}</span>
                <span>{this.state.title}</span>
            </React.Fragment>
        )
    }
}
```

And their state can be mutated by using the `setState` instance method:

```
class Example extends React.Component {
    state = {
        title: "Example",
        date: null,
    }
    componentDidMount() {
        this.setState((prevState) => ({
            date: new Date().toDateString(),
        }))
    }
    render() {
        return (
            <React.Fragment>
                <span>{this.state.title}</span>
                <span>{this.state.date}</span>
            </React.Fragment>
        )
    }
}
```

The state is initialized once. Then, when the component is mounted, the state should only be mutated using the `setState` method. This way, React is able to detect changes in the state and update the component.

The `setState` method accepts a callback function as the first argument which will be executed passing the current state (`prevState` for convention) as the first argument to the callback function and the current `props` as the second argument. This is so because `setState` works asynchronously and the state could be mutated while you are performing other actions in different parts of your component.

If you don't need access to the current state while updating the state, you can directly pass an object as the first argument. For instance, the previous example could have been written as:

```
componentDidMount() {
   this.setState({
      date: new Date().toDateString(),
   })
}
```

`setState` also accepts an optional callback function as a second argument that gets called once the state has been updated. Because `setState` is asynchronous, you may want to use the second callback to perform an action only once the state has been updated:

```
componentDidMount() {
   this.setState({
      date: new Date().toDateString(),
   }, () => {
      console.log('date has been updated!')
   })
   console.log(this.state.date) // null
}
```

Once the component is mounted, the console will first output `null` even though we used `setState` before it; that's because the state is set asynchronously. However, once the state is updated, the console will display "date has been updated".

> *When using the `setState` method, React merges the previous state with the current given state. Internally, it's similar to doing:*

```
currentState = Object.assign({}, currentState, nextState)
```

Every class component has *life cycle methods* that give you control over the life of your component since its creation until it's destroyed, as well as giving you control over other properties, such as knowing when the component has received new properties and if the component should be updated or not. These are the life cycle methods present in all class components:

- `constructor(props)`: This is invoked when initializing a new instance of the component, before the component is mounted. `props` must be passed to the super class using `super(props)` to let React set the `props` correctly. The `constructor` method is useful as well to initialize the initial state of the component.

- `static getDerivedStateFromProps(nextProps, nextState)`: This is invoked when the component has been instantiated and when the component will receive new `props`. This method is useful when the state or part of it depends on values received from the `props` passed to the component. It must return an object which will be merged with the current state or `null` if the state doesn't need to be updated after receiving new `props`.

- `componentDidMount()`: This is invoked after the component has been mounted and after the first `render` call. It's useful for integrating with third-party libraries, accessing the DOM, or making HTTP requests to an endpoint.
- `shouldComponentUpdate(nextProps, nextState)`: This is invoked when the component has updated the state or new props have been received. This method allows React to know if it should update the component or not. If you don't implement this method in your component, it defaults to returning `true`, which means the component should be updated every time the state has changed or new props have been received. If implementing this method and returning `false`, it will tell React not to update the component.
- `componentDidUpdate(prevProps, prevState, snapshot)`: This is invoked after the render method or when an update occurs, except for the first rendering.
- `getSnapshotBeforeUpdate(prevProps, prevState)`: This is invoked after the render method or when an update occurs but before the `componentDidUpdate` life cycle method. The returned value of this method is passed as the third argument of `componentDidUpdate`.
- `componentWillUnmount()`: This is invoked before a component is unmounted and its instance destroyed. If using third-party libraries, this method is helpful for cleaning up. For instance, clearing timers or cancelling network requests.
- `componentDidCatch(error, info)` : This is a new feature of React v16 for error handling. We will look at this in more detail in the following

recipes.

```
                                        {

  "scripts": {

  "start": "parcel serve -p 1337 index.html"

  },

  "devDependencies": {

  "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env": "1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler": "1.8.1", "react": "16.3.2",

  "react-dom": "16.3.2"

                                        }

                                        }

                                        {

  "presets": ["env","react"], "plugins": ["transform-class-properties"]

                                        }
```

<strong>npm install</strong>

```
<!DOCTYPE html>
    <html lang="en">
    <head>
    <meta charset="UTF-8">
    <title>Life cycle methods</title>
    </head>
    <body>
    <div role="main"></div>
    <script src="./stateful-react.js"></script>
    </body>
    </html>
import * as React from 'react'
    import * as ReactDOM from 'react-dom'
class LifeCycleTime extends React.Component {
    constructor(props) {
    super(props)
    this.state = {
    time: new Date().toTimeString(),
    color: null,
    dontUpdate: false,
                                        }
                                        }
    static getDerivedStateFromProps(nextProps, prevState) {
    return nextProps
                                        }
    componentDidMount() {
    this.intervalId = setInterval(() => {
    this.setState({
    time: new Date().toTimeString(),
    })
    }, 100)
                                        }
    componentWillUnmount() {
    clearInterval(this.intervalId)
                                        }
    shouldComponentUpdate(nextProps, nextState) {
    if (nextState.dontUpdate) {
    return false
                                        }
    return true
                                        }
```

```
  getSnapshotBeforeUpdate(prevProps, prevState) {
  return 'snapshot before update'
                              }
  componentDidUpdate(prevProps, prevState, snapshot) {
  console.log(
  'Component did update and received snapshot:',
  snapshot,
  )
                              }
  render() {
  return (
  <span style={{ color: this.state.color }}>
  {this.state.time}
  </span>
  )
                              }
                              }
class App extends React.Component {
  constructor(props) {
  super(props)
  this.state = {
                              }
color: 'red',
dontUpdate: false,
unmount: false,
                              }
this.toggleColor = this.toggleColor.bind(this)
this.toggleUpdate = this.toggleUpdate.bind(this)
this.toggleUnmount = this.toggleUnmount.bind(this)
                              }
toggleColor() {
this.setState((prevState) => ({
color: prevState.color === 'red'
? 'blue'
: 'red',
}))
                              }
toggleUpdate() {
this.setState((prevState) => ({
dontUpdate: !prevState.dontUpdate,
}))
                              }
toggleUnmount() {
```

```
this.setState((prevState) => ({
unmount: !prevState.unmount,
}))
                                     }
render() {
const {
color,
dontUpdate,
unmount,
} = this.state
return (
<React.Fragment>
{unmount === false && <LifeCycleTime
color={color}
dontUpdate={dontUpdate}
/>}
<button onClick={this.toggleColor}>
Toggle color
{JSON.stringify({ color })}
</button>
<button onClick={this.toggleUpdate}>
```

```
  Should update?

  {JSON.stringify({ dontUpdate })}

  </button>

  <button onClick={this.toggleUnmount}>

  Should unmount?

  {JSON.stringify({ unmount })}

  </button>

  </React.Fragment>

  )

                                        }

                                        }

ReactDOM.render(

  <App />,

  document.querySelector('[role="main"]'),

  )
```

6. Save the file.

<strong> npm start</strong>

<strong> http://localhost:1337/</strong>

3. Use the buttons to toggle the state of the component and understand how the life cycle methods affect the component's functionality.

Working with React.PureComponent

`React.PureComponent` is similar to `React.Component`. The difference is that `React.Component` implements the `shouldComponentUpdate` life cycle method internally to make a shallow comparison of the `state` and `props` to decide if the component should update or not.

```
                                        {
  "scripts": {
  "start": "parcel serve -p 1337 index.html"
  },
  "devDependencies": {
  "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env": "1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler": "1.8.1", "react": "16.3.2",
  "react-dom": "16.3.2"
                                        }
                                        }
```

```
                                        {
  "presets": ["env","react"], "plugins": ["transform-class-properties"]
                                        }
```

<strong>npm install</strong>

```
<!DOCTYPE html>
   <html lang="en"> <head>
   <meta charset="UTF-8"> <title>React.PureComponent</title> </head>
   <body>
   <div role="main"></div> <script src="./pure-component.js"></script>
</body>
   </html>
import * as React from 'react'
   import * as ReactDOM from 'react-dom'
class Button extends React.PureComponent {
   componentDidUpdate() {
   console.log('Button Component did update!') }
   render() {
   return (
   <button>{this.props.children}</button> )
                                                }
                                                }
class Text extends React.Component {
   componentDidUpdate() {
   console.log('Text Component did update!') }
   render() {
```

```
  return this.props.children }

                                        }

class App extends React.Component {

  state = {

  counter: 0,

                                        }

  componentDidMount() {

  this.intervalId = setInterval(() => {

  this.setState(({ counter }) => ({

  counter: counter + 1, }))

  }, 1000)

                                        }

  componentWillUnmount() {

  clearInterval(this.intervalId) }

  render() {

  const { counter } = this.state return (

  <React.Fragment> <h1>Counter: {counter}</h1> <Text>I'm just a text</Text> <Button>I'm a button</Button> </React.Fragment> )

                                        }

                                        }

ReactDOM.render(
  <App />,

  document.querySelector('[role="main"]'), )
```

7. Save the file.

<strong> npm start</strong>

<strong> </strong> http://localhost:1337/

[N] Text Component did update!

How it works...

Because `React.PureComponent` implements the `shouldComponentUpdate`**life cycle method** internally, it doesn't update the `Button` component because its `state` or `props` have not changed. It does, however, update the `Text` component because `shouldComponentUpdate` returns `true` by default, telling React to update the component, even though its props or state have not changed.

React event handlers

React's event system uses internally a wrapper, called `SyntheticEvent`, around the native HTML DOM events for cross-browser support. React events follow the W3C spec, which can be found at `https://www.w3.org/TR/DOM-Level-3-Events/`.

React event names are camel-cased as opposed to HTML DOM events, which are lowercased. For instance, the HTML DOM event `onclick` would be called `onClick` in React. For a complete list of supported events, visit the React official documentation about events: `https://reactjs.org/docs/events.html`

```
{
  "scripts": {
  "start": "parcel serve -p 1337 index.html"
  },
  "devDependencies": {
  "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env":
"1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler":
"1.8.1", "react": "16.3.2",
  "react-dom": "16.3.2"
}
}
```

```
{
  "presets": ["env","react"], "plugins": ["transform-class-properties"]
}
```

<strong>npm install</strong>

```
<!DOCTYPE html>
  <html lang="en">
  <head>
  <meta charset="UTF-8">
  <title>React Events Handlers</title>
  </head>
  <body>
  <div role="main"></div>
  <script src="./events.js"></script>
  </body>
  </html>
import * as React from 'react'
  import * as ReactDOM from 'react-dom'
class App extends React.Component {
  constructor(props) {
  super(props)
  this.state = {
  title: 'Untitled',
                              }
  this.onBtnClick = this.onBtnClick.bind(this)
```

```
                                        }
  onBtnClick() {
  this.setState({
  title: 'Hello there!',
  })
                                        }
  render() {
  return (
  <section>
  <h1>{this.state.title}</h1>
  <button onClick={this.onBtnClick}>
  Click me to change the title
  </button>
  </section>
  )
                                        }
                                        }
ReactDOM.render(
  <App />,
  document.querySelector('[role="main"]'),
  )
```

5. Save the file.

Let's test it...

To see the application working, perform the following steps:

1. Open a Terminal at the root of your project directory and run:

```
npm start
```

2. Then, open a new tab in your web browser and go to:

```
http://localhost:1337/
```

3. Click on the button to change the title.

How it works...

React events are passed to React elements as `props`. For instance, we passed the `onClick` prop to the `button` React element and a reference to a callback function that we expect to be called when the user clicks on the button.

```
class Example {

    fn() { return this }

}
```

```
const examp = new Example() const props = examp.fn const bound = examp.fn.bind(examp) console.log('1:', typeof examp.fn()) console.log('2:', typeof props()) console.log('3:', typeof bound())
```

<strong>1: object

2: undefined

3: object</strong>

Even though the constant `props` has a reference to the `fn` method of the `examp` instance of the `Example` class, it loses the context of `this`. That's why binding allows you to keep the original context. In React, we bind a method to the original context of `this` to be able to use our own instance methods, such as `setState`, when passing the function down to child components. Otherwise, the context of `this` will be `undefined` and the function will fail.

Conditional rendering of components

Usually when building complex UIs, you would need to render a component or a React element according to the state or props received.

React components allow JavaScript to be executed within curly brackets and it can be used with the conditional ternary operator to decide which component or React element to render. For instance: const Meal = ({ timeOfDay }) => (<span>{timeOfDay === 'noon' ? 'Pizza' : 'Sandwich' } </span>)

This also could have been written as:

```
const Meal = ({ timeOfDay }) => (
    <span children={timeOfDay === 'noon'
        ? 'Pizza'
        : 'Sandwich'
    } />
)
```

If passing `"noon"` as the `timeOfDay` property value, it will generate the following HTML content:

```
<span>Pizza</span>
```

Or the following when the `timeOfDay` property is not set to `"noon"`:

```
<span>Sandwich</span>
```

```
                                        {

  "scripts": {

  "start": "parcel serve -p 1337 index.html"

  },

  "devDependencies": {

  "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env":
"1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler":
"1.8.1", "react": "16.3.2",

  "react-dom": "16.3.2"

                                        }

                                        }

                                        {

  "presets": ["env","react"], "plugins": ["transform-class-properties"]

                                        }
```

<strong>npm install</strong>

```
<!DOCTYPE html>
    <html lang="en">
    <head>
    <meta charset="UTF-8">
    <title>Conditional Rendering</title>
    </head>
    <body>
    <div role="main"></div>
    <script src="./conditions.js"></script>
    </body>
    </html>
import * as React from 'react'
    import * as ReactDOM from 'react-dom'
const Toggle = ({ condition, children }) => (
    condition
    ? children[0]
    : children[1]
    )
class App extends React.Component {
    constructor(props) {
```

```
super(props)
this.state = {
color: 'blue',
                              }
this.onClick = this.onClick.bind(this)
                              }
onClick() {
this.setState(({ color }) => ({
color: (color === 'blue') ? 'lime' : 'blue'
}))
                              }
render() {
const { color } = this.state
return (
<React.Fragment>
<Toggle condition={color === 'blue'}>
<p style={{ color }}>Blue!</p>
<p style={{ color }}>Lime!</p>
</Toggle>
<button onClick={this.onClick}>
Toggle Colors
```

```
    </button>
    </React.Fragment>
    )
                                                            }
                                                            }
ReactDOM.render(
    <App />,
    document.querySelector('[role="main"]'),
    )
```

6. Save the file.

<strong> npm start</strong>

http://localhost:1337/

3. Click on the button to toggle which React element is displayed

How it works...

Because the `children` property can be an array of React elements, we can access each individual React element and decide which one to render. We used the `condition` property to evaluate if the given condition is truthy to render the first React element. Otherwise, if the value is falsy, then the second React element is rendered.

```
<ul>
                                   {[
  <li key={0}>One</li>,
  <li key={1}>Two</li>,
                                   ]}
  </ul>
```

Collections of React elements or components must be given a special props property named `key`. This property lets React know which of the elements in the collection have changed, moved, or been removed in/from the array when an update occurs.

```
{
"scripts": {
"start": "parcel serve -p 1337 index.html"
},
"devDependencies": {
"babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env":
"1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler":
"1.8.1", "react": "16.3.2",
"react-dom": "16.3.2"
}
}
```

```
{
"presets": ["env","react"], "plugins": ["transform-class-properties"]
}
```

<strong> npm install</strong>

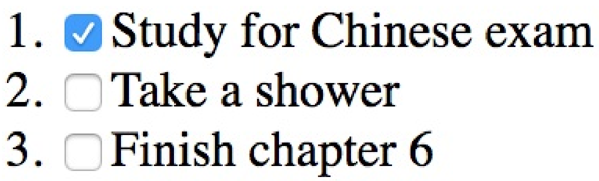
```
<!DOCTYPE html>
    <html lang="en">
    <head>
    <meta charset="UTF-8">
    <title>Rendering Lists</title>
    </head>
    <body>
    <div role="main"></div>
    <script src="./lists.js"></script>
    </body>
    </html>
import * as React from 'react'
    import * as ReactDOM from 'react-dom'
const MapArray = ({
    from,
    mapToProps,
    children: Child,
    }) => (
    <React.Fragment>
    {from.map((item) => (
    <Child {...mapToProps(item)} />
                                                              ))}
    </React.Fragment>
    )
const TodoItem = ({ done, label }) => (
    <li>
    <input type="checkbox" checked={done} readOnly />
    <label>{label}</label>
    </li>
    )
const list = [
    { id: 1, done: true, title: 'Study for Chinese exam' },
    { id: 2, done: false, title: 'Take a shower' },
    { id: 3, done: false, title: 'Finish chapter 6' },
                                                                ]
const mapToProps = ({ id: key, done, title: label }) => ({
    key,
    done,
    label,
    })
const TodoListApp = ({ items }) => (
    <ol>
    <MapArray from={list} mapToProps={mapToProps}>
    {TodoItem}
    </MapArray>
    </ol>
    )
ReactDOM.render(
    <TodoListApp items={list} />,
    document.querySelector('[role="main"]'),
    )
```

9. Save the file.

<strong> npm start</strong>

http://localhost:1337/

3. A list of to-do items should be displayed:



1. ☑ Study for Chinese exam
2. ☐ Take a shower
3. ☐ Finish chapter 6

List of to-do items

```
<ol>

   <MapArray from={list} mapToProps={mapToProps}>

   {TodoItem}

   </MapArray>

</ol>

<ol>

   <React.Fragment>

   {from.map((item) => (

   <TodoItem {...mapToProps(item) } />

                                        ))}

   </React.Fragment>

</ol>
```

However, `MapArray` acts as a helper component to do the same job while keeping the code more readable.

Have you noticed that the `TodoItem` component expects only two properties? However, we're also passing the `id` of the items as `key`. If the `key` property is not passed, then while rendering the components, a warning will be displayed.

Working with forms and inputs in React

Form-associated elements, such as `<input>` and `<textarea>`, usually maintain their own internal state and update it according to the user input. In React, when the input of a **form-associated element** is managed using the React state, it's called a **controlled component**.

By default, in React, if the `value` property of an input is not set, then the input internal state can be mutated by the user input. However, if the `value` property is set, then the input is read-only and it expects React to manage the user input by using the `onChange` React event and manage the input's state using the React state to update it if necessary. For example, this `input` React element will be rendered as read-only: <input type="text" value="Ms.Huang Jx" />

However, because React expects to find an `onChange` event handler, the previous code will output a warning message on the console. To fix this, we can provide to the `onChange` property a callback function to handle the user input:

```
<input type="text" value="Ms.Huang Jx" onChange={event => null} />
```

Because the user input is handled by React and, in the previous example, we don't update the input's value, then the input will appear to be read-only. The previous code is similar to just setting a `readOnly` property instead of providing a useless `onChange` property.

React also allows you to define **uncontrolled components,** which basically keep out of React's control what or input how the input is updated. For instance, when a third-party library is used instead to act over the input, **uncontrolled components** have a property called `defaultValue`, which is similar to the `value` property. However, it lets the input control its internal state by the user input and not by React. That means a **form-associated element** with a `defaultValue` property allows its state to be mutated by the user input: <input type="text" defaultValue="Ms.Huang Jx" />

As opposed to using the `value` property, you can now type in the input box to change its value because the internal state of the input is mutable.

```
{

  "scripts": {

  "start": "parcel serve -p 1337 index.html"

  },

  "devDependencies": {

  "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env":
"1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler":
"1.8.1", "react": "16.3.2",

  "react-dom": "16.3.2"

}

}
```

```
{

  "presets": ["env","react"], "plugins": ["transform-class-properties"]

}
```

<strong> npm install</strong>

```
<!DOCTYPE html>
  <html lang="en">
  <head>
  <meta charset="UTF-8">
  <title>Forms and Inputs</title>
  </head>
  <body>
  <div role="main"></div>
  <script src="./forms.js"></script>
  </body>
  </html>
import * as React from 'react'
  import * as ReactDOM from 'react-dom'
class LoginForm extends React.Component {
  constructor(props) {
  super(props)
  this.state = {
  username: '',
  password: '',
                                     }
```

```
this.onChange = this.onChange.bind(this)
                                   }
onChange(event) {
const { name, value } = event.target
this.setState({
[name]: name === 'username'
? value.replace(/d/gi, ")
: value
})
                                   }
render() {
return (
<form>
<input
type="text"
name="username"
placeholder="Username"
value={this.state.username}
onChange={this.onChange}
/>
<input
```

```
    type="password"
    name="password"
    placeholder="Password"
    value={this.state.password}
    onChange={this.onChange}
    />
    <pre>
    {JSON.stringify(this.state, null, 2)}
    </pre>
    </form>
    )
                                        }
                                        }
ReactDOM.render(
    <LoginForm />,
    document.querySelector('[role="main"]'),
    )
```

5. Save the file.

<strong> npm start</strong>

<strong> </strong>http://localhost:1337/

3. Try to introduce a number in the `username` input to see how the validation against numbers is working

How it works...

We define an `onChange` event handler used in both input elements. However, we check if the input's name is `username` to decide if the validation should be applied. `RegExp` is used to test for numbers in the input and replace them with an empty string. That's why numbers are not displayed while typing on the `username` input.

Understanding refs and how to use them

In the usual workflow, React components communicate with their children by passing `props`. However, there are a few cases where it's needed to access the instance of a child to communicate or modify its behavior. React uses `refs` to allow us to access the instance of a child.

It's important to understand that React components' instances give you access to their instance methods and properties. However, an instance of a React element is an instance of an HTML DOM element. Refs are accessed by giving a `ref` attribute to the React component or React element. It expects the value to be a callback function that will be invoked once the instance is created, providing a reference to the instance in the first argument passed to the callback function.

React provides a helper function named `createRef` to define function callbacks for setting refs correctly. Take, for example, the following code, which obtains a reference of a React component and a React element:

```
class Span extends React.Component {
    render() {
        return <span>{this.props.children}</span>
    }
}
class App extends React.Component {
    rf1 = React.createRef()
    rf2 = React.createRef()
    componentDidMount() {
        const { rf1, rf2 } = this
        console.log(rf1.current instanceof HTMLSpanElement)
        console.log(rf2.current instanceof Span)
    }
    render() {
        return (
            <React.Fragment>
```

```
                <span ref={this.rf1} >
                <Span ref={this.rf2} >
            </React.Fragment>
        )
    }
}
```

In this example, the console will output `true` twice:

```
true // rf1.current instanceof HTMLSpanElement
true // rf2.current instanceof Span
```

This proves what we have just learned.

> *Functional components do not have `refs`. Thus, giving a `ref` property to a functional component will display a warning in the console and fail.*

Refs are especially useful for working with *uncontrolled components* in the following cases:

- Integration with third-party libraries
- Accessing an HTML DOM element's native methods that are otherwise inaccessible from React, such as the `HTMLElement.focus()` method
- Using certain web APIs, such as the Selection Web API, the Web Animations API, and media playback methods

```
{
    "scripts": {
    "start": "parcel serve -p 1337 index.html"
    },
    "devDependencies": {
    "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env":
"1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler":
"1.8.1", "react": "16.3.2",
    "react-dom": "16.3.2"
}
}
```

```
{
    "presets": ["env","react"], "plugins": ["transform-class-properties"]
}
```

<strong> npm install</strong>

```
<!DOCTYPE html>

    <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Refs</title> </head>

    <body>

    <div role="main"></div> <script src="./refs.js"></script> </body>

    </html>

import * as React from 'react'

import * as ReactDOM from 'react-dom'

class LoginForm extends React.Component {

    refForm = React.createRef() constructor(props) {

    super(props)

    this.state = {}

    this.onSubmit = this.onSubmit.bind(this) this.onClick = this.onClick.bind(this) }

    onSubmit(event) {

    const form = this.refForm.current const data = new FormData(form) this.setState({

    user: data.get('user'), pass: data.get('pass'), })

    event.preventDefault() }

    onClick(event) {

    const form = this.refForm.current form.dispatchEvent(new Event('submit')) }
    render() {

    const { onSubmit, onClick, refForm, state } = this return (

    <React.Fragment> <form onSubmit={onSubmit} ref={refForm}> <input type="text" name="user" /> <input type="text" name="pass" /> </form>

    <button onClick={onClick}>LogIn</button> <pre>{JSON.stringify(state, null, 2)}</pre> </React.Fragment> )

}

}

ReactDOM.render(

    <LoginForm />, document.querySelector('[role="main"]'), )
```

5. Save the file.

Let's test it...

To run and test the application, perform the following steps:

1. Open a Terminal at the root of your project directory and run:

```
npm start
```

2. Then, open a new tab in your web browser and go to:

```
http://localhost:1337/
```

How it works...

1. Click on the `LogIn` button to test that the form `onSubmit` events gets triggered.
2. First, a reference to the instance of the form DOM element is kept in an instance property called `reform`.
3. Then, once the button is submitted, we use the `EventTarget` web API `dispatchEvent` method to dispatch a custom event `submit` on the form DOM element.
4. Then, the dispatched `submit` method is caught by the React `SyntheticEvent`.
5. Finally, React triggers the callback method passed to the form's `onSubmit` property.

```
ReactDOM.createPortal(
    ReactComponent,
    DOMNode,
)
<article>
    {ReactDOM.createPortal(
    <h1>Example</h1>,
    document.querySelector('[id="heading"]'),
                                                                  )}
</article>
```

```
                                        {
  "scripts": {
  "start": "parcel serve -p 1337 index.html"
  },
  "devDependencies": {
  "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env":
"1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler":
"1.8.1", "react": "16.3.2",
  "react-dom": "16.3.2"
                                        }
                                        }
```

```
                                        {
  "presets": ["env","react"], "plugins": ["transform-class-properties"]
                                        }
```

<strong> npm install</strong>

```
<!DOCTYPE html> <html lang="en"> <head>

    <meta charset="UTF-8"> <title>Portals</title> </head>

    <body>

    <header id="heading"></header> <div role="main"></div> <script
src="./portals.js"></script> </body>

    </html>
```

```
import * as React from 'react'

    import * as ReactDOM from 'react-dom'

const Header = () => ReactDOM.createPortal(

    <h1>React Portals</h1>, document.querySelector('[id="heading"]'), )

const App = () => (

    <React.Fragment> <p>Hello World!</p> <Header />

    </React.Fragment> )

ReactDOM.render(

    <App />,

    document.querySelector('[role="main"]'), )
```

6. Save the file.

<strong> npm start</strong>

<strong> </strong>http://localhost:1337/

<header id="heading"> <h1>React Portals</h1> </header>

<section role="main"> <p>Hello World!</p> </section>

How it works...

Even though in the React tree the `Header` component appears to be rendered after the paragraph `p` HTML tag, the rendered `Header` component renders before it. That's because the `Header` component is actually rendered on a `header` HTML tag that appears before the `section` HTML tag where the main application is rendered.

Catching errors with error boundary components

Error boundary components are just React components that implement the `componentDidCatch` **life cycle method** to catch errors in their children. They catch errors in `constructor` methods when a class component is initialized but fails, in life cycle methods, and while rendering. Errors that cannot be caught are from asynchronous code, event handlers, and errors in the error component boundary itself.

The `componentDidCatch` life cycle method receives two arguments: the first one is an `error` object while the second received argument is an object containing a `componentStack` property with a friendly stack trace that describes where in the React tree a component failed.

```
{

    "scripts": {

    "start": "parcel serve -p 1337 index.html"

    },

    "devDependencies": {

    "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env":
"1.6.1", "babel-preset-react": "6.24.1", "babel-core": "6.26.3", "parcel-bundler":
"1.8.1", "react": "16.3.2",

    "react-dom": "16.3.2"

}

}

{

    "presets": ["env","react"], "plugins": ["transform-class-properties"]

}
```

<strong> npm install</strong>

```
<!DOCTYPE html>
    <html lang="en">
    <head>
    <meta charset="UTF-8">
    <title>Catching Errors</title>
    </head>
    <body>
    <div role="main"></div>
    <script src="./error-boundary.js"></script>
    </body>
    </html>
import * as React from 'react'
    import * as ReactDOM from 'react-dom'
class ErrorBoundary extends React.Component {
    constructor(props) {
    super(props)
    this.state = {
    hasError: false,
    message: null,
    where: null,
                                       }
                                       }
    componentDidCatch(error, info) {
    this.setState({
    hasError: true,
    message: error.message,
    where: info.componentStack,
    })
                                       }
    render() {
    const { hasError, message, where } = this.state
    return (hasError
    ? <details style={{ whiteSpace: 'pre-wrap' }}>
    <summary>{message}</summary>
    <p>{where}</p>
    </details>
    : this.props.children
    )
                                       }
                                       }
class App extends React.Component {
    constructor(props) {

    super(props)

    this.onClick = this.onClick.bind(this)

                                       }

    onClick() {

    this.setState(() => {

    throw new Error('Error while setting state.')

    })

                                       }

    render() {

    return (

    <button onClick={this.onClick}>

    Buggy button!

    </button>

    )

                                       }

                                       }

ReactDOM.render(

    <ErrorBoundary>

    <App />

    </ErrorBoundary>,
    document.querySelector('[role="main"]'),

    )
```

6. Save the file.

```
<strong> npm start</strong>
```

http://localhost:1337/

```
<strong>Error while setting state.

    in App

    in ErrorBoundary</strong>
```

Type checking properties with PropTypes

React allows you to implement runtime type checking of components' properties. It's useful to catch bugs and make sure that your components are receiving `props` correctly. This can be easily done by just setting a static `propType` property on your components. For instance:

```
class MyComponent extends React.Component {
   static propTypes = {
      children: propTypes.string.isRequired,
   }
   render() {
      return<span>{this.props.children}</span>
   }
}
```

The previous code will require `MyComponent`'s `children` property to be a `string`. Otherwise, if a different property type is given, React will display a warning in the console.

`propTypes'` methods are functions that get triggered when the component's instance is created to check if the given `props` match the `propTypes` schema.

`propTypes` have an extensive list of methods that can be used for the validation of properties. You can find the complete list in the React official documentation: `https://reactjs.org/docs/typechecking-with-proptypes.html`.

```
{

  "scripts": {

  "start": "parcel serve -p 1337 index.html"

  },

  "devDependencies": {

  "babel-core": "6.26.3", "babel-plugin-transform-class-properties": "6.24.1", "babel-preset-env": "1.6.1", "babel-preset-react": "6.24.1", "parcel-bundler": "1.8.1", "prop-types": "15.6.1", "react": "16.3.2",

  "react-dom": "16.3.2"

}

}
```

```
{

  "presets": ["env","react"], "plugins": ["transform-class-properties"]

}
```

<strong>npm install</strong>

```
<!DOCTYPE html>
  <html lang="en"> <head>
  <meta charset="UTF-8"> <title>Type Checking</title> </head>
  <body>
  <div role="main"></div> <script src="./type-checking.js"></script> </body>
  </html>
import * as React from 'react'
  import * as ReactDOM from 'react-dom'
  import * as propTypes from 'prop-types'
class Toggle extends React.Component {
  static propTypes = {
  condition: propTypes.any.isRequired, children: (props, propName,
componentName) => {
  const customPropTypes = {
  children: propTypes .arrayOf(propTypes.element) .isRequired
                                      }
  const isArrayOfElements = propTypes .checkPropTypes(
  customPropTypes,
  props,
  propName,
  componentName,
  )

  const children = props[propName]

  const count = React.Children.count(children) if (isArrayOfElements instanceof Error) {

  return isArrayOfElements } else if (count !== 2) {

  return new Error(

  `"${componentName}"` +

  ` expected ${propName}` +

  ` to contain exactly 2 React elements`

  )

                            }

                            }

                            }

  render() {

  const { condition, children } = this.props return condition ? children[0] : children[1]

                            }

                            }

class App extends React.Component {

  constructor(props) {

  super(props)

  this.state = { value: false }
```

```
   this.onClick = this.onClick.bind(this) }

   onClick() {

   this.setState(({ value }) => ({

   value: !value,

   }))

                                               }

   render() {

   const { value } = this.state return (

   <React.Fragment> <Toggle condition={value}> <p style={{ color: 'blue'
}}>Blue!</p> <p style={{ color: 'lime' }}>Lime!</p> <p style={{ color: 'pink'
}}>Pink!</p> </Toggle>

   <button onClick={this.onClick}> Toggle Colors

   </button>

   </React.Fragment> )

                                               }

                                               }

ReactDOM.render(

   <App />,

   document.querySelector('[role="main"]'), )
```

6. Save the file.

<strong> npm start</strong>

http://localhost:1337/

<strong>Warning: Failed prop type: "Toggle" expected children to contain exactly 2 React elements in Toggle (created by App) in App</strong>

4. Clicking the `button` will toggle between the first two React elements while the third React element will be ignored

How it works...

We define a custom function validator for the `children` property. Inside the function, we first use the built-in `propTypes` functions to check if `children` is an array of React elements. If the result of the validation is not an instance of `Error`, then we use the React `Children`'s `count` utility method to know how many React elements were given and we return an error if the number of React elements in children is not `2`.

There's more...

Did you notice that we used the `propTypes.checkPropTypes` method? It's a utility function that allows us to check for `propTypes` even outside React. For instance:

```
const pTypes = {
   name: propTypes.string.isRequired,
   age: propTypes.number.isRequired,
}
const props = {
   name: 'Huang Jx',
   age: 20,
}
propTypes.checkPropTypes(pTypes, props, 'property', 'props')
```

The `pTypes` object works as a schema providing validation functions from `propTypes`. The `props` constant is just a plain object containing properties defined in `pTypes`.

Running the previous example won't output any warning in the console since all properties in `props` are valid. However, change the `props` object to:

```
const props = {
   name: 20,
   age: 'Huang Jx',
}
```

Then we will see the following warning in the console output:

```
Warning: Failed property type: Invalid property `name` of type `number`
supplied to `props`, expected `string`.
Warning: Failed property type: Invalid property `age` of type `string`
supplied to `props`, expected `number`.
```

The `checkPropTypes` utility method has the following signature:

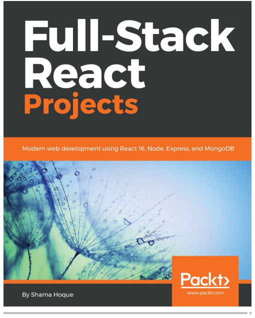
```
checkPropTypes(typeSpecs, values, location, componentName, getStack)
```

Here, `typeSpecs` refers to an object containing `propTypes` function validators. The `values` argument expects to receive an object whose values need to be validated against `typeSpecs`. `componentName` refers to the source's name, which usually is a component's name that is used in the warning message to display where the `Error` was originated. The last argument, `getStack,` is optional and it's expected to be a callback function that should return a `Stack Trace` that is added at the end of the warning message to better describe where exactly the error was originated.

`propTypes` are used only in development and for using the production build of React, you must set up the bundler to replace `process.env.NODE_ENV` with `"production"`. This way, `propTypes` are removed in the production build of your application.

Other Books You May Enjoy

If you enjoyed this book, you may be interested in these other books by Packt:


Full-Stack
React
Projects
Modern web development using React 16, Node, Express, and MongoDB
Packt>
www.packt.com
By Shama Hoque

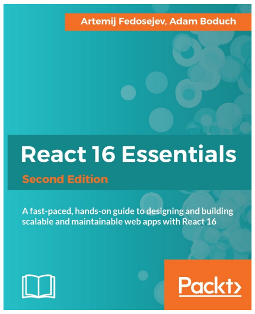
Full-Stack React Projects
Shama Hoque

ISBN: 978-1-78883-553-4

- Set up your development environment and develop a MERN application
- Implement user authentication and authorization using JSON Web Tokens
- Build a social media application by extending the basic MERN application
- Create an online marketplace application with shopping cart and Stripe payments
- Develop a media streaming application using MongoDB GridFS
- Implement server-side rendering with data to improve SEO
- Set up and use React 360 to develop user interfaces with VR

capabilities

- Learn industry best practices to make MERN stack applications reliable and scalable


Artemij Fedosejev, Adam Boduch
React 16 Essentials
Second Edition
A fast-paced, hands-on guide to designing and building scalable and maintainable web apps with React 16
Packt

React 16 Essentials - Second Edition
Artemij Fedosejev, Adam Boduch

ISBN: 978-1-78712-604-6

- Learn to code React 16 with hands-on examples and clear tutorials
- Install powerful React 16 tools to make development much more efficient
- Understand the impact of React Fiber today and the future of your web development
- Utilize the Redux application architecture with your React components
- Create React 16 elements with properties and children
- Get started with stateless and stateful React components
- Use JSX to speed up your React 16 development process
- Add reactivity to your React 16 components with lifecycle

methods

- Test your React 16 components with the Jest test framework

Leave a review - let other readers know what you think

Please share your thoughts on this book with others by leaving a review on the site that you bought it from. If you purchased the book from Amazon, please leave us an honest review on this book's Amazon page. This is vital so that other potential readers can see and use your unbiased opinion to make purchasing decisions, we can understand what our customers think about our products, and our authors can see your feedback on the title that they have worked with Packt to create. It will only take a few minutes of your time, but is valuable to other potential customers, our authors, and Packt. Thank you!