EVERYTHING YOU NEED
TO BUILD REAL PROJECTS
WITH REDUX

THE COMPLETE REDUX BOOK

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The Complete Redux Book

Everything you need to build real projects with Redux

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Chapter 9. Reducers

The word *reducer* is commonly associated in computer science with a function that takes an array or object and converts it to a simpler structure—for example, summing all the items in an array. In Redux, the role of the reducer is somewhat different: reducers create a new state out of the old one, based on an action.

In essence, a reducer is a simple JavaScript function that receives two parameters (two objects) and returns an object (a modified copy of the first argument):

A simple reducer example

```
const sum = (result, next) => result + next;

[1,2,3].reduce(sum); // -> 6
```

Reducers in Redux are *pure functions*, meaning they don't have any side effects such as changing local storage, contacting the server, or saving any data in variables. A typical reducer looks like this:

Basic reducer

```
function reducer(state, action) {
  switch (action.type) {

    case 'ADD_RECIPE':
    // Create new state with a recipe

    default:
      return state;
  }
}
```

Reducers in Practice

In Redux, reducers are the final stage in the unidirectional data flow. After an action is dispatched to the store and has passed through all the middleware, reducers receive it together with the current state of the application. Then they create a new state that has been modified according to the action and return it to the store.

The way we connect the store and the reducers is via the `createStore()` method, which can receive three parameters: a reducer, an optional initial state, and an optional store enhancer (covered in detail in the Store and Store Enhancers Chapter.

As an example, we will use the application built in Chapter 2—a simple Recipe Book application.

Our state contains three substates:

- Recipes – A list of recipes
- Ingredients – A list of ingredients and amounts used in each recipe
- UI – An object containing the state of various UI elements

We support a number of actions, like `ADD_RECIPE`, `FETCH_RECIPES`, and `SET_RECIPES`.

The simplest approach to build a reducer would be to use a large `switch` statement that knows how to handle all the actions our application supports. But it is quite clear that this approach will break down fast as our application (and the number of actions) grows.

Using a switch statement to build a reducer

```
switch (action.type) {

  case 'ADD_RECIPE':
    /* handle add recipe action */

  case 'FETCH_RECIPES':
    /* handle fetch recipes action */

  ...
}
```

Reducer Separation

The obvious solution would be to find a way to split the reducer code into multiple chunks. The way Redux handles this is by creating multiple reducers. The reducer passed as a first argument to `createStore()` is a plain function, and we can extract code out of it to put in other functions.

Splitting and writing reducers becomes a much easier job if we correctly build the structure of the state in our store. Given our example of the Recipe Book, we can see that we can create a reducer for each of the substates. What's more, each of the reducers only needs to know about its part of the state, and they have no dependency on each other. For example, the recipes reducer only handles recipe management, like adding and removing recipes, and doesn't care about how ingredients or the UI states are managed.

Following this separation of concerns, we can put each reducer into a different file and have a single *root reducer* manage all of them. Another side effect of this approach is that the root reducer will pass each of its children only the part of the state that it cares about (e.g., the ingredients reducer will only get the ingredients substate of the store). This ensures the individual reducers can't "break out" out of their encapsulation.

Recipes reducer

```
const initialState = [];

export default function recipesReducer(recipes = initialState, action) {
  switch (action.type) {
    case ADD_RECIPE:
      return [...recipes, action.payload];
    ...
  }
}
```

Ingredients reducer

```
const initialState = [];

export default function ingredientsReducer(ingredients = initialState, action) {
  switch (action.type) {
    case ADD_INGREDIENT:
      return [...ingredients, action.payload];
    ...
  }
}
```

Root reducer

```
import recipesReducer from 'reducers/recipes';
import ingredientsReducer  from 'reducers/ingredients';

const rootReducer = (state = {}, action) => Object.assign({}, state, {
  recipes: recipesReducer(state.recipes, action),
  ingredients: ingredientsReducer(state.ingredients, action)
});

export default rootReducer;
```

This approach results in smaller, cleaner, more testable reducers. Each of the reducers receives a subset of the whole state tree and is responsible only for that, without even being aware of the other parts of the state. As the project and the complexity of the state grows, more nested reducers appear, each responsible for a smaller subset of the state tree.

Combining Reducers

This technique of reducer combination is so convenient and broadly used that Redux provides a very useful function named `combineReducers()` to facilitate it. This helper function does exactly what `rootReducer()` did in our previous example, with some additions and validations:

Root reducer using combineReducers()

```
import { combineReducers } from 'redux';
import recipesReducer from 'reducers/recipes';
import ingredientsReducer from 'reducers/ingredients';

const rootReducer = combineReducers({
  recipes: recipesReducer,
  ingredients: ingredientsReducer
});

export const store = createStore(rootReducer);
```

We can make this code even simpler by using ES2016's property shorthand feature:

Using ES2016 syntax in combineReducers()

```
import { combineReducers } from 'redux';
import recipes from 'reducers/recipes';
import ingredients from 'reducers/ingredients';

const rootReducer = combineReducers({ recipes, ingredients });

export const store = createStore(rootReducer);
```

In this example we provided `combineReducers()` with a configuration object holding two keys named `recipes` and `ingredients`. The ES2016 syntax we used automatically assigned the value of each key to be the corresponding reducer.

It is important to note that `combineReducers()` is not limited to the root reducer only. As our state grows in size and depth, nested reducers will be combining other reducers for substate calculations. Using nested `combineReducers()` calls and other combination methods is a common practice in larger projects.

Default Values

One of the requirements of `combineReducers()` is for each reducer to define the default value for its substate. Both our recipes and ingredients reducers defined the initial state for their subtrees as an empty object. Using this approach, the structure of the state tree as a whole is not defined in a single place but rather built up by the reducers. This guarantees that changes to the tree require us only to change the applicable reducers and do not affect the rest of the tree.

This is possible because when the store is created, Redux dispatches a special action called `@@redux/INIT`. Each reducer receives that action together with the undefined initial state, which gets replaced with the default parameter defined inside the reducer. Since our `switch` statements do not process this special action type and simpy return the state (previously assigned by the default parameter), the initial state of the store is automatically populated by the reducers.

Tree Mirroring

This brings us to an important conclusion: that we want to structure our reducers tree to mimic the application state tree. As a rule of thumb, we will want to have a reducer for each leaf of the tree. It would also be handy to mimic the folder structure in the *reducers* directory, as it will be self-depicting of how the state tree is structured.

As complicated manipulations might be required to add some parts of the tree, some reducers might not fall into this pattern. We might find ourselves having two or more reducers process the same subtree (sequentially), or a single reducer operating on multiple branches (if it needs to update structures at two different branches). This might cause complications in the structure and composition of our application. Such issues can usually be avoided by normalizing the tree, splitting a single action into multiple ones, and other Redux tricks.

Alternative to switch Statements

After a while, it becomes apparent that most reducers are just `switch` statements over `action.type`. Since the `switch` syntax can be hard to read and prone to errors, there are a few libraries that try to make writing reducers easier and cleaner.

While it is most common for a reducer to examine the `type` property of the action to determine if it should act, in some cases other parts of the action's object are used. For example, you might want to show an error notification on every action that has an error in the payload.

A common library is redux-create-reducer[1], which builds a reducer from a configuration object that defines how to respond to different actions:

[1] https://github.com/kolodny/redux-create-reducer

Reducer using redux-create-reducer

```
import { createReducer } from 'redux-create-reducer';

const initialState = [];
const recipesReducer = createReducer(initialState, {

  [ADD_RECIPE](recipes, action) {
    return [...recipes, action.payload];
  },

  [REMOVE_RECIPE](recipes, action) {
    const index = recipes.indexOf(action.payload);

    return [
      ...recipes.slice(0, index),
      ...recipes.slice(index + 1)
    ];
  }
});

export default recipesReducer;
```

Removing the `case` and `default` statements can make the code easier to read, especially when combined with the ES2016 property shorthand syntax. The implementation is trivial:

Reducer using redux-create-reducer with ES2016 syntax

```
function createReducer(initialState, handlers) {
  return function reducer(state, action) {
    if (state === undefined) state = initialState;

    if (handlers.hasOwnProperty(action.type)) {
      return handlers[action.type](state, action);
    } else {
      return state;
    }
  };
};
```

If you are using the `redux-actions` library described in the previous chapter, you can also use the `handleActions()` utility function from that library. It behaves basically the same way as `createReducer()`, with one distinction—`initialState` is passed as a second argument:

Using redux-actions instead of createReducer()

```
import { handleActions } from 'redux-actions';

const initialState = [];

const recipesReducer = handleActions({
  [ADD_RECIPE](recipes, action) {
    return [...recipes, action.payload];
  },

  [REMOVE_RECIPE](recipes, action) {
    const index = recipes.indexOf(action.payload);
    return [
      ...recipes.slice(0, index),
      ...recipes.slice(index + 1)
    ];
  }
}, initialState);

export default recipesReducer;
```

If you are using Immutable.js, you might also want to take a look at the redux-immutablejs[2] library, which provides you with `createReducer()` and `combineReducers()` functions that are aware of Immutable.js features like getters and setters.

Avoiding Mutations

The most important thing about reducers in Redux is that *they should **never mutate** the existing state*. There are a number of functions in JavaScript that can help when working with immutable objects.

Why Do We Need to Avoid Mutations?

One of the reasons behind the immutability requirement for the reducers is due to *change detection* requirements. After the store passes the current state and action to the root reducer, it and the various UI components of the application need a way to determine what changes, if any, have happened to the global state. For small objects, a deep compare or other similar methods might suffice. But if the state is large and only a small part may have changed due to an action, we need a faster and better method.

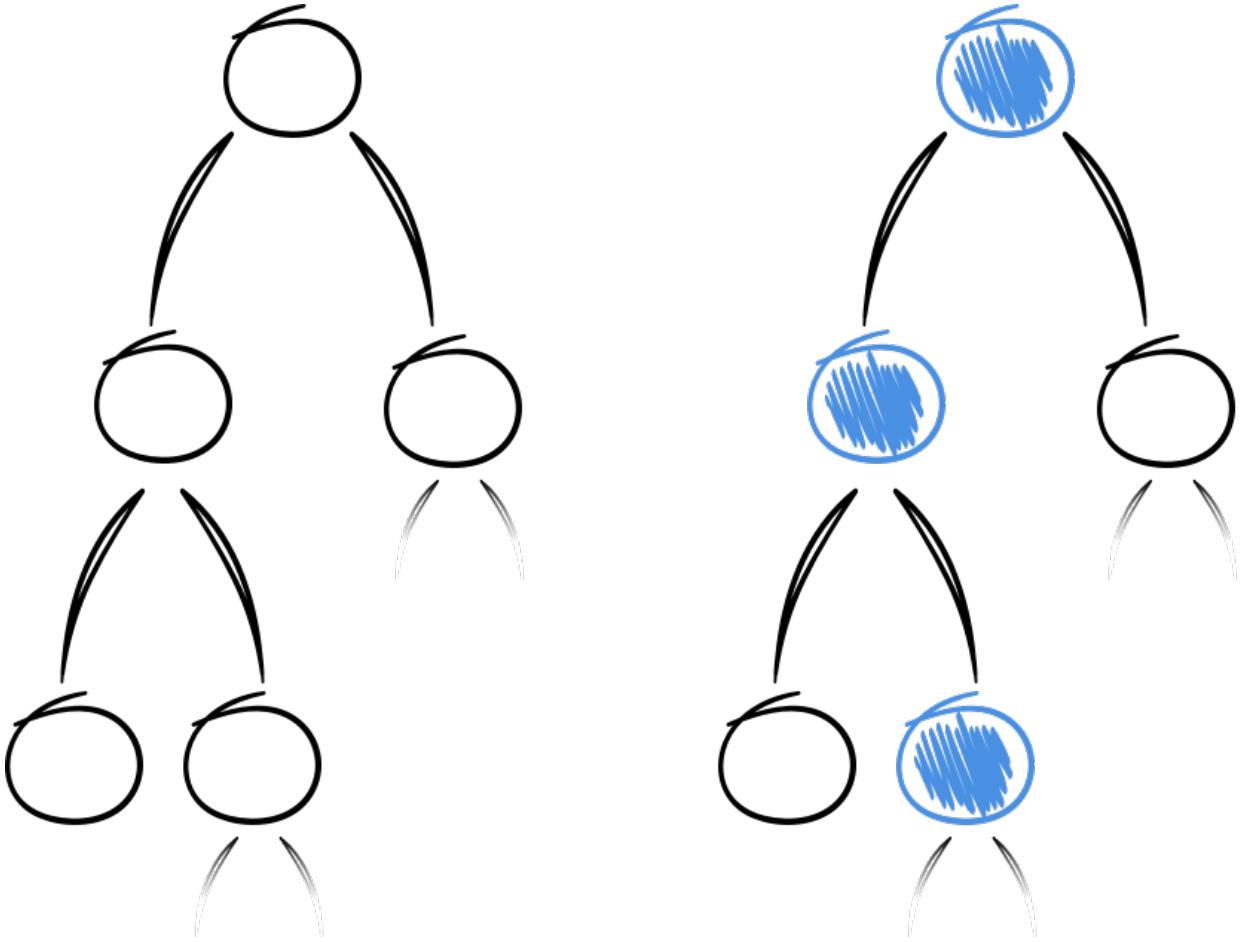
[2] https://github.com/indexiatech/redux-immutablejs

There are a number of ways to detect a change made to a tree, each with its pros and cons. Among the many solutions, one is to mark where changes were made in the tree. We can use simple methods like setting a `dirty` flag, use more complicated approaches like adding a version to each node, or (the preferred Redux way) use *reference comparison*.

If you are unsure of how references work, jump ahead to the next two chapters and come back to this one after.

Redux and its accompanying libraries rely on reference comparison. After the root reducer has run, we should be able to compare the state at each level of the state tree with the same level on the previous tree to determine if it has changed. But instead of comparing each key and value, we can compare only the reference or the *pointer* to the structure.

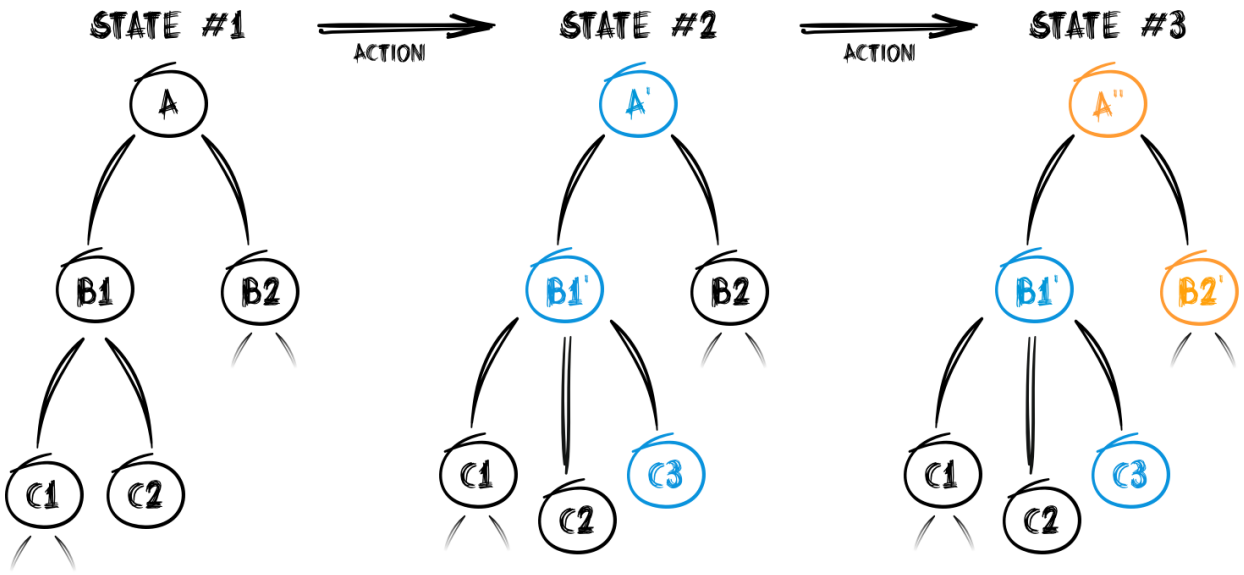
In Redux, each changed node or leaf is replaced by a new copy of itself that has the changed data. Since the node's parent still points to the old copy of the node, we need to create a copy of it as well, with the new copy pointing to the new child. This process continues with each parent being recreated until we reach the root of the tree. This means that a change to a leaf must cause its parent, the parent's parent, etc. to be modified—i.e., it causes new objects to be created. The following illustration shows the state before and after it is run through a reducers tree and highlights the changed nodes.



Example of changing nodes

The main reason reference comparison is used is that this method ensures that each reference to the previous state is kept coherent. We can examine it at any time and get the state exactly as it was before a change. If we create an array and push the current state into it before running actions, we will be able to pick any of the pointers to the previous state in the array and see the state tree exactly as it was before all the subsequent actions happened. And no matter how many more actions we process, our original pointers stay exactly as they were.

This might sound similar to copying the state each time before changing it, but the reference system will not require 10 times the memory for 10 states. It will smartly reuse all the unchanged nodes. Consider the next illustration, where two different actions have been run on the state, and how the three trees look afterward.



Example of saving references

The first action added a new node, C3, under B1. If we look closely we can see that the reducer didn't change anything in the original A tree. It only created a new A' object that holds B2 and a new B1' that holds the original C1 and C2 and the new C3'. At this point we can still use the A tree and have access to all the nodes like they were before. What's more, the new A' tree didn't copy the old one, but only created some new links that allow efficient memory reuse.

The next action modified something in the B2 subtree. Again, the only change is a new A'' root object that points to the previous B1' and the new B2'. The old states of A and A' are still intact and memory is reused between all three trees.

Since we have a coherent version of each previous state, we can implement nifty features like undo and redo (we simply save the previous state in an array and, in the case of "undo," make it the current one). We can also implement more advanced features like "time travel," where we can easily jump between versions of our state for debugging.

What Is Immutability?

The ideas we just discussed are the root of the concept of immutability. If you are familiar with immutability in JavaScript, feel free to skip the remainder of this discussion and proceed to the "Ensuring Immutability" section.

Let's define what the word *mutation* means. In JavaScript, there are two types of variables: ones that are copied by value, and ones that are passed by reference. Primitive values such as numbers, strings, and booleans are copied when you assign them to other variables, and a change to the target variable will not affect the source:

Primitive values example

```
let string = "Hello";
let copiedString = string;

copiedString += " World!";

console.log(string); // => "Hello"
console.log(copiedString); => "Hello World!"
```

In contrast, *collections* in JavaScript aren't copied when you assign them; they only receive a pointer to the location in memory of the object pointed to by the source variable. This means that any change to the new variable will modify the same memory location, which is pointed to by both the old and new variables:

Collections example

```
const object = {};
const referencedObject = object;

referencedObject.number = 42;

console.log(object); // => { number: 42 }
console.log(referencedObject); // => { number: 42 }
```

As you can see, the original object is changed when we change the copy. We used `const` here to emphasize that a constant in JavaScript holds only a pointer to the object, not its value, and no error will be thrown if you change the properties of the object (or the contents of an array). This is also true for collections passed as arguments to functions, as what is being passed is the reference and not the value itself.

Luckily for us, ES2016 lets us avoid mutations for collections in a much cleaner way than before, thanks to the `Object.assign()` method and the *spread operator*.

The spread operator is fully supported by the ES2016 standard. More information is available on MDN[3].

[3] https://developer.mozilla.org/en/docs/Web/JavaScript/Reference/Operators/Spread_operator

Objects

`Object.assign()` can be used to copy all the key/value pairs of one or more source objects into one target object. The method receives the following parameters:

1. The target object to copy to
2. One or more source objects to copy from

Complete `Object.assign()` documentation is available on MDN[4].

Since our reducers need to create a new object and make some changes to it, we will pass a new empty object as the first parameter to `Object.assign()`. The second parameter will be the original subtree to copy and the third will contain any changes we want to make to the object. This will result in us always having a fresh object with a new reference, having all the key/value pairs from the original state and any overrides needed by the current action:

Example of Object.assign()

```
function reduce(state, action) {
  const overrides = { price: 0 };

  return Object.assign({}, state, overrides);
}

const state = { ... };
const newState = reducer(state, action);

state === newState; // false!
```

Deleting properties can be done in a similar way using ES2016 syntax. To delete the key `name` from our state we can use the following:

Example of deleting a key from an object

```
return Object.assign({}, state, { name: undefined } );
```

Arrays

Arrays are a bit trickier, since they have multiple methods for adding and removing values. In general, you just have to remember which methods create a new copy of the array and which change the original one. For your convenience, here is a table outlining the basic array methods.

[4] https://developer.mozilla.org/en/docs/Web/JavaScript/Reference/Global_Objects/Object/assign

Mutating arrays

Safe methods	Mutating methods
`concat()`	`push()`
`slice()`	`splice()`
`map()`	`pop()`
`reduce()`	`shift()`
`reduceRight()`	`unshift()`
`filter()`	`fill()`
	`reverse()`
	`sort()`

The basic array operations we will be doing in most reducers are appending, deleting, and modifying an array. To keep to the immutability principles, we can achieve these using the following methods:

Adding items to an array with ES2016

```
function reducer(state, action) {
  return state.concat(newValue);
}
```

Removing items from an array with ES2016

```
function reducer(state, action) {
  return state.filter(item => item.id !== action.payload);
}
```

Changing items in an array with ES2016

```
function reducer(state, action) {
  return state.map((item) => item.id !== action.payload
    ? item
    : Object.assign({}, item, { favorite: action.payload }
  );
}
```

Ensuring Immutability

The bitter truth is that in teams with more than one developer, we can't always rely on everyone avoiding state mutations all the time. As humans, we make mistakes, and even with the strictest pull request, code review, and testing practices, sometimes they crawl into the code base. Fortunately,

there are a number of methods and tools that strive to protect developers from these hard-to-find bugs.

One approach is to use libraries like deep-freeze[5] that will throw errors every time someone tries to mutate a "frozen" object. While JavaScript provides an `Object.freeze()` method, it freezes only the object it is applied to, not its children. `deep-freeze` and similar libraries perform nested freezes and method overrides to better catch such errors.

Another approach is to use libraries that manage truly immutable objects. While they add additional dependencies to the project, they offer a number of benefits as well: they ensure true immutability, offer cleaner syntax to update collections, support nested objects and provide performance improvements on very large data sets.

The most common library is Facebook's Immutable.js[6], which offers a number of key advantages (in addition to many more advanced features):

- Fast updates on very large objects and arrays
- Lazy sequences
- Additional data types not available in plain JavaScript
- Convenient methods for deep mutation of trees
- Batched updates

It also has a few disadvantages:

- Additional large dependency for the project
- Requires the use of custom getters and setters to access the data
- Might degrade performance where large structures are not used

It is important to carefully consider your state tree before choosing an immutable library. The performance gains might only become perceptible for a small percentage of the project, and the library will require all of the developers to understand a new access syntax and collection of methods.

Another library in this space is seamless-immutable[7], which is smaller, works on plain JavaScript objects, and treats immutable objects the same way as regular JavaScript objects (though it has similar convenient setters to Immutable.js). Its author has written a great post[8] where he describes some of the issues he had with Immutable.js and what his reasoning was for creating a smaller library.

`seamless-immutable` does not offer many of the advantages of Immutable.js (sequences, batching, smart underlying data structures, etc.), and you can't use advanced ES2016 data structures with it, such as `Map`, `Set`, `WeakMap`, and `WeakSet`.

[5] https://www.npmjs.com/package/deep-freeze

[6] https://facebook.github.io/immutable-js/

[7] https://github.com/rtfeldman/seamless-immutable

[8] http://tech.noredink.com/post/107617838018/switching-from-immutablejs-to-seamless-immutable

The last approach is to use special helper functions that can receive a regular object and an instruction on how to change it and return a new object as a result. There is such an immutability helper[9] named `update()`. Its syntax might look a bit weird, but if you don't want to work with immutable objects and clog object prototypes with new functions, it might be a good option.

Example of using the update() function

```
import update from 'immutability-helper';

const newData = update(myData, {
  x: { y: { z: { $set: 7 }}},
  a: { b: { $push: [9] }}
});
```

Higher-Order Reducers

The power of Redux is that it allows you to solve complex problems using functional programming. One approach is to use higher-order functions. Since reducers are nothing more than pure functions, we can wrap them in other functions and create very simple solutions for very complicated problems.

There are a few good examples of using higher-order reducers—for example, for implementing undo/redo functionality. There is a library called redux-undo[10] that takes your reducer and enhances it with undo functionality. It creates three substates: *past, present,* and *future*. Every time your reducer creates a new state, the previous one is pushed to the past states array and the new one becomes the present state. You can then use special actions to undo, redo, or reset the present state.

Using a higher-order reducer is as simple as passing your reducer into an imported function:

Using a higher-order reducer

```
import { combineReducers } from 'redux';
import recipesReducer from 'reducers/recipes';
import ingredientsReducer from 'reducers/ingredients';
import undoable from 'redux-undo';

const rootReducer = combineReducers({
  recipes: undoable(recipesReducer),
  ingredients: ingredientsReducer
});
```

[9] https://github.com/kolodny/immutability-helper

[10] https://github.com/omnidan/redux-undo

Another example of a higher-order reducer is redux-ignore[11]. This library allows your reducers to immediately return the current state without handling the passed action, or to handle only a defined subset of actions.

The following example will disable removing recipes from our recipe book. You might even use it to filter allowed actions based on user roles:

Using the ignoreActions() higher-order reducer

```
import { combineReducers } from 'redux';
import recipesReducer from 'reducers/recipes';
import ingredientsReducer from 'reducers/ingredients';
import { ignoreActions } from 'redux-ignore';
import { REMOVE_RECIPE } from 'constants/action-types';

const rootReducer = combineReducers({
  recipes: ignoreActions(recipesReducer, [REMOVE_RECIPE])
  ingredients: ingredientsReducer
});
```

Testing Reducers

The fact that reducers are just pure functions allows us to write small and concise tests for them. To test a reducer we need to define an initial state, an action and the state we expect to have. Calling the reducer with the first two should always produce the expected state.

This idea works best when we avoid a lot of logic and control flow in reducers.

Two things that are often forgotten while testing reducers are testing unknown actions and ensuring the immutability of initial and expected objects.

Summary

In this chapter we learned about the part of Redux responsible for changing the application state. Reducers are meant to be pure functions that should never mutate the state or make any asynchronous calls. We also learned how to avoid and catch mutations in JavaScript.

In the next and final chapter, we are going to talk about *middleware*, the most powerful entity provided by Redux. When used wisely, middleware can reduce a lot of code and let us handle very complicated scenarios with ease.

[11] https://github.com/omnidan/redux-ignore