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Redux

Redux is a predictable state container for JavaScript apps.

(Not to be confused with a WordPress framework – [Redux Framework](#).)

It helps you write applications that behave consistently, run in different environments (client, server, and native), and are easy to test. On top of that, it provides a great developer experience, such as [live code editing combined with a time traveling debugger](#).

You can use Redux together with [React](#), or with any other view library.

It is tiny (2kB, including dependencies).

[build](#) [passing](#) [npm v3.7.2](#) [downloads 4M/month](#) [discord #redux @ reactiflux](#) [irc #rackt @ freenode](#)
[changelog #187](#)

Learn Redux from its creator:

[Part 1: Getting Started with Redux](#) (30 free videos)

[Part 2: Building React Applications with Idiomatic Redux](#) (27 free videos)

Testimonials

[“Love what you’re doing with Redux”](#)

Jing Chen, creator of Flux

[“I asked for comments on Redux in FB’s internal JS discussion group, and it was universally praised. Really awesome work.”](#)

Bill Fisher, author of Flux documentation

[“It’s cool that you are inventing a better Flux by not doing Flux at all.”](#)

André Staltz, creator of Cycle

Before Proceeding Further

Also read:

[You Might Not Need Redux](#)

Developer Experience

I wrote Redux while working on my React Europe talk called [“Hot Reloading with Time Travel”](#). My goal was to create a state management library with minimal API but completely predictable behavior, so it is possible to implement logging, hot reloading, time travel, universal apps, record and replay, without any buy-in from the developer.

Influences

Redux evolves the ideas of [Flux](#), but avoids its complexity by taking cues from [Elm](#).

Whether you have used them or not, Redux only takes a few minutes to get started with.

Installation

To install the stable version:

```
npm install --save redux
```

This assumes you are using [npm](#) as your package manager.

If you're not, you can [access these files on unpkg](#), download them, or point your package manager to them.

Most commonly people consume Redux as a collection of [CommonJS](#) modules. These modules are what you get when you import `redux` in a [Webpack](#), [Browserify](#), or a Node environment. If you like to live on the edge and use [Rollup](#), we support that as well.

If you don't use a module bundler, it's also fine. The `redux` npm package includes precompiled production and development UMD builds in the `dist` folder. They can be used directly without a bundler and are thus compatible with many popular JavaScript module loaders and environments. For example, you can drop a UMD build as a `<script>` tag on the page, or [tell Bower to install it](#). The UMD builds make Redux available as a `window.Redux` global variable.

The Redux source code is written in ES2015 but we precompile both CommonJS and UMD builds to ES5 so they work in [any modern browser](#). You don't need to use Babel or a module bundler to [get started with Redux](#).

Complementary Packages

Most likely, you'll also need [the React bindings](#) and [the developer tools](#).

```
npm install --save react-redux
npm install --save-dev redux-devtools
```

Note that unlike Redux itself, many packages in the Redux ecosystem don't provide UMD builds, so we recommend using CommonJS module bundlers like [Webpack](#) and [Browserify](#) for the most comfortable development experience.

The Gist

The whole state of your app is stored in an object tree inside a single *store*.

The only way to change the state tree is to emit an *action*, an object describing what happened.

To specify how the actions transform the state tree, you write pure *reducers*.

That's it!

```
import { createStore } from 'redux'

/**
 * This is a reducer, a pure function with (state, action) => state signature.
 * It describes how an action transforms the state into the next state.
 *
 * The shape of the state is up to you: it can be a primitive, an array, an object,
 * or even an Immutable.js data structure. The only important part is that you should
 * not mutate the state object, but return a new object if the state changes.
 *
 * In this example, we use a `switch` statement and strings, but you can use a helper that
 * follows a different convention (such as function maps) if it makes sense for your
 * project.
 */
function counter(state = 0, action) {
  switch (action.type) {
    case 'INCREMENT':
      return state + 1
    case 'DECREMENT':
      return state - 1
  }
}
```

```

    return state - 1
  default:
    return state
  }
}

// Create a Redux store holding the state of your app.
// Its API is { subscribe, dispatch, getState }.
let store = createStore(counter)

// You can use subscribe() to update the UI in response to state changes.
// Normally you'd use a view binding library (e.g. React Redux) rather than subscribe() directly.
// However it can also be handy to persist the current state in the localStorage.

store.subscribe(() =>
  console.log(store.getState())
)

// The only way to mutate the internal state is to dispatch an action.
// The actions can be serialized, logged or stored and later replayed.
store.dispatch({ type: 'INCREMENT' })
// 1
store.dispatch({ type: 'INCREMENT' })
// 2
store.dispatch({ type: 'DECREMENT' })
// 1

```

Instead of mutating the state directly, you specify the mutations you want to happen with plain objects called *actions*. Then you write a special function called a *reducer* to decide how every action transforms the entire application's state.

If you're coming from Flux, there is a single important difference you need to understand. Redux doesn't have a Dispatcher or support many stores. Instead, there is just a single store with a single root reducing function. As your app grows, instead of adding stores, you split the root reducer into smaller reducers independently operating on the different parts of the state tree. This is exactly like how there is just one root component in a React app, but it is composed out of many small components.

This architecture might seem like an overkill for a counter app, but the beauty of this pattern is how well it scales to large and complex apps. It also enables very powerful developer tools, because it is possible to trace every mutation to the action that caused it. You can record user sessions and reproduce them just by replaying every action.

Learn Redux from Its Creator

[Getting Started with Redux](#) is a video course consisting of 30 videos narrated by Dan Abramov, author of Redux. It is designed to complement the “Basics” part of the docs while bringing additional insights about immutability, testing, Redux best practices, and using Redux with React. **This course is free and will always be.**

“Great course on egghead.io by @dan_abramov - instead of just showing you how to use #redux, it also shows how and why redux was built!”

Sandrino Di Mattia

“Plowing through @dan_abramov 'Getting Started with Redux' - its amazing how much simpler concepts get with video.”

Chris Dhanaraj

“This video series on Redux by @dan_abramov on @eggheadio is spectacular!”

Eddie Zaneski

“Come for the name hype. Stay for the rock solid fundamentals. (Thanks, and great job @dan_abramov and @eggheadio!)”

Dan

"This series of videos on Redux by @dan_abramov is repeatedly blowing my mind - gunna do some serious refactoring"

Laurence Roberts

So, what are you waiting for?

Watch the 30 Free Videos!

If you enjoyed my course, consider supporting Egghead by [buying a subscription](#). Subscribers have access to the source code of every example in my videos and tons of advanced lessons on other topics, including JavaScript in depth, React, Angular, and more. Many [Egghead instructors](#) are also open source library authors, so buying a subscription is a nice way to thank them for the work that they've done.

Documentation

- [Introduction](#)
- [Basics](#)
- [Advanced](#)
- [Recipes](#)
- [FAQ](#)
- [Troubleshooting](#)
- [Glossary](#)
- [API Reference](#)

For PDF, ePub, and MOBI exports for offline reading, and instructions on how to create them, please see: [paulkogel/redux-offline-docs](#).

For Offline docs, please see: [devdocs](#)

Examples

Almost all examples have a corresponding CodeSandbox sandbox. This is an interactive version of the code that you can play with online.

- [Counter Vanilla \(source\)](#)
- [Counter \(source, sandbox\)](#)
- [Todos \(source, sandbox\)](#)
- [Todos with Undo \(source, sandbox\)](#)
- [TodoMVC \(source, sandbox\)](#)
- [Shopping Cart \(source, sandbox\)](#)
- [Tree View \(source, sandbox\)](#)
- [Async \(source, sandbox\)](#)
- [Universal \(source\)](#)
- [Real World \(source, sandbox\)](#)

If you're new to the NPM ecosystem and have troubles getting a project up and running, or aren't sure where to paste the gist above, check out [simplest-redux-example](#) that uses Redux together with React and Browserify.

Discussion

Join the [#redux](#) channel of the [Reactiflux](#) Discord community.

Thanks

- [The Elm Architecture](#) for a great intro to modeling state updates with reducers;
- [Turning the database inside-out](#) for blowing my mind;
- [Developing ClojureScript with Figwheel](#) for convincing me that re-evaluation should “just work”;
- [Webpack](#) for Hot Module Replacement;
- [Flummox](#) for teaching me to approach Flux without boilerplate or singletons;
- [disto](#) for a proof of concept of hot reloadable Stores;
- [NuclearJS](#) for proving this architecture can be performant;
- [Om](#) for popularizing the idea of a single state atom;
- [Cycle](#) for showing how often a function is the best tool;
- [React](#) for the pragmatic innovation.

Special thanks to [Jamie Paton](#) for handing over the `redux` NPM package name.

Logo

You can find the official logo [on GitHub](#).

Change Log

This project adheres to [Semantic Versioning](#).

Every release, along with the migration instructions, is documented on the Github [Releases](#) page.

Patrons

The work on Redux was [funded by the community](#).

Meet some of the outstanding companies that made it possible:

- [Webflow](#)
- [Ximedes](#)

See the full list of [Redux patrons](#), as well as the always-growing list of [people and companies that use Redux](#).

License

MIT

Introduction

- Motivation
- Core Concepts
- Three Principles
- Prior Art
- Ecosystem
- Examples

Motivation

As the requirements for JavaScript single-page applications have become increasingly complicated, **our code must manage more state than ever before**. This state can include server responses and cached data, as well as locally created data that has not yet been persisted to the server. UI state is also increasing in complexity, as we need to manage active routes, selected tabs, spinners, pagination controls, and so on.

Managing this ever-changing state is hard. If a model can update another model, then a view can update a model, which updates another model, and this, in turn, might cause another view to update. At some point, you no longer understand what happens in your app as you have **lost control over the when, why, and how of its state**. When a system is opaque and non-deterministic, it's hard to reproduce bugs or add new features.

As if this wasn't bad enough, consider the **new requirements becoming common in front-end product development**. As developers, we are expected to handle optimistic updates, server-side rendering, fetching data before performing route transitions, and so on. We find ourselves trying to manage a complexity that we have never had to deal with before, and we inevitably ask the question: [is it time to give up?](#) The answer is *no*.

This complexity is difficult to handle as **we're mixing two concepts** that are very hard for the human mind to reason about: **mutation and asynchronicity**. I call them *Mentos and Coke*. Both can be great in separation, but together they create a mess. Libraries like [React](#) attempt to solve this problem in the view layer by removing both asynchrony and direct DOM manipulation. However, managing the state of your data is left up to you. This is where Redux enters.

Following in the steps of [Flux](#), [CQRS](#), and [Event Sourcing](#), **Redux attempts to make state mutations predictable** by imposing certain restrictions on how and when updates can happen. These restrictions are reflected in the [three principles](#) of Redux.

Core Concepts

Redux itself is very simple.

Imagine your app's state is described as a plain object. For example, the state of a todo app might look like this:

```
{
  todos: [
    {
      text: 'Eat food',
      completed: true
    },
    {
      text: 'Exercise',
      completed: false
    }
  ],
  visibilityFilter: 'SHOW_COMPLETED'
}
```

This object is like a “model” except that there are no setters. This is so that different parts of the code can't change the state arbitrarily, causing hard-to-reproduce bugs.

To change something in the state, you need to dispatch an action. An action is a plain JavaScript object (notice how we don't introduce any magic?) that describes what happened. Here are a few example actions:

```
{ type: 'ADD_TODO', text: 'Go to swimming pool' }
{ type: 'TOGGLE_TODO', index: 1 }
{ type: 'SET_VISIBILITY_FILTER', filter: 'SHOW_ALL' }
```

Enforcing that every change is described as an action lets us have a clear understanding of what's going on in the app. If something changed, we know why it changed. Actions are like breadcrumbs of what has happened. Finally, to tie state and actions together, we write a function called a reducer. Again, nothing magical about it—it's just a function that takes state and action as arguments, and returns the next state of the app. It would be hard to write such a function for a big app, so we write smaller functions managing parts of the state:

```
function visibilityFilter(state = 'SHOW_ALL', action) {
  if (action.type === 'SET_VISIBILITY_FILTER') {
    return action.filter
  } else {
    return state
  }
}

function todos(state = [], action) {
  switch (action.type) {
    case 'ADD_TODO':
      return state.concat([{ text: action.text, completed: false }])
    case 'TOGGLE_TODO':
      return state.map(
        (todo, index) =>
          action.index === index
            ? { text: todo.text, completed: !todo.completed }
            : todo
      )
    default:
      return state
  }
}
```

And we write another reducer that manages the complete state of our app by calling those two reducers for the corresponding state keys:

```
function todoApp(state = {}, action) {
  return {
    todos: todos(state.todos, action),
    visibilityFilter: visibilityFilter(state.visibilityFilter, action)
  }
}
```

This is basically the whole idea of Redux. Note that we haven't used any Redux APIs. It comes with a few utilities to facilitate this pattern, but the main idea is that you describe how your state is updated over time in response to action objects, and 90% of the code you write is just plain JavaScript, with no use of Redux itself, its APIs, or any magic.

Three Principles

Redux can be described in three fundamental principles:

Single source of truth

The **state** of your whole application is stored in an object tree within a single **store**.

This makes it easy to create universal apps, as the state from your server can be serialized and hydrated into the client with no extra coding effort. A single state tree also makes it easier to debug or inspect an application; it also enables you to persist your app's state in development, for a faster development cycle. Some functionality which has been traditionally difficult to implement - Undo/Redo, for example - can suddenly become trivial to implement, if all of your state is stored in a single tree.

```
console.log(store.getState())

/* Prints
{
  visibilityFilter: 'SHOW_ALL',
  todos: [
    {
      text: 'Consider using Redux',
      completed: true,
    },
    {
      text: 'Keep all state in a single tree',
      completed: false
    }
  ]
} */
*/
```

State is read-only

The only way to change the state is to emit an **action**, an object describing what happened.

This ensures that neither the views nor the network callbacks will ever write directly to the state. Instead, they express an intent to transform the state. Because all changes are centralized and happen one by one in a strict order, there are no subtle race conditions to watch out for. As actions are just plain objects, they can be logged, serialized, stored, and later replayed for debugging or testing purposes.

```
store.dispatch({
  type: 'COMPLETE_TODO',
  index: 1
})

store.dispatch({
  type: 'SET_VISIBILITY_FILTER',
  filter: 'SHOW_COMPLETED'
})
```

Changes are made with pure functions

To specify how the state tree is transformed by actions, you write pure **reducers**.

Reducers are just pure functions that take the previous state and an action, and return the next state. Remember to return new state objects, instead of mutating the previous state. You can start with a single reducer, and as your app grows, split it off into smaller reducers that manage specific parts of the state tree. Because reducers are just

functions, you can control the order in which they are called, pass additional data, or even make reusable reducers for common tasks such as pagination.

```
function visibilityFilter(state = 'SHOW_ALL', action) {
  switch (action.type) {
    case 'SET_VISIBILITY_FILTER':
      return action.filter
    default:
      return state
  }
}

function todos(state = [], action) {
  switch (action.type) {
    case 'ADD_TODO':
      return [
        ...state,
        {
          text: action.text,
          completed: false
        }
      ]
    case 'COMPLETE_TODO':
      return state.map((todo, index) => {
        if (index === action.index) {
          return Object.assign({}, todo, {
            completed: true
          })
        }
        return todo
      })
    default:
      return state
  }
}

import { combineReducers, createStore } from 'redux'
const reducer = combineReducers({ visibilityFilter, todos })
const store = createStore(reducer)
```

That's it! Now you know what Redux is all about.

Prior Art

Redux has a mixed heritage. It is similar to some patterns and technologies, but is also different from them in important ways. We'll explore some of the similarities and the differences below.

Flux

Can Redux be considered a [Flux](#) implementation?

[Yes](#), and [no](#).

(Don't worry, [Flux creators approve of it](#), if that's all you wanted to know.)

Redux was inspired by several important qualities of Flux. Like Flux, Redux prescribes that you concentrate your model update logic in a certain layer of your application ("stores" in Flux, "reducers" in Redux). Instead of letting the application code directly mutate the data, both tell you to describe every mutation as a plain object called an "action".

Unlike Flux, **Redux does not have the concept of a Dispatcher**. This is because it relies on pure functions instead of event emitters, and pure functions are easy to compose and don't need an additional entity managing them.

Depending on how you view Flux, you may see this as either a deviation or an implementation detail. Flux has often been [described as](#) `(state, action) => state`. In this sense, Redux is true to the Flux architecture, but makes it simpler thanks to pure functions.

Another important difference from Flux is that **Redux assumes you never mutate your data**. You can use plain objects and arrays for your state just fine, but mutating them inside the reducers is strongly discouraged. You should always return a new object, which is easy with the [object spread operator proposal](#), or with a library like [Immutable](#).

While it is technically *possible* to [write impure reducers](#) that mutate the data for performance corner cases, we actively discourage you from doing this. Development features like time travel, record/replay, or hot reloading will break.

Moreover it doesn't seem like immutability poses performance problems in most real apps, because, as [Om](#) demonstrates, even if you lose out on object allocation, you still win by avoiding expensive re-renders and re-calculations, as you know exactly what changed thanks to reducer purity.

Elm

[Elm](#) is a functional programming language inspired by Haskell and created by [Evan Czaplicki](#). It enforces a "model view update" architecture, where the update has the following signature: `(action, state) => state`. Elm "updaters" serve the same purpose as reducers in Redux.

Unlike Redux, Elm is a language, so it is able to benefit from many things like enforced purity, static typing, out of the box immutability, and pattern matching (using the `case` expression). Even if you don't plan to use Elm, you should read about the Elm architecture, and play with it. There is an interesting [JavaScript library playground implementing similar ideas](#). We should look there for inspiration on Redux! One way that we can get closer to the static typing of Elm is by [using a gradual typing solution like Flow](#).

Immutable

[Immutable](#) is a JavaScript library implementing persistent data structures. It is performant and has an idiomatic JavaScript API.

Immutable and most similar libraries are orthogonal to Redux. Feel free to use them together!

Redux doesn't care how you store the state—it can be a plain object, an Immutable object, or anything else. You'll probably want a (de)serialization mechanism for writing universal apps and hydrating their state from the server, but other than that, you can use any data storage library *as long as it supports immutability*. For example, it doesn't make sense to use Backbone for Redux state, because Backbone models are mutable.

Note that, even if your immutable library supports cursors, you shouldn't use them in a Redux app. The whole state tree should be considered read-only, and you should use Redux for updating the state, and subscribing to the updates. Therefore writing via cursor doesn't make sense for Redux. **If your only use case for cursors is decoupling the state tree from the UI tree and gradually refining the cursors, you should look at selectors instead.** Selectors are composable getter functions. See [reselect](#) for a really great and concise implementation of composable selectors.

Baobab

[Baobab](#) is another popular library implementing immutable API for updating plain JavaScript objects. While you can use it with Redux, there is little benefit in using them together.

Most of the functionality Baobab provides is related to updating the data with cursors, but Redux enforces that the only way to update the data is to dispatch an action. Therefore they solve the same problem differently, and don't complement each other.

Unlike Immutable, Baobab doesn't yet implement any special efficient data structures under the hood, so you don't really win anything from using it together with Redux. It's easier to just use plain objects in this case.

RxJS

[RxJS](#) is a superb way to manage the complexity of asynchronous apps. In fact there is an effort to create a library that models human-computer interaction as interdependent observables.

Does it make sense to use Redux together with RxJS? Sure! They work great together. For example, it is easy to expose a Redux store as an observable:

```
function toObservable(store) {
  return {
    subscribe({ next }) {
      const unsubscribe = store.subscribe(() => next(store.getState()))
      next(store.getState())
      return { unsubscribe }
    }
  }
}
```

Similarly, you can compose different asynchronous streams to turn them into actions before feeding them to `store.dispatch()`.

The question is: do you really need Redux if you already use Rx? Maybe not. It's not hard to [re-implement Redux in Rx](#). Some say it's a two-liner using Rx `.scan()` method. It may very well be!

If you're in doubt, check out the Redux source code (there isn't much going on there), as well as its ecosystem (for example, [the developer tools](#)). If you don't care too much about it and want to go with the reactive data flow all the way, you might want to explore something like [Cycle](#) instead, or even combine it with Redux. Let us know how it goes!

Ecosystem

Redux is a tiny library, but its contracts and APIs are carefully chosen to spawn an ecosystem of tools and extensions.

For an extensive list of everything related to Redux, we recommend [Awesome Redux](#). It contains examples, boilerplates, middleware, utility libraries, and more. [React/Redux Links](#) contains tutorials and other useful resources for anyone learning React or Redux, and [Redux Ecosystem Links](#) lists many Redux-related libraries and addons.

On this page we will only feature a few of them that the Redux maintainers have vetted personally. Don't let this discourage you from trying the rest of them! The ecosystem is growing too fast, and we have a limited time to look at everything. Consider these the "staff picks", and don't hesitate to submit a PR if you've built something wonderful with Redux.

Learning Redux

Screencasts

- [Getting Started with Redux](#) — Learn the basics of Redux directly from its creator (30 free videos)
- [Learn Redux](#) — Build a simple photo app that will simplify the core ideas behind Redux, React Router and React.js

Example Apps

- [Official Examples](#) — A few official examples covering different Redux techniques
- [SoundRedux](#) — A SoundCloud client built with Redux
- [grafgiti](#) — Create graffiti on your GitHub contributions wall
- [React-lego](#) — How to plug into React, one block at a time.

Tutorials and Articles

- [Redux Tutorial](#)
- [Redux Egghead Course Notes](#)
- [Integrating Data with React Native](#)
- [What the Flux?! Let's Redux.](#)
- [Leveling Up with React: Redux](#)
- [A cartoon intro to Redux](#)
- [Understanding Redux](#)
- [Handcrafting an Isomorphic Redux Application \(With Love\)](#)
- [Full-Stack Redux Tutorial](#)
- [Getting Started with React, Redux, and Immutable](#)
- [Secure Your React and Redux App with JWT Authentication](#)
- [Understanding Redux Middleware](#)
- [Angular 2 — Introduction to Redux](#)
- [Apollo Client: GraphQL with React and Redux](#)
- [Using redux-saga To Simplify Your Growing React Native Codebase](#)
- [Build an Image Gallery Using Redux Saga](#)
- [Working with VK API \(in Russian\)](#)

Talks

- [Live React: Hot Reloading and Time Travel](#) — See how constraints enforced by Redux make hot reloading with time travel easy
- [Cleaning the Tar: Using React within the Firefox Developer Tools](#) — Learn how to gradually migrate existing MVC applications to Redux
- [Redux: Simplifying Application State](#) — An intro to Redux architecture

Using Redux

Bindings

- [react-redux](#) — React
- [ng-redux](#) — Angular
- [ng2-redux](#) — Angular 2
- [backbone-redux](#) — Backbone
- [redux-falcor](#) — Falcor
- [deku-redux](#) — Deku
- [polymer-redux](#) - Polymer
- [ember-redux](#) - Ember.js

Middleware

- [redux-thunk](#) — The easiest way to write async action creators
- [redux-promise](#) — FSA-compliant promise middleware
- [redux-axios-middleware](#) — Redux middleware for fetching data with axios HTTP client
- [redux-observable](#) — RxJS middleware for action side effects using "Epics"
- [redux-cycles](#) — Handle Redux async actions using Cycle.js
- [redux-logger](#) — Log every Redux action and the next state
- [redux-immutable-state-invariant](#) — Warns about state mutations in development
- [redux-unhandled-action](#) — Warns about actions that produced no state changes in development
- [redux-analytics](#) — Analytics middleware for Redux
- [redux-gen](#) — Generator middleware for Redux
- [redux-saga](#) — An alternative side effect model for Redux apps
- [redux-action-tree](#) — Composable Cerebral-style signals for Redux
- [apollo-client](#) — A simple caching client for any GraphQL server and UI framework built on top of Redux

Routing

- [react-router-redux](#) — Ruthlessly simple bindings to keep React Router and Redux in sync
- [redial](#) — Universal data fetching and route lifecycle management for React that works great with Redux

Components

- [redux-form](#) — Keep React form state in Redux
- [react-redux-form](#) — Create forms easily in React with Redux

Enhancers

- [redux-batched-subscribe](#) — Customize batching and debouncing calls to the store subscribers
- [redux-history-transitions](#) — History transitions based on arbitrary actions
- [redux-optimist](#) — Optimistically apply actions that can be later committed or reverted
- [redux-optimistic-ui](#) — A reducer enhancer to enable type-agnostic optimistic updates

- [redux-undo](#) — Effortless undo/redo and action history for your reducers
- [redux-ignore](#) — Ignore redux actions by array or filter function
- [redux-recycle](#) — Reset the redux state on certain actions
- [redux-batched-actions](#) — Dispatch several actions with a single subscriber notification
- [redux-search](#) — Automatically index resources in a web worker and search them without blocking
- [redux-electron-store](#) — Store enhancers that synchronize Redux stores across Electron processes
- [redux-loop](#) — Sequence effects purely and naturally by returning them from your reducers
- [redux-side-effects](#) — Utilize Generators for declarative yielding of side effects from your pure reducers

Utilities

- [reselect](#) — Efficient derived data selectors inspired by NuclearJS
- [normalizr](#) — Normalize nested API responses for easier consumption by the reducers
- [redux-actions](#) — Reduces the boilerplate in writing reducers and action creators
- [redux-act](#) — An opinionated library for making reducers and action creators
- [redux-transducers](#) — Transducer utilities for Redux
- [redux-immutable](#) — Used to create an equivalent function of Redux `combineReducers` that works with [Immutable.js](#) state.
- [redux-tcomb](#) — Immutable and type-checked state and actions for Redux
- [redux-mock-store](#) — Mock redux store for testing your app
- [redux-actions-assertions](#) — Assertions for Redux actions testing
- [redux-bootstrap](#) — Bootstrapping function for Redux applications
- [redux-data-structures](#) — Reducer factory (higher-order functions) for counters, maps, lists (queues, stacks), sets, etc.

DevTools

- [Redux DevTools](#) — An action logger with time travel UI, hot reloading and error handling for the reducers, [first demoed at React Europe](#)
- [Redux DevTools Extension](#) — A Chrome extension wrapping Redux DevTools and providing additional functionality

DevTools Monitors

- [Log Monitor](#) — The default monitor for Redux DevTools with a tree view
- [Dock Monitor](#) — A resizable and movable dock for Redux DevTools monitors
- [Slider Monitor](#) — A custom monitor for Redux DevTools to replay recorded Redux actions
- [Inspector](#) — A custom monitor for Redux DevTools that lets you filter actions, inspect diffs, and pin deep paths in the state to observe their changes
- [Diff Monitor](#) — A monitor for Redux Devtools that diffs the Redux store mutations between actions
- [Filterable Log Monitor](#) — Filterable tree view monitor for Redux DevTools
- [Chart Monitor](#) — A chart monitor for Redux DevTools
- [Filter Actions](#) — Redux DevTools composable monitor with the ability to filter actions

Community Conventions

- [Flux Standard Action](#) — A human-friendly standard for Flux action objects
- [Canonical Reducer Composition](#) — An opinionated standard for nested reducer composition
- [Ducks: Redux Reducer Bundles](#) — A proposal for bundling reducers, action types and actions

Translations

- [中文文档 — Chinese](#)
- [繁體中文文件 — Traditional Chinese](#)
- [Redux in Russian — Russian](#)
- [Redux en Español - Spanish](#)

More

[Awesome Redux](#) is an extensive list of Redux-related repositories.

[React-Redux Links](#) is a curated list of high-quality articles, tutorials, and related content for React, Redux, ES6, and more.

[Redux Ecosystem Links](#) is a categorized collection of Redux-related libraries, addons, and utilities.

Examples

Redux is distributed with a few examples in its [source code](#). Most of these examples are also on [CodeSandbox](#), this is an online editor that lets you play with the examples online.

Counter Vanilla

Run the [Counter Vanilla](#) example:

```
git clone https://github.com/reactjs/redux.git
cd redux/examples/counter-vanilla
open index.html
```

It does not require a build system or a view framework and exists to show the raw Redux API used with ES5.

Counter

Run the [Counter](#) example:

```
git clone https://github.com/reactjs/redux.git
cd redux/examples/counter
npm install
npm start

open http://localhost:3000/
```

Or check out the [sandbox](#).

This is the most basic example of using Redux together with React. For simplicity, it re-renders the React component manually when the store changes. In real projects, you will likely want to use the highly performant [React Redux](#) bindings instead.

This example includes tests.

Todos

Run the [Todos](#) example:

```
git clone https://github.com/reactjs/redux.git
cd redux/examples/todos
npm install
npm start

open http://localhost:3000/
```

Or check out the [sandbox](#).

This is the best example to get a deeper understanding of how the state updates work together with components in Redux. It shows how reducers can delegate handling actions to other reducers, and how you can use [React Redux](#) to generate container components from your presentational components.

This example includes tests.

Todos with Undo

Run the [Todos with Undo](#) example:

```
git clone https://github.com/reactjs/redux.git
cd redux/examples/todos-with-undo
npm install
npm start

open http://localhost:3000/
```

Or check out the [sandbox](#).

This is a variation on the previous example. It is almost identical, but additionally shows how wrapping your reducer with [Redux Undo](#) lets you add a Undo/Redo functionality to your app with a few lines of code.

TodoMVC

Run the [TodoMVC](#) example:

```
git clone https://github.com/reactjs/redux.git
cd redux/examples/todomvc
npm install
npm start

open http://localhost:3000/
```

Or check out the [sandbox](#).

This is the classical [TodoMVC](#) example. It's here for the sake of comparison, but it covers the same points as the Todos example.

This example includes tests.

Shopping Cart

Run the [Shopping Cart](#) example:

```
git clone https://github.com/reactjs/redux.git
cd redux/examples/shopping-cart
npm install
npm start

open http://localhost:3000/
```

Or check out the [sandbox](#).

This example shows important idiomatic Redux patterns that become important as your app grows. In particular, it shows how to store entities in a normalized way by their IDs, how to compose reducers on several levels, and how to define selectors alongside the reducers so the knowledge about the state shape is encapsulated. It also demonstrates logging with [Redux Logger](#) and conditional dispatching of actions with [Redux Thunk](#) middleware.

Tree View

Run the [Tree View](#) example:

```
git clone https://github.com/reactjs/redux.git  
cd redux/examples/tree-view  
npm install  
npm start  
  
open http://localhost:3000/
```

Or check out the [sandbox](#).

This example demonstrates rendering a deeply nested tree view and representing its state in a normalized form so it is easy to update from reducers. Good rendering performance is achieved by the container components granularly subscribing only to the tree nodes that they render.

This example includes tests.

Async

Run the [Async](#) example:

```
git clone https://github.com/reactjs/redux.git  
cd redux/examples/async  
npm install  
npm start  
  
open http://localhost:3000/
```

Or check out the [sandbox](#).

This example includes reading from an asynchronous API, fetching data in response to user input, showing loading indicators, caching the response, and invalidating the cache. It uses [Redux Thunk](#) middleware to encapsulate asynchronous side effects.

Universal

Run the [Universal](#) example:

```
git clone https://github.com/reactjs/redux.git  
cd redux/examples/universal  
npm install  
npm start  
  
open http://localhost:3000/
```

This is a basic demonstration of [server rendering](#) with Redux and React. It shows how to prepare the initial store state on the server, and pass it down to the client so the client store can boot up from an existing state.

Real World

Run the [Real World](#) example:

```
git clone https://github.com/reactjs/redux.git  
cd redux/examples/real-world  
npm install  
npm start  
  
open http://localhost:3000/
```

Or check out the [sandbox](#).

This is the most advanced example. It is dense by design. It covers keeping fetched entities in a normalized cache, implementing a custom middleware for API calls, rendering partially loaded data, pagination, caching responses, displaying error messages, and routing. Additionally, it includes Redux DevTools.

More Examples

You can find more examples in [Awesome Redux](#).

Basics

Don't be fooled by all the fancy talk about reducers, middleware, store enhancers—Redux is incredibly simple. If you've ever built a Flux application, you will feel right at home. If you're new to Flux, it's easy too!

In this guide, we'll walk through the process of creating a simple Todo app.

- [Actions](#)
- [Reducers](#)
- [Store](#)
- [Data Flow](#)
- [Usage with React](#)
- [Example: Todo List](#)

Actions

First, let's define some actions.

Actions are payloads of information that send data from your application to your store. They are the *only* source of information for the store. You send them to the store using `store.dispatch()`.

Here's an example action which represents adding a new todo item:

```
const ADD_TODO = 'ADD_TODO'

{
  type: ADD_TODO,
  text: 'Build my first Redux app'
}
```

Actions are plain JavaScript objects. Actions must have a `type` property that indicates the type of action being performed. Types should typically be defined as string constants. Once your app is large enough, you may want to move them into a separate module.

```
import { ADD_TODO, REMOVE_TODO } from '../actionTypes'
```

Note on Boilerplate

You don't have to define action type constants in a separate file, or even to define them at all. For a small project, it might be easier to just use string literals for action types. However, there are some benefits to explicitly declaring constants in larger codebases. Read [Reducing Boilerplate](#) for more practical tips on keeping your codebase clean.

Other than `type`, the structure of an action object is really up to you. If you're interested, check out [Flux Standard Action](#) for recommendations on how actions could be constructed.

We'll add one more action type to describe a user ticking off a todo as completed. We refer to a particular todo by `index` because we store them in an array. In a real app, it is wiser to generate a unique ID every time something new is created.

```
{
  type: TOGGLE_TODO,
  index: 5
}
```

It's a good idea to pass as little data in each action as possible. For example, it's better to pass `index` than the whole todo object.

Finally, we'll add one more action type for changing the currently visible todos.

```
{
  type: SET_VISIBILITY_FILTER,
  filter: SHOW_COMPLETED
}
```

Action Creators

Action creators are exactly that—functions that create actions. It's easy to conflate the terms “action” and “action creator,” so do your best to use the proper term.

In Redux action creators simply return an action:

```
function addTodo(text) {
  return {
    type: ADD_TODO,
    text
  }
}
```

This makes them portable and easy to test.

In [traditional Flux](#), action creators often trigger a dispatch when invoked, like so:

```
function addTodoWithDispatch(text) {
  const action = {
    type: ADD_TODO,
    text
  }
  dispatch(action)
}
```

In Redux this is *not* the case.

Instead, to actually initiate a dispatch, pass the result to the `dispatch()` function:

```
dispatch(addTodo(text))
dispatch(completeTodo(index))
```

Alternatively, you can create a **bound action creator** that automatically dispatches:

```
const boundAddTodo = text => dispatch(addTodo(text))
const boundCompleteTodo = index => dispatch(completeTodo(index))
```

Now you'll be able to call them directly:

```
boundAddTodo(text)
boundCompleteTodo(index)
```

The `dispatch()` function can be accessed directly from the store as `store.dispatch()`, but more likely you'll access it using a helper like [react-redux](#)'s `connect()`. You can use `bindActionCreators()` to automatically bind many action creators to a `dispatch()` function.

Action creators can also be asynchronous and have side-effects. You can read about [async actions](#) in the [advanced tutorial](#) to learn how to handle AJAX responses and compose action creators into async control flow. Don't skip ahead to async actions until you've completed the basics tutorial, as it covers other important concepts that are prerequisite for the advanced tutorial and async actions.

Source Code

actions.js

```
/*
 * action types
 */
```

```
export const ADD_TODO = 'ADD_TODO'
export const TOGGLE_TODO = 'TOGGLE_TODO'
export const SET_VISIBILITY_FILTER = 'SET_VISIBILITY_FILTER'

/*
 * other constants
 */

export const VisibilityFilters = {
  SHOW_ALL: 'SHOW_ALL',
  SHOW_COMPLETED: 'SHOW_COMPLETED',
  SHOW_ACTIVE: 'SHOW_ACTIVE'
}

/*
 * action creators
 */

export function addTodo(text) {
  return { type: ADD_TODO, text }
}

export function toggleTodo(index) {
  return { type: TOGGLE_TODO, index }
}

export function setVisibilityFilter(filter) {
  return { type: SET_VISIBILITY_FILTER, filter }
}
```

Next Steps

Now let's [define some reducers](#) to specify how the state updates when you dispatch these actions!

Reducers

[Actions](#) describe the fact that *something happened*, but don't specify how the application's state changes in response. This is the job of reducers.

Designing the State Shape

In Redux, all the application state is stored as a single object. It's a good idea to think of its shape before writing any code. What's the minimal representation of your app's state as an object?

For our todo app, we want to store two different things:

- The currently selected visibility filter;
- The actual list of todos.

You'll often find that you need to store some data, as well as some UI state, in the state tree. This is fine, but try to keep the data separate from the UI state.

```
{
  visibilityFilter: 'SHOW_ALL',
  todos: [
    {
      text: 'Consider using Redux',
      completed: true,
    },
    {
      text: 'Keep all state in a single tree',
      completed: false
    }
  ]
}
```

Note on Relationships

In a more complex app, you're going to want different entities to reference each other. We suggest that you keep your state as normalized as possible, without any nesting. Keep every entity in an object stored with an ID as a key, and use IDs to reference it from other entities, or lists. Think of the app's state as a database. This approach is described in [normalizr's](#) documentation in detail. For example, keeping `todosById: { id -> todo }` and `todos: array<id>` inside the state would be a better idea in a real app, but we're keeping the example simple.

Handling Actions

Now that we've decided what our state object looks like, we're ready to write a reducer for it. The reducer is a pure function that takes the previous state and an action, and returns the next state.

```
(previousState, action) => newState
```

It's called a reducer because it's the type of function you would pass to `Array.prototype.reduce(reducer, ? initialValue)`. It's very important that the reducer stays pure. Things you should **never** do inside a reducer:

- Mutate its arguments;
- Perform side effects like API calls and routing transitions;

- Call non-pure functions, e.g. `Date.now()` or `Math.random()`.

We'll explore how to perform side effects in the [advanced walkthrough](#). For now, just remember that the reducer must be pure. **Given the same arguments, it should calculate the next state and return it. No surprises. No side effects. No API calls. No mutations. Just a calculation.**

With this out of the way, let's start writing our reducer by gradually teaching it to understand the `actions` we defined earlier.

We'll start by specifying the initial state. Redux will call our reducer with an `undefined` state for the first time. This is our chance to return the initial state of our app:

```
import { VisibilityFilters } from './actions'

const initialState = {
  visibilityFilter: VisibilityFilters.SHOW_ALL,
  todos: []
}

function todoApp(state, action) {
  if (typeof state === 'undefined') {
    return initialState
  }

  // For now, don't handle any actions
  // and just return the state given to us.
  return state
}
```

One neat trick is to use the [ES6 default arguments syntax](#) to write this in a more compact way:

```
function todoApp(state = initialState, action) {
  // For now, don't handle any actions
  // and just return the state given to us.
  return state
}
```

Now let's handle `SET_VISIBILITY_FILTER`. All it needs to do is to change `visibilityFilter` on the state. Easy:

```
function todoApp(state = initialState, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return Object.assign({}, state, {
        visibilityFilter: action.filter
      })
    default:
      return state
  }
}
```

Note that:

1. **We don't mutate the `state`.** We create a copy with `Object.assign()`. `Object.assign(state, { visibilityFilter: action.filter })` is also wrong: it will mutate the first argument. You **must supply an empty object as the first parameter**. You can also enable the [object spread operator proposal](#) to write `{ ...state, ...newState }` instead.
2. **We return the previous `state` in the `default case`.** It's important to return the previous `state` for any unknown action.

Note on `Object.assign`

`Object.assign()` is a part of ES6, but is not implemented by most browsers yet. You'll need to either use a polyfill, a [Babel plugin](#), or a helper from another library like `_.assign()`.

Note on `switch` and Boilerplate

The `switch` statement is *not* the real boilerplate. The real boilerplate of Flux is conceptual: the need to emit an update, the need to register the Store with a Dispatcher, the need for the Store to be an object (and the complications that arise when you want a universal app). Redux solves these problems by using pure reducers instead of event emitters.

It's unfortunate that many still choose a framework based on whether it uses `switch` statements in the documentation. If you don't like `switch`, you can use a custom `createReducer` function that accepts a handler map, as shown in "[reducing boilerplate](#)".

Handling More Actions

We have two more actions to handle! Just like we did with `SET_VISIBILITY_FILTER`, we'll import the `ADD_TODO` and `TOGGLE_TODO` actions and then extend our reducer to handle `ADD_TODO`.

```
import {
  ADD_TODO,
  TOGGLE_TODO,
  SET_VISIBILITY_FILTER,
  VisibilityFilters
} from './actions'

...

function todoApp(state = initialState, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return Object.assign({}, state, {
        visibilityFilter: action.filter
      })
    case ADD_TODO:
      return Object.assign({}, state, {
        todos: [
          ...state.todos,
          {
            text: action.text,
            completed: false
          }
        ]
      })
    default:
      return state
  }
}
```

Just like before, we never write directly to `state` or its fields, and instead we return new objects. The new `todos` is equal to the old `todos` concatenated with a single new item at the end. The fresh todo was constructed using the data from the action.

Finally, the implementation of the `TOGGLE_TODO` handler shouldn't come as a complete surprise:

```
case TOGGLE_TODO:
  return Object.assign({}, state, {
    todos: state.todos.map((todo, index) => {
      if (index === action.index) {
        return Object.assign({}, todo, {
          completed: !todo.completed
        })
      }
      return todo
    })
  })
```

Because we want to update a specific item in the array without resorting to mutations, we have to create a new array with the same items except the item at the index. If you find yourself often writing such operations, it's a good idea to use a helper like [immutability-helper](#), [updeep](#), or even a library like [Immutable](#) that has native support for deep updates. Just remember to never assign to anything inside the `state` unless you clone it first.

Splitting Reducers

Here is our code so far. It is rather verbose:

```
function todoApp(state = initialState, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return Object.assign({}, state, {
        visibilityFilter: action.filter
      })
    case ADD_TODO:
      return Object.assign({}, state, {
        todos: [
          ...state.todos,
          {
            text: action.text,
            completed: false
          }
        ]
      })
    case TOGGLE_TODO:
      return Object.assign({}, state, {
        todos: state.todos.map((todo, index) => {
          if (index === action.index) {
            return Object.assign({}, todo, {
              completed: !todo.completed
            })
          }
          return todo
        })
      })
    default:
      return state
  }
}
```

Is there a way to make it easier to comprehend? It seems like `todos` and `visibilityFilter` are updated completely independently. Sometimes state fields depend on one another and more consideration is required, but in our case we can easily split updating `todos` into a separate function:

```
function todos(state = [], action) {
  switch (action.type) {
    case ADD_TODO:
      return [
        ...state,
        {
          text: action.text,
          completed: false
        }
      ]
    case TOGGLE_TODO:
      return state.map((todo, index) => {
        if (index === action.index) {
          return Object.assign({}, todo, {
            completed: !todo.completed
          })
        }
        return todo
      })
    default:
      return state
  }
}
```

```

    }

}

function todoApp(state = initialState, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return Object.assign({}, state, {
        visibilityFilter: action.filter
      })
    case ADD_TODO:
    case TOGGLE_TODO:
      return Object.assign({}, state, {
        todos: todos(state.todos, action)
      })
    default:
      return state
  }
}

```

Note that `todos` also accepts `state` —but it's an array! Now `todoApp` just gives it the slice of the state to manage, and `todos` knows how to update just that slice. **This is called *reducer composition*, and it's the fundamental pattern of building Redux apps.**

Let's explore reducer composition more. Can we also extract a reducer managing just `visibilityFilter`? We can.

Below our imports, let's use [ES6 Object Destructuring](#) to declare `SHOW_ALL`:

```
const { SHOW_ALL } = VisibilityFilters
```

Then:

```

function visibilityFilter(state = SHOW_ALL, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return action.filter
    default:
      return state
  }
}

```

Now we can rewrite the main reducer as a function that calls the reducers managing parts of the state, and combines them into a single object. It also doesn't need to know the complete initial state anymore. It's enough that the child reducers return their initial state when given `undefined` at first.

```

function todos(state = [], action) {
  switch (action.type) {
    case ADD_TODO:
      return [
        ...state,
        {
          text: action.text,
          completed: false
        }
      ]
    case TOGGLE_TODO:
      return state.map((todo, index) => {
        if (index === action.index) {
          return Object.assign({}, todo, {
            completed: !todo.completed
          })
        }
        return todo
      })
    default:
      return state
  }
}

```

```

}

function visibilityFilter(state = SHOW_ALL, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return action.filter
    default:
      return state
  }
}

function todoApp(state = {}, action) {
  return {
    visibilityFilter: visibilityFilter(state.visibilityFilter, action),
    todos: todos(state.todos, action)
  }
}

```

Note that each of these reducers is managing its own part of the global state. The `state` parameter is different for every reducer, and corresponds to the part of the state it manages.

This is already looking good! When the app is larger, we can split the reducers into separate files and keep them completely independent and managing different data domains.

Finally, Redux provides a utility called `combineReducers()` that does the same boilerplate logic that the `todoApp` above currently does. With its help, we can rewrite `todoApp` like this:

```

import { combineReducers } from 'redux'

const todoApp = combineReducers({
  visibilityFilter,
  todos
})

export default todoApp

```

Note that this is equivalent to:

```

export default function todoApp(state = {}, action) {
  return {
    visibilityFilter: visibilityFilter(state.visibilityFilter, action),
    todos: todos(state.todos, action)
  }
}

```

You could also give them different keys, or call functions differently. These two ways to write a combined reducer are equivalent:

```

const reducer = combineReducers({
  a: doSomethingWithA,
  b: processB,
  c: c
})

function reducer(state = {}, action) {
  return {
    a: doSomethingWithA(state.a, action),
    b: processB(state.b, action),
    c: c(state.c, action)
  }
}

```

All `combineReducers()` does is generate a function that calls your reducers **with the slices of state selected according to their keys**, and combining their results into a single object again. It's not magic. And like other reducers, `combineReducers()` does not create a new object if all of the reducers provided to it do not change state.

Note for ES6 Savvy Users

Because `combineReducers` expects an object, we can put all top-level reducers into a separate file, `export` each reducer function, and use `import * as reducers` to get them as an object with their names as the keys:

```
import { combineReducers } from 'redux'
import * as reducers from './reducers'

const todoApp = combineReducers(reducers)
```

Because `import *` is still new syntax, we don't use it anymore in the documentation to avoid [confusion](#), but you may encounter it in some community examples.

Source Code

reducers.js

```
import { combineReducers } from 'redux'
import {
  ADD_TODO,
  TOGGLE_TODO,
  SET_VISIBILITY_FILTER,
  VisibilityFilters
} from './actions'
const { SHOW_ALL } = VisibilityFilters

function visibilityFilter(state = SHOW_ALL, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return action.filter
    default:
      return state
  }
}

function todos(state = [], action) {
  switch (action.type) {
    case ADD_TODO:
      return [
        ...state,
        {
          text: action.text,
          completed: false
        }
      ]
    case TOGGLE_TODO:
      return state.map((todo, index) => {
        if (index === action.index) {
          return Object.assign({}, todo, {
            completed: !todo.completed
          })
        }
        return todo
      })
    default:
      return state
  }
}

const todoApp = combineReducers({
  visibilityFilter,
  todos
})
```

```
})  
export default todoApp
```

Next Steps

Next, we'll explore how to [create a Redux store](#) that holds the state and takes care of calling your reducer when you dispatch an action.

Store

In the previous sections, we defined the [actions](#) that represent the facts about “what happened” and the [reducers](#) that update the state according to those actions.

The **Store** is the object that brings them together. The store has the following responsibilities:

- Holds application state;
- Allows access to state via `getState()` ;
- Allows state to be updated via `dispatch(action)` ;
- Registers listeners via `subscribe(listener)` ;
- Handles unregistering of listeners via the function returned by `subscribe(listener)` .

It's important to note that you'll only have a single store in a Redux application. When you want to split your data handling logic, you'll use [reducer composition](#) instead of many stores.

It's easy to create a store if you have a reducer. In the [previous section](#), we used `combineReducers()` to combine several reducers into one. We will now import it, and pass it to `createStore()` .

```
import { createStore } from 'redux'
import todoApp from './reducers'
let store = createStore(todoApp)
```

You may optionally specify the initial state as the second argument to `createStore()` . This is useful for hydrating the state of the client to match the state of a Redux application running on the server.

```
let store = createStore(todoApp, window.STATE_FROM_SERVER)
```

Dispatching Actions

Now that we have created a store, let's verify our program works! Even without any UI, we can already test the update logic.

```
import {
  addTodo,
  toggleTodo,
  setVisibilityFilter,
  VisibilityFilters
} from './actions'

// Log the initial state
console.log(store.getState())

// Every time the state changes, log it
// Note that subscribe() returns a function for unregistering the listener
const unsubscribe = store.subscribe(() =>
  console.log(store.getState())
)

// Dispatch some actions
store.dispatch(addTodo('Learn about actions'))
store.dispatch(addTodo('Learn about reducers'))
store.dispatch(addTodo('Learn about store'))
store.dispatch(toggleTodo(0))
store.dispatch(toggleTodo(1))
store.dispatch(setVisibilityFilter(VisibilityFilters.SHOW_COMPLETED))

// Stop listening to state updates
unsubscribe()
```

```
unsubscribe()
```

You can see how this causes the state held by the store to change:

```
▶ Object {visibleTodoFilter: "SHOW_ALL", todos: Array[0]}
▶ Object {visibleTodoFilter: "SHOW_ALL", todos: Array[1]}
▶ Object {visibleTodoFilter: "SHOW_ALL", todos: Array[2]}
▶ Object {visibleTodoFilter: "SHOW_ALL", todos: Array[3]}
▶ Object {visibleTodoFilter: "SHOW_ALL", todos: Array[3]}
▶ Object {visibleTodoFilter: "SHOW_ALL", todos: Array[3]}
▼ Object {visibleTodoFilter: "SHOW_COMPLETED", todos: Array[3]} ⓘ
  ▼ todos: Array[3]
    ▼ 0: Object
      completed: true
      text: "Learn about actions"
      ► __proto__: Object
    ▼ 1: Object
      completed: true
      text: "Learn about reducers"
      ► __proto__: Object
    ▼ 2: Object
      completed: false
      text: "Learn about store"
      ► __proto__: Object
      length: 3
      ► __proto__: Array[0]
  visibleTodoFilter: "SHOW_COMPLETED"
  ► __proto__: Object
```

We specified the behavior of our app before we even started writing the UI. We won't do this in this tutorial, but at this point you can write tests for your reducers and action creators. You won't need to mock anything because they are just [pure](#) functions. Call them, and make assertions on what they return.

Source Code

`index.js`

```
import { createStore } from 'redux'
import todoApp from './reducers'

let store = createStore(todoApp)
```

Next Steps

Before creating a UI for our todo app, we will take a detour to see [how the data flows in a Redux application](#).

Data Flow

Redux architecture revolves around a **strict unidirectional data flow**.

This means that all data in an application follows the same lifecycle pattern, making the logic of your app more predictable and easier to understand. It also encourages data normalization, so that you don't end up with multiple, independent copies of the same data that are unaware of one another.

If you're still not convinced, read [Motivation](#) and [The Case for Flux](#) for a compelling argument in favor of unidirectional data flow. Although [Redux is not exactly Flux](#), it shares the same key benefits.

The data lifecycle in any Redux app follows these 4 steps:

1. You call `store.dispatch(action)`.

An `action` is a plain object describing *what happened*. For example:

```
{ type: 'LIKE_ARTICLE', articleId: 42 }
{ type: 'FETCH_USER_SUCCESS', response: { id: 3, name: 'Mary' } }
{ type: 'ADD_TODO', text: 'Read the Redux docs.' }
```

Think of an action as a very brief snippet of news. “Mary liked article 42.” or “Read the Redux docs.” was added to the list of todos.”

You can call `store.dispatch(action)` from anywhere in your app, including components and XHR callbacks, or even at scheduled intervals.

2. The Redux store calls the reducer function you gave it.

The `store` will pass two arguments to the `reducer`: the current state tree and the action. For example, in the todo app, the root reducer might receive something like this:

```
// The current application state (list of todos and chosen filter)
let previousState = {
  visibleTodoFilter: 'SHOW_ALL',
  todos: [
    {
      text: 'Read the docs.',
      complete: false
    }
  ]
}

// The action being performed (adding a todo)
let action = {
  type: 'ADD_TODO',
  text: 'Understand the flow.'
}

// Your reducer returns the next application state
let nextState = todoApp(previousState, action)
```

Note that a reducer is a pure function. It only *computes* the next state. It should be completely predictable: calling it with the same inputs many times should produce the same outputs. It shouldn't perform any side effects like API calls or router transitions. These should happen before an action is dispatched.

3. The root reducer may combine the output of multiple reducers into a single state tree.

How you structure the root reducer is completely up to you. Redux ships with a `combineReducers()` helper function, useful for “splitting” the root reducer into separate functions that each manage one branch of the state tree.

Here's how `combineReducers()` works. Let's say you have two reducers, one for a list of todos, and another for the currently selected filter setting:

```
function todos(state = [], action) {
  // Somehow calculate it...
  return nextState
}

function visibleTodoFilter(state = 'SHOW_ALL', action) {
  // Somehow calculate it...
  return nextState
}

let todoApp = combineReducers({
  todos,
  visibleTodoFilter
})
```

When you emit an action, `todoApp` returned by `combineReducers` will call both reducers:

```
let nextTodos = todos(state.todos, action)
let nextVisibleTodoFilter = visibleTodoFilter(state.visibleTodoFilter, action)
```

It will then combine both sets of results into a single state tree:

```
return {
  todos: nextTodos,
  visibleTodoFilter: nextVisibleTodoFilter
}
```

While `combineReducers()` is a handy helper utility, you don't have to use it; feel free to write your own root reducer!

4. The Redux store saves the complete state tree returned by the root reducer.

This new tree is now the next state of your app! Every listener registered with `store.subscribe(listener)` will now be invoked; listeners may call `store.getState()` to get the current state.

Now, the UI can be updated to reflect the new state. If you use bindings like [React Redux](#), this is the point at which `component.setState(newState)` is called.

Next Steps

Now that you know how Redux works, let's [connect it to a React app](#).

Note for Advanced Users

If you're already familiar with the basic concepts and have previously completed this tutorial, don't forget to check out [async flow](#) in the [advanced tutorial](#) to learn how middleware transforms [async actions](#) before they reach the reducer.

Usage with React

From the very beginning, we need to stress that Redux has no relation to React. You can write Redux apps with React, Angular, Ember, jQuery, or vanilla JavaScript.

That said, Redux works especially well with libraries like [React](#) and [Deku](#) because they let you describe UI as a function of state, and Redux emits state updates in response to actions.

We will use React to build our simple todo app.

Installing React Redux

[React bindings](#) are not included in Redux by default. You need to install them explicitly:

```
npm install --save react-redux
```

If you don't use npm, you may grab the latest UMD build from unpkg (either a [development](#) or a [production](#) build). The UMD build exports a global called `window.ReactRedux` if you add it to your page via a `<script>` tag.

Presentational and Container Components

React bindings for Redux embrace the idea of **separating presentational and container components**. If you're not familiar with these terms, [read about them first](#), and then come back. They are important, so we'll wait!

Finished reading the article? Let's recount their differences:

	Presentational Components	Container Components
Purpose	How things look (markup, styles)	How things work (data fetching, state updates)
Aware of Redux	No	Yes
To read data	Read data from props	Subscribe to Redux state
To change data	Invoke callbacks from props	Dispatch Redux actions
Are written	By hand	Usually generated by React Redux

Most of the components we'll write will be presentational, but we'll need to generate a few container components to connect them to the Redux store. This and the design brief below do not imply container components must be near the top of the component tree. If a container component becomes too complex (i.e. it has heavily nested presentational components with countless callbacks being passed down), introduce another container within the component tree as noted in the [FAQ](#).

Technically you could write the container components by hand using `store.subscribe()`. We don't advise you to do this because React Redux makes many performance optimizations that are hard to do by hand. For this reason, rather than write container components, we will generate them using the `connect()` function provided by React Redux, as you will see below.

Designing Component Hierarchy

Remember how we [designed the shape of the root state object](#)? It's time we design the UI hierarchy to match it. This is not a Redux-specific task. [Thinking in React](#) is a great tutorial that explains the process.

Our design brief is simple. We want to show a list of todo items. On click, a todo item is crossed out as completed. We want to show a field where the user may add a new todo. In the footer, we want to show a toggle to show all, only completed, or only active todos.

Designing Presentational Components

I see the following presentational components and their props emerge from this brief:

- `TodoList` is a list showing visible todos.
 - `todos: Array` is an array of todo items with `{ id, text, completed }` shape.
 - `onTodoClick(id: number)` is a callback to invoke when a todo is clicked.
- `Todo` is a single todo item.
 - `text: string` is the text to show.
 - `completed: boolean` is whether todo should appear crossed out.
 - `onClick()` is a callback to invoke when a todo is clicked.
- `Link` is a link with a callback.
 - `onClick()` is a callback to invoke when link is clicked.
- `Footer` is where we let the user change currently visible todos.
- `App` is the root component that renders everything else.

They describe the *look* but don't know *where* the data comes from, or *how* to change it. They only render what's given to them. If you migrate from Redux to something else, you'll be able to keep all these components exactly the same. They have no dependency on Redux.

Designing Container Components

We will also need some container components to connect the presentational components to Redux. For example, the presentational `TodoList` component needs a container like `VisibleTodoList` that subscribes to the Redux store and knows how to apply the current visibility filter. To change the visibility filter, we will provide a `FilterLink` container component that renders a `Link` that dispatches an appropriate action on click:

- `VisibleTodoList` filters the todos according to the current visibility filter and renders a `TodoList`.
- `FilterLink` gets the current visibility filter and renders a `Link`.
 - `filter: string` is the visibility filter it represents.

Designing Other Components

Sometimes it's hard to tell if some component should be a presentational component or a container. For example, sometimes form and function are really coupled together, such as in case of this tiny component:

- `AddTodo` is an input field with an "Add" button

Technically we could split it into two components but it might be too early at this stage. It's fine to mix presentation and logic in a component that is very small. As it grows, it will be more obvious how to split it, so we'll leave it mixed.

Implementing Components

Let's write the components! We begin with the presentational components so we don't need to think about binding to Redux yet.

Implementing Presentational Components

These are all normal React components, so we won't examine them in detail. We write functional stateless components unless we need to use local state or the lifecycle methods. This doesn't mean that presentational components *have to* be functions—it's just easier to define them this way. If and when you need to add local state, lifecycle methods, or performance optimizations, you can convert them to classes.

components/Todo.js

```
import React from 'react'
import PropTypes from 'prop-types'

const Todo = ({ onClick, completed, text }) => (
  <li
    onClick={onClick}
    style={{
      textDecoration: completed ? 'line-through' : 'none'
    }}
  >
    {text}
  </li>
)

Todo.propTypes = {
  onClick: PropTypes.func.isRequired,
  completed: PropTypes.bool.isRequired,
  text: PropTypes.string.isRequired
}

export default Todo
```

components/TodoList.js

```
import React from 'react'
import PropTypes from 'prop-types'
import Todo from './Todo'

const TodoList = ({ todos, onTodoClick }) => (
  <ul>
    {todos.map((todo, index) => (
      <Todo key={index} {...todo} onClick={() => onTodoClick(index)} />
    ))}
  </ul>
)

TodoList.propTypes = {
  todos: PropTypes.arrayOf(
    PropTypes.shape({
      id: PropTypes.number.isRequired,
      completed: PropTypes.bool.isRequired,
      text: PropTypes.string.isRequired
    }).isRequired
  ).isRequired,
  onTodoClick: PropTypes.func.isRequired
}

export default TodoList
```

components/Link.js

```
import React from 'react'
import PropTypes from 'prop-types'

const Link = ({ active, children, onClick }) => {
  if (active) {
```

```
        return <span>{children}</span>
    }

    return (
      <a
        href="#"
        onClick={e => {
          e.preventDefault()
          onClick()
        }}
      >
        {children}
      </a>
    )
}

Link.propTypes = {
  active: PropTypes.bool.isRequired,
  children: PropTypes.node.isRequired,
  onClick: PropTypes.func.isRequired
}

export default Link
```

components/Footer.js

```
import React from 'react'
import FilterLink from '../containers/FilterLink'

const Footer = () => (
  <p>
    Show:
    {', '}
    <FilterLink filter="SHOW_ALL">
      All
    </FilterLink>
    {', '}
    <FilterLink filter="SHOW_ACTIVE">
      Active
    </FilterLink>
    {', '}
    <FilterLink filter="SHOW_COMPLETED">
      Completed
    </FilterLink>
  </p>
)

export default Footer
```

Implementing Container Components

Now it's time to hook up those presentational components to Redux by creating some containers. Technically, a container component is just a React component that uses `store.subscribe()` to read a part of the Redux state tree and supply props to a presentational component it renders. You could write a container component by hand, but we suggest instead generating container components with the React Redux library's `connect()` function, which provides many useful optimizations to prevent unnecessary re-renders. (One result of this is that you shouldn't have to worry about the [React performance suggestion](#) of implementing `shouldComponentUpdate` yourself.)

To use `connect()`, you need to define a special function called `mapStateToProps` that tells how to transform the current Redux store state into the props you want to pass to a presentational component you are wrapping. For example, `VisibleTodoList` needs to calculate `todos` to pass to the `TodoList`, so we define a function that filters the `state.todos` according to the `state.visibilityFilter`, and use it in its `mapStateToProps`:

```
const getVisibleTodos = (todos, filter) => {
  switch (filter) {
```

```
    case 'SHOW_ALL':
      return todos
    case 'SHOW_COMPLETED':
      return todos.filter(t => t.completed)
    case 'SHOW_ACTIVE':
      return todos.filter(t => !t.completed)
  }
}

const mapStateToProps = state => {
  return {
    todos: getVisibleTodos(state.todos, state.visibilityFilter)
  }
}
```

In addition to reading the state, container components can dispatch actions. In a similar fashion, you can define a function called `mapDispatchToProps()` that receives the `dispatch()` method and returns callback props that you want to inject into the presentational component. For example, we want the `VisibleTodoList` to inject a prop called `onTodoClick` into the `TodoList` component, and we want `onTodoClick` to dispatch a `TOGGLE_TODO` action:

```
const mapDispatchToProps = dispatch => {
  return {
    onTodoClick: id => {
      dispatch(toggleTodo(id))
    }
  }
}
```

Finally, we create the `VisibleTodoList` by calling `connect()` and passing these two functions:

```
import { connect } from 'react-redux'

const VisibleTodoList = connect(
  mapStateToProps,
  mapDispatchToProps
)(TodoList)

export default VisibleTodoList
```

These are the basics of the React Redux API, but there are a few shortcuts and power options so we encourage you to check out [its documentation](#) in detail. In case you are worried about `mapStateToProps` creating new objects too often, you might want to learn about [computing derived data with reselect](#).

Find the rest of the container components defined below:

containers/FilterLink.js

```
import { connect } from 'react-redux'
import { setVisibilityFilter } from '../actions'
import Link from '../components/Link'

const mapStateToProps = (state, ownProps) => {
  return {
    active: ownProps.filter === state.visibilityFilter
  }
}

const mapDispatchToProps = (dispatch, ownProps) => {
  return {
    onClick: () => {
      dispatch(setVisibilityFilter(ownProps.filter))
    }
  }
}
```

```
const FilterLink = connect(
  mapStateToProps,
  mapDispatchToProps
)(Link)

export default FilterLink
```

containers/VisibleTodoList.js

```
import { connect } from 'react-redux'
import { toggleTodo } from '../actions'
import TodoList from '../components/TodoList'

const getVisibleTodos = (todos, filter) => {
  switch (filter) {
    case 'SHOW_ALL':
      return todos
    case 'SHOW_COMPLETED':
      return todos.filter(t => t.completed)
    case 'SHOW_ACTIVE':
      return todos.filter(t => !t.completed)
  }
}

const mapStateToProps = state => {
  return {
    todos: getVisibleTodos(state.todos, state.visibilityFilter)
  }
}

const mapDispatchToProps = dispatch => {
  return {
    onTodoClick: id => {
      dispatch(toggleTodo(id))
    }
  }
}

const VisibleTodoList = connect(
  mapStateToProps,
  mapDispatchToProps
)(TodoList)

export default VisibleTodoList
```

Implementing Other Components

containers/AddTodo.js

Recall as mentioned previously, both the presentation and logic for the `AddTodo` component are mixed into a single definition.

```
import React from 'react'
import { connect } from 'react-redux'
import { addTodo } from '../actions'

let AddTodo = ({ dispatch }) => {
  let input

  return (
    <div>
      <form
        onSubmit={e => {
          e.preventDefault()
          if (!input.value.trim()) {
            return
          }
          dispatch(addTodo(input.value))
        }}
      >
```

```
        input.value = ''
    )}
>
<input
  ref={node => {
    input = node
  }}
/>
<button type="submit">
  Add Todo
</button>
</form>
</div>
)
}
AddTodo = connect()(AddTodo)

export default AddTodo
```

If you are unfamiliar with the `ref` attribute, please read this [documentation](#) to familiarize yourself with the recommended use of this attribute.

Tying the containers together within a component

components/App.js

```
import React from 'react'
import Footer from './Footer'
import AddTodo from '../containers/AddTodo'
import VisibleTodoList from '../containers/VisibleTodoList'

const App = () => (
  <div>
    <AddTodo />
    <VisibleTodoList />
    <Footer />
  </div>
)

export default App
```

Passing the Store

All container components need access to the Redux store so they can subscribe to it. One option would be to pass it as a prop to every container component. However it gets tedious, as you have to wire `store` even through presentational components just because they happen to render a container deep in the component tree.

The option we recommend is to use a special React Redux component called `<Provider>` to [magically](#) make the store available to all container components in the application without passing it explicitly. You only need to use it once when you render the root component:

index.js

```
import React from 'react'
import { render } from 'react-dom'
import { Provider } from 'react-redux'
import { createStore } from 'redux'
import todoApp from './reducers'
import App from './components/App'

let store = createStore(todoApp)
```

```
render(  
  <Provider store={store}>  
    <App />  
  </Provider>,  
  document.getElementById('root')  
)
```

Next Steps

Read the [complete source code for this tutorial](#) to better internalize the knowledge you have gained. Then, head straight to the [advanced tutorial](#) to learn how to handle network requests and routing!

Example: Todo List

This is the complete source code of the tiny todo app we built during the [basics tutorial](#).

Entry Point

index.js

```
import React from 'react'
import { render } from 'react-dom'
import { Provider } from 'react-redux'
import { createStore } from 'redux'
import todoApp from './reducers'
import App from './components/App'

let store = createStore(todoApp)

render(
  <Provider store={store}>
    <App />
  </Provider>,
  document.getElementById('root')
)
```

Action Creators

actions/index.js

```
let nextTodoId = 0
export const addTodo = text => {
  return {
    type: 'ADD_TODO',
    id: nextTodoId++,
    text
  }
}

export const setVisibilityFilter = filter => {
  return {
    type: 'SET_VISIBILITY_FILTER',
    filter
  }
}

export const toggleTodo = id => {
  return {
    type: 'TOGGLE_TODO',
    id
  }
}
```

Reducers

reducers/todos.js

```
const todos = (state = [], action) => {
  switch (action.type) {
```

```
case 'ADD_TODO':
  return [
    ...state,
    {
      id: action.id,
      text: action.text,
      completed: false
    }
  ]
case 'TOGGLE_TODO':
  return state.map(todo =>
  (todo.id === action.id)
    ? {...todo, completed: !todo.completed}
    : todo
  )
default:
  return state
}

export default todos
```

reducers/visibilityFilter.js

```
const visibilityFilter = (state = 'SHOW_ALL', action) => {
  switch (action.type) {
    case 'SET_VISIBILITY_FILTER':
      return action.filter
    default:
      return state
  }
}

export default visibilityFilter
```

reducers/index.js

```
import { combineReducers } from 'redux'
import todos from './todos'
import visibilityFilter from './visibilityFilter'

const todoApp = combineReducers({
  todos,
  visibilityFilter
})

export default todoApp
```

Presentational Components

components/Todo.js

```
import React from 'react'
import PropTypes from 'prop-types'

const Todo = ({ onClick, completed, text }) => (
<li
  onClick={onClick}
  style={{
    textDecoration: completed ? 'line-through' : 'none'
  }}
>
  {text}
</li>
)
```

```
Todo.propTypes = {
  onClick: PropTypes.func.isRequired,
  completed: PropTypes.bool.isRequired,
  text: PropTypes.string.isRequired
}

export default Todo
```

components/TodoList.js

```
import React from 'react'
import PropTypes from 'prop-types'
import Todo from './Todo'

const TodoList = ({ todos, onTodoClick }) => (
  <ul>
    {todos.map(todo => (
      <Todo key={todo.id} {...todo} onClick={() => onTodoClick(todo.id)} />
    ))}
  </ul>
)

TodoList.propTypes = {
  todos: PropTypes.arrayOf(
    PropTypes.shape({
      id: PropTypes.number.isRequired,
      completed: PropTypes.bool.isRequired,
      text: PropTypes.string.isRequired
    }).isRequired
  ).isRequired,
  onTodoClick: PropTypes.func.isRequired
}

export default TodoList
```

components/Link.js

```
import React from 'react'
import PropTypes from 'prop-types'

const Link = ({ active, children, onClick }) => {
  if (active) {
    return <span>{children}</span>
  }

  return (
    <a
      href="#"
      onClick={e => {
        e.preventDefault()
        onClick()
      }}
    >
      {children}
    </a>
  )
}

Link.propTypes = {
  active: PropTypes.bool.isRequired,
  children: PropTypes.node.isRequired,
  onClick: PropTypes.func.isRequired
}

export default Link
```

components/Footer.js

```
import React from 'react'
import FilterLink from '../containers/FilterLink'

const Footer = () => (
  <p>
    Show:
    {', '}
    <FilterLink filter="SHOW_ALL">
      All
    </FilterLink>
    {', '}
    <FilterLink filter="SHOW_ACTIVE">
      Active
    </FilterLink>
    {', '}
    <FilterLink filter="SHOW_COMPLETED">
      Completed
    </FilterLink>
  </p>
)

export default Footer
```

components/App.js

```
import React from 'react'
import Footer from './Footer'
import AddTodo from '../containers/AddTodo'
import VisibleTodoList from '../containers/VisibleTodoList'

const App = () => (
  <div>
    <AddTodo />
    <VisibleTodoList />
    <Footer />
  </div>
)

export default App
```

Container Components

containers/VisibleTodoList.js

```
import { connect } from 'react-redux'
import { toggleTodo } from '../actions'
import TodoList from '../components/TodoList'

const getVisibleTodos = (todos, filter) => {
  switch (filter) {
    case 'SHOW_ALL':
      return todos
    case 'SHOW_COMPLETED':
      return todos.filter(t => t.completed)
    case 'SHOW_ACTIVE':
      return todos.filter(t => !t.completed)
  }
}

const mapStateToProps = state => {
  return {
    todos: getVisibleTodos(state.todos, state.visibilityFilter)
  }
}

const mapDispatchToProps = dispatch => {
  return {
```

```
    onTodoClick: id => {
      dispatch(toggleTodo(id))
    }
}

const VisibleTodoList = connect(
  mapStateToProps,
  mapDispatchToProps
)(TodoList)

export default VisibleTodoList
```

containers/FilterLink.js

```
import { connect } from 'react-redux'
import { setVisibilityFilter } from '../actions'
import Link from '../components/Link'

const mapStateToProps = (state, ownProps) => {
  return {
    active: ownProps.filter === state.visibilityFilter
  }
}

const mapDispatchToProps = (dispatch, ownProps) => {
  return {
    onClick: () => {
      dispatch(setVisibilityFilter(ownProps.filter))
    }
  }
}

const FilterLink = connect(
  mapStateToProps,
  mapDispatchToProps
)(Link)

export default FilterLink
```

Other Components

containers/AddTodo.js

```
import React from 'react'
import { connect } from 'react-redux'
import { addTodo } from '../actions'

let AddTodo = ({ dispatch }) => {
  let input

  return (
    <div>
      <form
        onSubmit={e => {
          e.preventDefault()
          if (!input.value.trim()) {
            return
          }
          dispatch(addTodo(input.value))
          input.value = ''
        }}
      >
        <input
          ref={node => {
            input = node
          }}
        />
      </form>
    </div>
  )
}
```

Example: Todo List

```
<button type="submit">
  Add Todo
</button>
</form>
</div>
)
}
AddTodo = connect()(AddTodo)

export default AddTodo
```

Advanced

In the [basics walkthrough](#), we explored how to structure a simple Redux application. In this walkthrough, we will explore how AJAX and routing fit into the picture.

- [Async Actions](#)
- [Async Flow](#)
- [Middleware](#)
- [Usage with React Router](#)
- [Example: Reddit API](#)
- [Next Steps](#)

Async Actions

In the [basics guide](#), we built a simple todo application. It was fully synchronous. Every time an action was dispatched, the state was updated immediately.

In this guide, we will build a different, asynchronous application. It will use the Reddit API to show the current headlines for a selected subreddit. How does asynchronicity fit into Redux flow?

Actions

When you call an asynchronous API, there are two crucial moments in time: the moment you start the call, and the moment when you receive an answer (or a timeout).

Each of these two moments usually require a change in the application state; to do that, you need to dispatch normal actions that will be processed by reducers synchronously. Usually, for any API request you'll want to dispatch at least three different kinds of actions:

- **An action informing the reducers that the request began.**

The reducers may handle this action by toggling an `isFetching` flag in the state. This way the UI knows it's time to show a spinner.

- **An action informing the reducers that the request finished successfully.**

The reducers may handle this action by merging the new data into the state they manage and resetting `isFetching`. The UI would hide the spinner, and display the fetched data.

- **An action informing the reducers that the request failed.**

The reducers may handle this action by resetting `isFetching`. Additionally, some reducers may want to store the error message so the UI can display it.

You may use a dedicated `status` field in your actions:

```
{ type: 'FETCH_POSTS' }
{ type: 'FETCH_POSTS', status: 'error', error: 'Oops' }
{ type: 'FETCH_POSTS', status: 'success', response: { ... } }
```

Or you can define separate types for them:

```
{ type: 'FETCH_POSTS_REQUEST' }
{ type: 'FETCH_POSTS_FAILURE', error: 'Oops' }
{ type: 'FETCH_POSTS_SUCCESS', response: { ... } }
```

Choosing whether to use a single action type with flags, or multiple action types, is up to you. It's a convention you need to decide with your team. Multiple types leave less room for a mistake, but this is not an issue if you generate action creators and reducers with a helper library like [redux-actions](#).

Whatever convention you choose, stick with it throughout the application.
We'll use separate types in this tutorial.

Synchronous Action Creators

Let's start by defining the several synchronous action types and action creators we need in our example app. Here, the user can select a subreddit to display:

actions.js (Synchronous)

```
export const SELECT_SUBREDDIT = 'SELECT_SUBREDDIT'

export function selectSubreddit(subreddit) {
  return {
    type: SELECT_SUBREDDIT,
    subreddit
  }
}
```

They can also press a “refresh” button to update it:

```
export const INVALIDATE_SUBREDDIT = 'INVALIDATE_SUBREDDIT'

export function invalidateSubreddit(subreddit) {
  return {
    type: INVALIDATE_SUBREDDIT,
    subreddit
  }
}
```

These were the actions governed by the user interaction. We will also have another kind of action, governed by the network requests. We will see how to dispatch them later, but for now, we just want to define them.

When it's time to fetch the posts for some subreddit, we will dispatch a `REQUEST_POSTS` action:

```
export const REQUEST_POSTS = 'REQUEST_POSTS'

function requestPosts(subreddit) {
  return {
    type: REQUEST_POSTS,
    subreddit
  }
}
```

It is important for it to be separate from `SELECT_SUBREDDIT` or `INVALIDATE_SUBREDDIT`. While they may occur one after another, as the app grows more complex, you might want to fetch some data independently of the user action (for example, to prefetch the most popular subreddits, or to refresh stale data once in a while). You may also want to fetch in response to a route change, so it's not wise to couple fetching to some particular UI event early on.

Finally, when the network request comes through, we will dispatch `RECEIVE_POSTS`:

```
export const RECEIVE_POSTS = 'RECEIVE_POSTS'

function receivePosts(subreddit, json) {
  return {
    type: RECEIVE_POSTS,
    subreddit,
    posts: json.data.children.map(child => child.data),
    receivedAt: Date.now()
  }
}
```

This is all we need to know for now. The particular mechanism to dispatch these actions together with network requests will be discussed later.

Note on Error Handling

In a real app, you'd also want to dispatch an action on request failure. We won't implement error handling in this tutorial, but the [real world example](#) shows one of the possible approaches.

Designing the State Shape

Just like in the basic tutorial, you'll need to [design the shape of your application's state](#) before rushing into the implementation. With asynchronous code, there is more state to take care of, so we need to think it through.

This part is often confusing to beginners, because it is not immediately clear what information describes the state of an asynchronous application, and how to organize it in a single tree.

We'll start with the most common use case: lists. Web applications often show lists of things. For example, a list of posts, or a list of friends. You'll need to figure out what sorts of lists your app can show. You want to store them separately in the state, because this way you can cache them and only fetch again if necessary.

Here's what the state shape for our "Reddit headlines" app might look like:

```
{
  selectedSubreddit: 'frontend',
  postsBySubreddit: {
    frontend: {
      isFetching: true,
      didInvalidate: false,
      items: []
    },
    reactjs: {
      isFetching: false,
      didInvalidate: false,
      lastUpdated: 1439478405547,
      items: [
        {
          id: 42,
          title: 'Confusion about Flux and Relay'
        },
        {
          id: 500,
          title: 'Creating a Simple Application Using React JS and Flux Architecture'
        }
      ]
    }
  }
}
```

There are a few important bits here:

- We store each subreddit's information separately so we can cache every subreddit. When the user switches between them the second time, the update will be instant, and we won't need to refetch unless we want to. Don't worry about all these items being in memory: unless you're dealing with tens of thousands of items, and your user rarely closes the tab, you won't need any sort of cleanup.
- For every list of items, you'll want to store `isFetching` to show a spinner, `didInvalidate` so you can later toggle it when the data is stale, `lastUpdated` so you know when it was fetched the last time, and the `items` themselves. In a real app, you'll also want to store pagination state like `fetchedPageCount` and `nextPageUrl`.

Note on Nested Entities

In this example, we store the received items together with the pagination information. However, this approach won't work well if you have nested entities referencing each other, or if you let the user edit items. Imagine the user wants to edit a fetched post, but this post is duplicated in several places in the state tree. This would be really painful to implement.

If you have nested entities, or if you let users edit received entities, you should keep them separately in the state as if it was a database. In pagination information, you would only refer to them by their IDs. This lets you always keep them up to date. The [real world example](#) shows this approach, together with [normalizr](#) to normalize the nested API responses. With this approach, your state might look like this:

```
{
  selectedSubreddit: 'frontend',
  entities: {
    users: {
      2: {
        id: 2,
        name: 'Andrew'
      }
    },
    posts: {
      42: {
        id: 42,
        title: 'Confusion about Flux and Relay',
        author: 2
      },
      100: {
        id: 100,
        title: 'Creating a Simple Application Using React JS and Flux Architecture',
        author: 2
      }
    }
  },
  postsBySubreddit: {
    frontend: {
      isFetching: true,
      didInvalidate: false,
      items: []
    },
    reactjs: {
      isFetching: false,
      didInvalidate: false,
      lastUpdated: 1439478405547,
      items: [ 42, 100 ]
    }
  }
}
```

In this guide, we won't normalize entities, but it's something you should consider for a more dynamic application.

Handling Actions

Before going into the details of dispatching actions together with network requests, we will write the reducers for the actions we defined above.

Note on Reducer Composition

Here, we assume that you understand reducer composition with `combineReducers()`, as described in the [Splitting Reducers](#) section on the [basics guide](#). If you don't, please [read it first](#).

reducers.js

```
import { combineReducers } from 'redux'
import {
  SELECT_SUBREDDIT,
  INVALIDATE_SUBREDDIT,
  REQUEST_POSTS,
  RECEIVE_POSTS
} from '../actions'
```

```

function selectedSubreddit(state = 'reactjs', action) {
  switch (action.type) {
    case SELECT_SUBREDDIT:
      return action.subreddit
    default:
      return state
  }
}

function posts(
  state = {
    isFetching: false,
    didInvalidate: false,
    items: []
  },
  action
) {
  switch (action.type) {
    case INVALIDATE_SUBREDDIT:
      return Object.assign({}, state, {
        didInvalidate: true
      })
    case REQUEST_POSTS:
      return Object.assign({}, state, {
        isFetching: true,
        didInvalidate: false
      })
    case RECEIVE_POSTS:
      return Object.assign({}, state, {
        isFetching: false,
        didInvalidate: false,
        items: action.posts,
        lastUpdated: action.receivedAt
      })
    default:
      return state
  }
}

function postsBySubreddit(state = {}, action) {
  switch (action.type) {
    case INVALIDATE_SUBREDDIT:
    case RECEIVE_POSTS:
    case REQUEST_POSTS:
      return Object.assign({}, state, {
        [action.subreddit]: posts(state[action.subreddit], action)
      })
    default:
      return state
  }
}

const rootReducer = combineReducers({
  postsBySubreddit,
  selectedSubreddit
})

export default rootReducer

```

In this code, there are two interesting parts:

- We use ES6 computed property syntax so we can update `state[action.subreddit]` with `Object.assign()` in a concise way. This:

```

return Object.assign({}, state, {
  [action.subreddit]: posts(state[action.subreddit], action)
})

```

is equivalent to this:

```
let nextState = {}
nextState[action.subreddit] = posts(state[action.subreddit], action)
return Object.assign({}, state, nextState)
```

- We extracted `posts(state, action)` that manages the state of a specific post list. This is just [reducer composition!](#) It is our choice how to split the reducer into smaller reducers, and in this case, we're delegating updating items inside an object to a `posts` reducer. The [real world example](#) goes even further, showing how to create a reducer factory for parameterized pagination reducers.

Remember that reducers are just functions, so you can use functional composition and higher-order functions as much as you feel comfortable.

Async Action Creators

Finally, how do we use the synchronous action creators we [defined earlier](#) together with network requests? The standard way to do it with Redux is to use the [Redux Thunk middleware](#). It comes in a separate package called `redux-thunk`. We'll explain how middleware works in general [later](#); for now, there is just one important thing you need to know: by using this specific middleware, an action creator can return a function instead of an action object. This way, the action creator becomes a [thunk](#).

When an action creator returns a function, that function will get executed by the Redux Thunk middleware. This function doesn't need to be pure; it is thus allowed to have side effects, including executing asynchronous API calls. The function can also dispatch actions—like those synchronous actions we defined earlier.

We can still define these special thunk action creators inside our `actions.js` file:

actions.js (Asynchronous)

```
import fetch from 'isomorphic-fetch'

export const REQUEST_POSTS = 'REQUEST_POSTS'
function requestPosts(subreddit) {
  return {
    type: REQUEST_POSTS,
    subreddit
  }
}

export const RECEIVE_POSTS = 'RECEIVE_POSTS'
function receivePosts(subreddit, json) {
  return {
    type: RECEIVE_POSTS,
    subreddit,
    posts: json.data.children.map(child => child.data),
    receivedAt: Date.now()
  }
}

export const INVALIDATE_SUBREDDIT = 'INVALIDATE_SUBREDDIT'
export function invalidateSubreddit(subreddit) {
  return {
    type: INVALIDATE_SUBREDDIT,
    subreddit
  }
}

// Meet our first thunk action creator!
// Though its insides are different, you would use it just like any other action creator:
// store.dispatch(fetchPosts('reactjs'))

export function fetchPosts(subreddit) {
  // Thunk middleware knows how to handle functions.
```

```
// It passes the dispatch method as an argument to the function,
// thus making it able to dispatch actions itself.

return function (dispatch) {
  // First dispatch: the app state is updated to inform
  // that the API call is starting.

  dispatch(requestPosts(subreddit))

  // The function called by the thunk middleware can return a value,
  // that is passed on as the return value of the dispatch method.

  // In this case, we return a promise to wait for.
  // This is not required by thunk middleware, but it is convenient for us.

  return fetch(`https://www.reddit.com/r/${subreddit}.json`)
    .then(
      response => response.json(),
      // Do not use catch, because that will also catch
      // any errors in the dispatch and resulting render,
      // causing a loop of 'Unexpected batch number' errors.
      // https://github.com/facebook/react/issues/6895
      error => console.log('An error occurred.', error)
    )
    .then(json =>
      // We can dispatch many times!
      // Here, we update the app state with the results of the API call.

      dispatch(receivePosts(subreddit, json))
    )
  }
}
```

Note on `fetch`

We use `fetch` API in the examples. It is a new API for making network requests that replaces `XMLHttpRequest` for most common needs. Because most browsers don't yet support it natively, we suggest that you use `isomorphic-fetch` library:

```
// Do this in every file where you use `fetch`
import fetch from 'isomorphic-fetch'
```

Internally, it uses `whatwg-fetch` polyfill on the client, and `node-fetch` on the server, so you won't need to change API calls if you change your app to be [universal](#).

Be aware that any `fetch` polyfill assumes a `Promise` polyfill is already present. The easiest way to ensure you have a `Promise` polyfill is to enable Babel's ES6 polyfill in your entry point before any other code runs:

```
// Do this once before any other code in your app
import 'babel-polyfill'
```

How do we include the Redux Thunk middleware in the dispatch mechanism? We use the `applyMiddleware()` store enhancer from Redux, as shown below:

`index.js`

```
import thunkMiddleware from 'redux-thunk'
import { createLogger } from 'redux-logger'
import { createStore, applyMiddleware } from 'redux'
import { selectSubreddit, fetchPosts } from './actions'
import rootReducer from './reducers'

const loggerMiddleware = createLogger()

const store = createStore(
```

```

    rootReducer,
  applyMiddleware(
    thunkMiddleware, // lets us dispatch() functions
    loggerMiddleware // neat middleware that logs actions
  )
)

store.dispatch(selectSubreddit('reactjs'))
store
  .dispatch(fetchPosts('reactjs'))
  .then(() => console.log(store.getState()))

```

The nice thing about thunks is that they can dispatch results of each other:

actions.js (with fetch)

```

import fetch from 'isomorphic-fetch'

export const REQUEST_POSTS = 'REQUEST_POSTS'
function requestPosts(subreddit) {
  return {
    type: REQUEST_POSTS,
    subreddit
  }
}

export const RECEIVE_POSTS = 'RECEIVE_POSTS'
function receivePosts(subreddit, json) {
  return {
    type: RECEIVE_POSTS,
    subreddit,
    posts: json.data.children.map(child => child.data),
    receivedAt: Date.now()
  }
}

export const INVALIDATE_SUBREDDIT = 'INVALIDATE_SUBREDDIT'
export function invalidateSubreddit(subreddit) {
  return {
    type: INVALIDATE_SUBREDDIT,
    subreddit
  }
}

function fetchPosts(subreddit) {
  return dispatch => {
    dispatch(requestPosts(subreddit))
    return fetch(`https://www.reddit.com/r/${subreddit}.json`)
      .then(response => response.json())
      .then(json => dispatch(receivePosts(subreddit, json)))
  }
}

function shouldFetchPosts(state, subreddit) {
  const posts = state.postsBySubreddit[subreddit]
  if (!posts) {
    return true
  } else if (posts.isFetching) {
    return false
  } else {
    return posts.didInvalidate
  }
}

export function fetchPostsIfNeeded(subreddit) {
  // Note that the function also receives getState()
  // which lets you choose what to dispatch next.

  // This is useful for avoiding a network request if
  // a cached value is already available.
}

```

```

    return (dispatch, getState) => {
      if (shouldFetchPosts(getState(), subreddit)) {
        // Dispatch a thunk from thunk!
        return dispatch(fetchPosts(subreddit))
      } else {
        // Let the calling code know there's nothing to wait for.
        return Promise.resolve()
      }
    }
}

```

This lets us write more sophisticated async control flow gradually, while the consuming code can stay pretty much the same:

index.js

```

store
  .dispatch(fetchPostsIfNeeded('reactjs'))
  .then(() => console.log(store.getState()))

```

Note about Server Rendering

Async action creators are especially convenient for server rendering. You can create a store, dispatch a single async action creator that dispatches other async action creators to fetch data for a whole section of your app, and only render after the Promise it returns, completes. Then your store will already be hydrated with the state you need before rendering.

[Thunk middleware](#) isn't the only way to orchestrate asynchronous actions in Redux:

- You can use [redux-promise](#) or [redux-promise-middleware](#) to dispatch Promises instead of functions.
- You can use [redux-observable](#) to dispatch Observables.
- You can use the [redux-saga](#) middleware to build more complex asynchronous actions.
- You can use the [redux-pack](#) middleware to dispatch promise-based asynchronous actions.
- You can even write a custom middleware to describe calls to your API, like the [real world example](#) does.

It is up to you to try a few options, choose a convention you like, and follow it, whether with, or without the middleware.

Connecting to UI

Dispatching async actions is no different from dispatching synchronous actions, so we won't discuss this in detail. See [Usage with React](#) for an introduction into using Redux from React components. See [Example: Reddit API](#) for the complete source code discussed in this example.

Next Steps

Read [Async Flow](#) to recap how async actions fit into the Redux flow.

Async Flow

Without [middleware](#), Redux store only supports [synchronous data flow](#). This is what you get by default with `createStore()`.

You may enhance `createStore()` with `applyMiddleware()`. It is not required, but it lets you [express asynchronous actions in a convenient way](#).

Asynchronous middleware like [redux-thunk](#) or [redux-promise](#) wraps the store's `dispatch()` method and allows you to dispatch something other than actions, for example, functions or Promises. Any middleware you use can then interpret anything you dispatch, and in turn, can pass actions to the next middleware in the chain. For example, a Promise middleware can intercept Promises and dispatch a pair of begin/end actions asynchronously in response to each Promise.

When the last middleware in the chain dispatches an action, it has to be a plain object. This is when the [synchronous Redux data flow](#) takes place.

Check out [the full source code for the async example](#).

Next Steps

Now you saw an example of what middleware can do in Redux, it's time to learn how it actually works, and how you can create your own. Go on to the next detailed section about [Middleware](#).

Middleware

You've seen middleware in action in the [Async Actions](#) example. If you've used server-side libraries like [Express](#) and [Koa](#), you were also probably already familiar with the concept of *middleware*. In these frameworks, middleware is some code you can put between the framework receiving a request, and the framework generating a response. For example, Express or Koa middleware may add CORS headers, logging, compression, and more. The best feature of middleware is that it's composable in a chain. You can use multiple independent third-party middleware in a single project.

Redux middleware solves different problems than Express or Koa middleware, but in a conceptually similar way. It **provides a third-party extension point between dispatching an action, and the moment it reaches the reducer**. People use Redux middleware for logging, crash reporting, talking to an asynchronous API, routing, and more.

This article is divided into an in-depth intro to help you grok the concept, and [a few practical examples](#) to show the power of middleware at the very end. You may find it helpful to switch back and forth between them, as you flip between feeling bored and inspired.

Understanding Middleware

While middleware can be used for a variety of things, including asynchronous API calls, it's really important that you understand where it comes from. We'll guide you through the thought process leading to middleware, by using logging and crash reporting as examples.

Problem: Logging

One of the benefits of Redux is that it makes state changes predictable and transparent. Every time an action is dispatched, the new state is computed and saved. The state cannot change by itself, it can only change as a consequence of a specific action.

Wouldn't it be nice if we logged every action that happens in the app, together with the state computed after it? When something goes wrong, we can look back at our log, and figure out which action corrupted the state.

```
▼ ADD_TODO
  i dispatching: Object {type: "ADD_TODO", text: "Use Redux"}
    next state: ► Object {visibilityFilter: "SHOW_ALL", todos: Array[1]}
▼ ADD_TODO
  i dispatching: Object {type: "ADD_TODO", text: "Learn about middleware"}
    next state: ► Object {visibilityFilter: "SHOW_ALL", todos: Array[2]}
▼ COMPLETE_TODO
  i dispatching: Object {type: "COMPLETE_TODO", index: 0}
    next state: ► Object {visibilityFilter: "SHOW_ALL", todos: Array[2]}
▼ SET_VISIBILITY_FILTER
  i dispatching: Object {type: "SET_VISIBILITY_FILTER", filter: "SHOW_COMPLETED"}
    next state: ► Object {visibilityFilter: "SHOW_COMPLETED", todos: Array[2]}
```

How do we approach this with Redux?

Attempt #1: Logging Manually

The most naïve solution is just to log the action and the next state yourself every time you call `store.dispatch(action)`. It's not really a solution, but just a first step towards understanding the problem.

Note

If you're using [react-redux](#) or similar bindings, you likely won't have direct access to the store instance in your components. For the next few paragraphs, just assume you pass the store down explicitly.

Say, you call this when creating a todo:

```
store.dispatch(addTodo('Use Redux'))
```

To log the action and state, you can change it to something like this:

```
let action = addTodo('Use Redux')

console.log('dispatching', action)
store.dispatch(action)
console.log('next state', store.getState())
```

This produces the desired effect, but you wouldn't want to do it every time.

Attempt #2: Wrapping Dispatch

You can extract logging into a function:

```
function dispatchAndLog(store, action) {
  console.log('dispatching', action)
  store.dispatch(action)
  console.log('next state', store.getState())
}
```

You can then use it everywhere instead of `store.dispatch()`:

```
dispatchAndLog(store, addTodo('Use Redux'))
```

We could end this here, but it's not very convenient to import a special function every time.

Attempt #3: Monkeypatching Dispatch

What if we just replace the `dispatch` function on the store instance? The Redux store is just a plain object with [a few methods](#), and we're writing JavaScript, so we can just monkeypatch the `dispatch` implementation:

```
let next = store.dispatch
store.dispatch = function dispatchAndLog(action) {
  console.log('dispatching', action)
  let result = next(action)
  console.log('next state', store.getState())
  return result
}
```

This is already closer to what we want! No matter where we dispatch an action, it is guaranteed to be logged. Monkeypatching never feels right, but we can live with this for now.

Problem: Crash Reporting

What if we want to apply **more than one** such transformation to `dispatch`?

A different useful transformation that comes to my mind is reporting JavaScript errors in production. The global `window.onerror` event is not reliable because it doesn't provide stack information in some older browsers, which is crucial to understand why an error is happening.

Wouldn't it be useful if, any time an error is thrown as a result of dispatching an action, we would send it to a crash reporting service like [Sentry](#) with the stack trace, the action that caused the error, and the current state? This way it's much easier to reproduce the error in development.

However, it is important that we keep logging and crash reporting separate. Ideally we want them to be different modules, potentially in different packages. Otherwise we can't have an ecosystem of such utilities. (Hint: we're slowly getting to what middleware is!)

If logging and crash reporting are separate utilities, they might look like this:

```
function patchStoreToAddLogging(store) {
  let next = store.dispatch
  store.dispatch = function dispatchAndLog(action) {
    console.log('dispatching', action)
    let result = next(action)
    console.log('next state', store.getState())
    return result
  }
}

function patchStoreToAddCrashReporting(store) {
  let next = store.dispatch
  store.dispatch = function dispatchAndReportErrors(action) {
    try {
      return next(action)
    } catch (err) {
      console.error('Caught an exception!', err)
      Raven.captureException(err, {
        extra: {
          action,
          state: store.getState()
        }
      })
      throw err
    }
  }
}
```

If these functions are published as separate modules, we can later use them to patch our store:

```
patchStoreToAddLogging(store)
patchStoreToAddCrashReporting(store)
```

Still, this isn't nice.

Attempt #4: Hiding Monkeypatching

Monkeypatching is a hack. “Replace any method you like”, what kind of API is that? Let's figure out the essence of it instead. Previously, our functions replaced `store.dispatch`. What if they *returned* the new `dispatch` function instead?

```
function logger(store) {
  let next = store.dispatch

  // Previously:
  // store.dispatch = function dispatchAndLog(action) {

  return function dispatchAndLog(action) {
    console.log('dispatching', action)
    let result = next(action)
```

```

    console.log('next state', store.getState())
    return result
}
}

```

We could provide a helper inside Redux that would apply the actual monkeypatching as an implementation detail:

```

function applyMiddlewareByMonkeypatching(store, middlewares) {
  middlewares = middlewares.slice()
  middlewares.reverse()

  // Transform dispatch function with each middleware.
  middlewares.forEach(middleware =>
    store.dispatch = middleware(store)
  )
}

```

We could use it to apply multiple middleware like this:

```
applyMiddlewareByMonkeypatching(store, [logger, crashReporter])
```

However, it is still monkeypatching.

The fact that we hide it inside the library doesn't alter this fact.

Attempt #5: Removing Monkeypatching

Why do we even overwrite `dispatch`? Of course, to be able to call it later, but there's also another reason: so that every middleware can access (and call) the previously wrapped `store.dispatch`:

```

function logger(store) {
  // Must point to the function returned by the previous middleware:
  let next = store.dispatch

  return function dispatchAndLog(action) {
    console.log('dispatching', action)
    let result = next(action)
    console.log('next state', store.getState())
    return result
  }
}

```

It is essential to chaining middleware!

If `applyMiddlewareByMonkeypatching` doesn't assign `store.dispatch` immediately after processing the first middleware, `store.dispatch` will keep pointing to the original `dispatch` function. Then the second middleware will also be bound to the original `dispatch` function.

But there's also a different way to enable chaining. The middleware could accept the `next()` `dispatch` function as a parameter instead of reading it from the `store` instance.

```

function logger(store) {
  return function wrapDispatchToAddLogging(next) {
    return function dispatchAndLog(action) {
      console.log('dispatching', action)
      let result = next(action)
      console.log('next state', store.getState())
      return result
    }
  }
}

```

It's a “we need to go deeper” kind of moment, so it might take a while for this to make sense. The function cascade feels intimidating. ES6 arrow functions make this [currying](#) easier on eyes:

```
const logger = store => next => action => {
  console.log('dispatching', action)
  let result = next(action)
  console.log('next state', store.getState())
  return result
}

const crashReporter = store => next => action => {
  try {
    return next(action)
  } catch (err) {
    console.error('Caught an exception!', err)
    Raven.captureException(err, {
      extra: {
        action,
        state: store.getState()
      }
    })
    throw err
  }
}
```

This is exactly what Redux middleware looks like.

Now middleware takes the `next()` dispatch function, and returns a dispatch function, which in turn serves as `next()` to the middleware to the left, and so on. It's still useful to have access to some store methods like `getState()`, so `store` stays available as the top-level argument.

Attempt #6: Naïvely Applying the Middleware

Instead of `applyMiddlewareByMonkeypatching()`, we could write `applyMiddleware()` that first obtains the final, fully wrapped `dispatch()` function, and returns a copy of the store using it:

```
// Warning: Naive implementation!
// That's *not* Redux API.
function applyMiddleware(store, middlewares) {
  middlewares = middlewares.slice()
  middlewares.reverse()
  let dispatch = store.dispatch
  middlewares.forEach(middleware =>
    dispatch = middleware(store)(dispatch)
  )
  return Object.assign({}, store, { dispatch })
}
```

The implementation of `applyMiddleware()` that ships with Redux is similar, but **different in three important aspects**:

- It only exposes a subset of the `store API` to the middleware: `dispatch(action)` and `getState()`.
- It does a bit of trickery to make sure that if you call `store.dispatch(action)` from your middleware instead of `next(action)`, the action will actually travel the whole middleware chain again, including the current middleware. This is useful for asynchronous middleware, as we have seen [previously](#).
- To ensure that you may only apply middleware once, it operates on `createStore()` rather than on `store` itself. Instead of `(store, middlewares) => store`, its signature is `(...middlewares) => (createStore) => createStore`.

Because it is cumbersome to apply functions to `createStore()` before using it, `createStore()` accepts an optional last argument to specify such functions.

The Final Approach

Given this middleware we just wrote:

```
const logger = store => next => action => {
  console.log('dispatching', action)
  let result = next(action)
  console.log('next state', store.getState())
  return result
}

const crashReporter = store => next => action => {
  try {
    return next(action)
  } catch (err) {
    console.error('Caught an exception!', err)
    Raven.captureException(err, {
      extra: {
        action,
        state: store.getState()
      }
    })
    throw err
  }
}
```

Here's how to apply it to a Redux store:

```
import { createStore, combineReducers, applyMiddleware } from 'redux'

let todoApp = combineReducers(reducers)
let store = createStore(
  todoApp,
  // applyMiddleware() tells createStore() how to handle middleware
  applyMiddleware(logger, crashReporter)
)
```

That's it! Now any actions dispatched to the store instance will flow through `logger` and `crashReporter`:

```
// Will flow through both logger and crashReporter middleware!
store.dispatch(addTodo('Use Redux'))
```

Seven Examples

If your head boiled from reading the above section, imagine what it was like to write it. This section is meant to be a relaxation for you and me, and will help get your gears turning.

Each function below is a valid Redux middleware. They are not equally useful, but at least they are equally fun.

```
/** 
 * Logs all actions and states after they are dispatched.
 */
const logger = store => next => action => {
  console.group(action.type)
  console.info('dispatching', action)
  let result = next(action)
  console.log('next state', store.getState())
  console.groupEnd(action.type)
  return result
}

/** 
 * Sends crash reports as state is updated and listeners are notified.
 */
const crashReporter = store => next => action => {
  try {
    return next(action)
```

```

    } catch (err) {
      console.error('Caught an exception!', err)
      Raven.captureException(err, {
        extra: {
          action,
          state: store.getState()
        }
      })
      throw err
    }
}

/**
 * Schedules actions with { meta: { delay: N } } to be delayed by N milliseconds.
 * Makes `dispatch` return a function to cancel the timeout in this case.
 */
const timeoutScheduler = store => next => action => {
  if (!action.meta || !action.meta.delay) {
    return next(action)
  }

  let timeoutId = setTimeout(
    () => next(action),
    action.meta.delay
  )

  return function cancel() {
    clearTimeout(timeoutId)
  }
}

/**
 * Schedules actions with { meta: { raf: true } } to be dispatched inside a rAF loop
 * frame. Makes `dispatch` return a function to remove the action from the queue in
 * this case.
 */
const rafScheduler = store => next => {
  let queuedActions = []
  let frame = null

  function loop() {
    frame = null
    try {
      if (queuedActions.length) {
        next(queuedActions.shift())
      }
    } finally {
      maybeRaf()
    }
  }

  function maybeRaf() {
    if (queuedActions.length && !frame) {
      frame = requestAnimationFrame(loop)
    }
  }

  return action => {
    if (!action.meta || !action.meta.raf) {
      return next(action)
    }

    queuedActions.push(action)
    maybeRaf()

    return function cancel() {
      queuedActions = queuedActions.filter(a => a !== action)
    }
  }
}

/**
 * Lets you dispatch promises in addition to actions.
 * If the promise is resolved, its result will be dispatched as an action.
 */

```

```

    * The promise is returned from `dispatch` so the caller may handle rejection.
    */
const vanillaPromise = store => next => action => {
  if (typeof action.then !== 'function') {
    return next(action)
  }

  return Promise.resolve(action).then(store.dispatch)
}

/**
 * Lets you dispatch special actions with a { promise } field.
 *
 * This middleware will turn them into a single action at the beginning,
 * and a single success (or failure) action when the `promise` resolves.
 *
 * For convenience, `dispatch` will return the promise so the caller can wait.
 */
const readyStatePromise = store => next => action => {
  if (!action.promise) {
    return next(action)
  }

  function makeAction(ready, data) {
    let newAction = Object.assign({}, action, { ready }, data)
    delete newAction.promise
    return newAction
  }

  next(makeAction(false))
  return action.promise.then(
    result => next(makeAction(true, { result })),
    error => next(makeAction(true, { error }))
  )
}

/**
 * Lets you dispatch a function instead of an action.
 * This function will receive `dispatch` and `getState` as arguments.
 *
 * Useful for early exits (conditions over `getState()`), as well
 * as for async control flow (it can `dispatch()` something else).
 *
 * `dispatch` will return the return value of the dispatched function.
 */
const thunk = store => next => action =>
  typeof action === 'function'
    ? action(store.dispatch, store.getState)
    : next(action)

// You can use all of them! (It doesn't mean you should.)
let todoApp = combineReducers(reducers)
let store = createStore(
  todoApp,
  applyMiddleware(
    rafScheduler,
    timeoutScheduler,
    thunk,
    vanillaPromise,
    readyStatePromise,
    logger,
    crashReporter
  )
)

```

Usage with React Router

Warning: This guide assumes you are using React Router 2.x or 3.x. The current version of React Router is 4.x. If you have just run `npm install --save react-router`, you will be using a version that does not match this guide.

So you want to do routing with your Redux app. You can use it with [React Router](#). Redux will be the source of truth for your data and React Router will be the source of truth for your URL. In most of the cases, **it is fine** to have them separate unless you need to time travel and rewind actions that triggers the change URL.

Installing React Router

`react-router-dom` is available on npm . This guides assumes you are using `react-router-dom@^4.1.1` .

```
npm install --save react-router-dom
```

Configuring the Fallback URL

Before integrating React Router, we need to configure our development server. Indeed, our development server may be unaware of the declared routes in React Router configuration. For example, if you access `/todos` and refresh, your development server needs to be instructed to serve `index.html` because it is a single-page app. Here's how to enable this with popular development servers.

Note on Create React App

If you are using Create React App, you won't need to configure a fallback URL, it is automatically done.

Configuring Express

If you are serving your `index.html` from Express:

```
app.get('/*', (req, res) => {
  res.sendFile(path.join(__dirname, 'index.html'))
})
```

Configuring WebpackDevServer

If you are serving your `index.html` from WebpackDevServer: You can add to your `webpack.config.dev.js`:

```
devServer: {
  historyApiFallback: true
}
```

Connecting React Router with Redux App

Along this chapter, we will be using the [Todos](#) example. We recommend you to clone it while reading this chapter.

First we will need to import `<Router />` and `<Route />` from React Router. Here's how to do it:

```
import { BrowserRouter as Router, Route } from 'react-router-dom'
```

In a React app, usually you would wrap `<Route />` in `<Router />` so that when the URL changes, `<Router />` will match a branch of its routes, and render their configured components. `<Route />` is used to declaratively map routes to your application's component hierarchy. You would declare in `path` the path used in the URL and in `component` the single component to be rendered when the route matches the URL.

```
const Root = () => (
  <Router>
    <Route path="/" component={App} />
  </Router>
)
```

However, in our Redux App we will still need `<Provider />`. `<Provider />` is the higher-order component provided by React Redux that lets you bind Redux to React (see [Usage with React](#)).

We will then import the `<Provider />` from React Redux:

```
import { Provider } from 'react-redux'
```

We will wrap `<Router />` in `<Provider />` so that route handlers can get access to the `store`.

```
const Root = ({ store }) => (
  <Provider store={store}>
    <Router>
      <Route path="/" component={App} />
    </Router>
  </Provider>
)
```

Now the `<App />` component will be rendered if the URL matches '/'. Additionally, we will add the optional `:filter?` parameter to `/`, because we will need it further on when we try to read the parameter `:filter` from the URL.

```
<Route path="/:filter?" component={App} />
```

components/Root.js

```
import React from 'react'
import PropTypes from 'prop-types'
import { Provider } from 'react-redux'
import { BrowserRouter as Router, Route } from 'react-router-dom'
import App from './App'

const Root = ({ store }) => (
  <Provider store={store}>
    <Router>
      <Route path="/:filter?" component={App} />
    </Router>
  </Provider>
)

Root.propTypes = {
  store: PropTypes.object.isRequired
}

export default Root
```

We will also need to refactor `index.js` to render the `<Root />` component to the DOM.

index.js

```
import React from 'react'
```

```

import { render } from 'react-dom'
import { createStore } from 'redux'
import todoApp from './reducers'
import Root from './components/Root'

let store = createStore(todoApp)

render(
  <Root store={store} />,
  document.getElementById('root')
)

```

Navigating with React Router

React Router comes with a `<Link />` component that lets you navigate around your application. In our example, we can wrap `<Link />` with a new container component `<FilterLink />` so as to dynamically change the URL. The `activeStyle={}` property lets us apply a style on the active state.

containers/FilterLink.js

```

import React from 'react'
import { NavLink } from 'react-router'

const FilterLink = ({ filter, children }) => (
  <NavLink
    to={filter === 'SHOW_ALL' ? '/' : `/${filter}`}
    activeStyle={{
      textDecoration: 'none',
      color: 'black'
    }}
    >
    {children}
  </NavLink>
)

export default FilterLink

```

components/Footer.js

```

import React from 'react'
import FilterLink from '../containers/FilterLink'

const Footer = () => (
  <p>
    Show:
    {' '}
    <FilterLink filter="SHOW_ALL">
      All
    </FilterLink>
    {' '}
    <FilterLink filter="SHOW_ACTIVE">
      Active
    </FilterLink>
    {' '}
    <FilterLink filter="SHOW_COMPLETED">
      Completed
    </FilterLink>
  </p>
)

export default Footer

```

Now if you click on `<FilterLink />` you will see that your URL will change between `'/SHOW_COMPLETED'`, `'/SHOW_ACTIVE'`, and `'/'`. Even if you are going back with your browser, it will use your browser's history and effectively go to your previous URL.

Reading From the URL

Currently, the todo list is not filtered even after the URL changed. This is because we are filtering from `<VisibleTodoList />`'s `mapStateToProps()` is still bound to the `state` and not to the URL. `mapStateToProps` has an optional second argument `ownProps` that is an object with every props passed to `<VisibleTodoList />`

`containers/VisibleTodoList.js`

```
const mapStateToProps = (state, ownProps) => {
  return {
    todos: getVisibleTodos(state.todos, ownProps.filter) // previously was getVisibleTodos(state.todos, state.visibilityFilter)
  }
}
```

Right now we are not passing anything to `<App />` so `ownProps` is an empty object. To filter our todos according to the URL, we want to pass the URL params to `<VisibleTodoList />`.

When previously we wrote: `<Route path="/:filter?" component={App} />`, it made available inside `App` a `params` property.

`params` property is an object with every param specified in the url with the `match` object. e.g: `match.params` will be equal to `{ filter: 'SHOW_COMPLETED' }` if we are navigating to `localhost:3000/SHOW_COMPLETED`. We can now read the URL from `<App />`.

Note that we are using [ES6 destructuring](#) on the properties to pass in `params` to `<VisibleTodoList />`.

`components/App.js`

```
const App = ({ match: { params } }) => {
  return (
    <div>
      <AddTodo />
      <VisibleTodoList filter={[params.filter || 'SHOW_ALL']} />
      <Footer />
    </div>
  )
}
```

Next Steps

Now that you know how to do basic routing, you can learn more about [React Router API](#)

Note About Other Routing Libraries

Redux Router is an experimental library, it lets you keep entirely the state of your URL inside your redux store. It has the same API with React Router API but has a smaller community support than react-router.

React Router Redux creates a binding between your redux app and react-router and it keeps them in sync. Without this binding, you will not be able to rewind the actions with Time Travel. Unless you need this, React Router and Redux can operate completely apart.

Example: Reddit API

This is the complete source code of the Reddit headline fetching example we built during the [advanced tutorial](#).

Entry Point

index.js

```
import 'babel-polyfill'

import React from 'react'
import { render } from 'react-dom'
import Root from './containers/Root'

render(
  <Root />,
  document.getElementById('root')
)
```

Action Creators and Constants

actions.js

```
import fetch from 'isomorphic-fetch'

export const REQUEST_POSTS = 'REQUEST_POSTS'
export const RECEIVE_POSTS = 'RECEIVE_POSTS'
export const SELECT_SUBREDDIT = 'SELECT_SUBREDDIT'
export const INVALIDATE_SUBREDDIT = 'INVALIDATE_SUBREDDIT'

export function selectSubreddit(subreddit) {
  return {
    type: SELECT_SUBREDDIT,
    subreddit
  }
}

export function invalidateSubreddit(subreddit) {
  return {
    type: INVALIDATE_SUBREDDIT,
    subreddit
  }
}

function requestPosts(subreddit) {
  return {
    type: REQUEST_POSTS,
    subreddit
  }
}

function receivePosts(subreddit, json) {
  return {
    type: RECEIVE_POSTS,
    subreddit,
    posts: json.data.children.map(child => child.data),
    receivedAt: Date.now()
  }
}

function fetchPosts(subreddit) {
  return dispatch =>
```

```

        dispatch(requestPosts(subreddit))
      return fetch(`https://www.reddit.com/r/${subreddit}.json`)
        .then(response => response.json())
        .then(json => dispatch(receivePosts(subreddit, json)))
    }
}

function shouldFetchPosts(state, subreddit) {
  const posts = state.postsBySubreddit[subreddit]
  if (!posts) {
    return true
  } else if (posts.isFetching) {
    return false
  } else {
    return posts.didInvalidate
  }
}

export function fetchPostsIfNeeded(subreddit) {
  return (dispatch, getState) => {
    if (shouldFetchPosts(getState(), subreddit)) {
      return dispatch(fetchPosts(subreddit))
    }
  }
}

```

Reducers

reducers.js

```

import { combineReducers } from 'redux'
import {
  SELECT_SUBREDDIT,
  INVALIDATE_SUBREDDIT,
  REQUEST_POSTS,
  RECEIVE_POSTS
} from './actions'

function selectedSubreddit(state = 'reactjs', action) {
  switch (action.type) {
    case SELECT_SUBREDDIT:
      return action.subreddit
    default:
      return state
  }
}

function posts(
  state = {
    isFetching: false,
    didInvalidate: false,
    items: []
  },
  action
) {
  switch (action.type) {
    case INVALIDATE_SUBREDDIT:
      return Object.assign({}, state, {
        didInvalidate: true
      })
    case REQUEST_POSTS:
      return Object.assign({}, state, {
        isFetching: true,
        didInvalidate: false
      })
    case RECEIVE_POSTS:
      return Object.assign({}, state, {
        isFetching: false,
        didInvalidate: false,
        items: action.posts,
      })
  }
}

```

```
        lastUpdated: action.receivedAt
    })
default:
    return state
}

function postsBySubreddit(state = {}, action) {
switch (action.type) {
    case INVALIDATE_SUBREDDIT:
    case RECEIVE_POSTS:
    case REQUEST_POSTS:
        return Object.assign({}, state, {
            [action.subreddit]: posts(state[action.subreddit], action)
        })
    default:
        return state
}
}

const rootReducer = combineReducers({
    postsBySubreddit,
    selectedSubreddit
})

export default rootReducer
```

Store

configureStore.js

```
import { createStore, applyMiddleware } from 'redux'
import thunkMiddleware from 'redux-thunk'
import { createLogger } from 'redux-logger'
import rootReducer from './reducers'

const loggerMiddleware = createLogger()

export default function configureStore(preloadedState) {
    return createStore(
        rootReducer,
        preloadedState,
        applyMiddleware(
            thunkMiddleware,
            loggerMiddleware
        )
    )
}
```

Container Components

containers/Root.js

```
import React, { Component } from 'react'
import { Provider } from 'react-redux'
import configureStore from '../configureStore'
import AsyncApp from './AsyncApp'

const store = configureStore()

export default class Root extends Component {
    render() {
        return (
            <Provider store={store}>
                <AsyncApp />
            </Provider>
        )
    }
}
```

```

        </Provider>
    )
}
}

```

containers/AsyncApp.js

```

import React, { Component } from 'react'
import PropTypes from 'prop-types'
import { connect } from 'react-redux'
import {
  selectSubreddit,
  fetchPostsIfNeeded,
  invalidateSubreddit
} from '../actions'
import Picker from '../components/Picker'
import Posts from '../components/Posts'

class AsyncApp extends Component {
  constructor(props) {
    super(props)
    this.handleChange = this.handleChange.bind(this)
    this.handleRefreshClick = this.handleRefreshClick.bind(this)
  }

  componentDidMount() {
    const { dispatch, selectedSubreddit } = this.props
    dispatch(fetchPostsIfNeeded(selectedSubreddit))
  }

  componentDidUpdate(prevProps) {
    if (this.props.selectedSubreddit !== prevProps.selectedSubreddit) {
      const { dispatch, selectedSubreddit } = this.props
      dispatch(fetchPostsIfNeeded(selectedSubreddit))
    }
  }

  handleChange(nextSubreddit) {
    this.props.dispatch(selectSubreddit(nextSubreddit))
    this.props.dispatch(fetchPostsIfNeeded(nextSubreddit))
  }

  handleRefreshClick(e) {
    e.preventDefault()

    const { dispatch, selectedSubreddit } = this.props
    dispatch(invalidateSubreddit(selectedSubreddit))
    dispatch(fetchPostsIfNeeded(selectedSubreddit))
  }

  render() {
    const { selectedSubreddit, posts, isFetching, lastUpdated } = this.props
    return (
      <div>
        <Picker
          value={selectedSubreddit}
          onChange={this.handleChange}
          options={['reactjs', 'frontend']}
        />
        <p>
          {lastUpdated &&
            <span>
              Last updated at {new Date(lastUpdated).toLocaleTimeString()}.
              {' '}
            </span>}
          {!isFetching &&
            <a href="#" onClick={this.handleRefreshClick}>
              Refresh
            </a>}
        </p>
        {isFetching && posts.length === 0 && <h2>Loading...</h2>}
        {!isFetching && posts.length === 0 && <h2>Empty.</h2>}
      </div>
    )
  }
}

```

```

        {posts.length > 0 &&
         <div style={{ opacity: isFetching ? 0.5 : 1 }}>
           <Posts posts={posts} />
         </div>
       )
    }
}

AsyncApp.propTypes = {
  selectedSubreddit: PropTypes.string.isRequired,
  posts: PropTypes.array.isRequired,
  isFetching: PropTypes.bool.isRequired,
  lastUpdated: PropTypes.number.isRequired,
  dispatch: PropTypes.func.isRequired
}

function mapStateToProps(state) {
  const { selectedSubreddit, postsBySubreddit } = state
  const {
    isFetching,
    lastUpdated,
    items: posts
  } = postsBySubreddit[selectedSubreddit] || {
    isFetching: true,
    items: []
  }

  return {
    selectedSubreddit,
    posts,
    isFetching,
    lastUpdated
  }
}

export default connect(mapStateToProps)(AsyncApp)

```

Presentational Components

components/Picker.js

```

import React, { Component } from 'react'
import PropTypes from 'prop-types'

export default class Picker extends Component {
  render() {
    const { value, onChange, options } = this.props

    return (
      <span>
        <h1>{value}</h1>
        <select onChange={e => onChange(e.target.value)} value={value}>
          {options.map(option => (
            <option value={option} key={option}>
              {option}
            </option>
          ))}
        </select>
      </span>
    )
  }
}

Picker.propTypes = {
  options: PropTypes.arrayOf(PropTypes.string.isRequired).isRequired,
  value: PropTypes.string.isRequired,
  onChange: PropTypes.func.isRequired
}

```

components/Posts.js

```
import React, { Component } from 'react'
import PropTypes from 'prop-types'

export default class Posts extends Component {
  render() {
    return (
      <ul>
        {this.props.posts.map((post, i) => <li key={i}>{post.title}</li>)}
      </ul>
    )
  }
}

Posts.propTypes = {
  posts: PropTypes.array.isRequired
}
```

Recipes

These are some use cases and code snippets to get you started with Redux in a real app. They assume you understand the topics in [basic](#) and [advanced](#) tutorials.

- [Migrating to Redux](#)
- [Using Object Spread Operator](#)
- [Reducing Boilerplate](#)
- [Server Rendering](#)
- [Writing Tests](#)
- [Computing Derived Data](#)
- [Implementing Undo History](#)
- [Isolating Subapps](#)
- [Using Immutable.JS with Redux](#)

Migrating to Redux

Redux is not a monolithic framework, but a set of contracts and a [few functions that make them work together](#). The majority of your “Redux code” will not even use Redux APIs, as most of the time you’ll be writing functions.

This makes it easy to migrate both to and from Redux.

We don’t want to lock you in!

From Flux

[Reducers](#) capture “the essence” of Flux Stores, so it’s possible to gradually migrate an existing Flux project towards Redux, whether you are using [Flummox](#), [Alt](#), [traditional Flux](#), or any other Flux library.

It is also possible to do the reverse and migrate from Redux to any of these libraries following the same steps.

Your process will look like this:

- Create a function called `createFluxStore(reducer)` that creates a Flux store compatible with your existing app from a reducer function. Internally it might look similar to [`createStore` \(source\)](#) implementation from Redux. Its dispatch handler should just call the `reducer` for any action, store the next state, and emit change.
- This allows you to gradually rewrite every Flux Store in your app as a reducer, but still export `createFluxStore(reducer)` so the rest of your app is not aware that this is happening and sees the Flux stores.
- As you rewrite your Stores, you will find that you need to avoid certain Flux anti-patterns such as fetching API inside the Store, or triggering actions inside the Stores. Your Flux code will be easier to follow once you port it to be based on reducers!
- When you have ported all of your Flux Stores to be implemented on top of reducers, you can replace the Flux library with a single Redux store, and combine those reducers you already have into one using [`combineReducers\(reducers\)`](#).
- Now all that’s left to do is to port the UI to [use react-redux](#) or equivalent.
- Finally, you might want to begin using some Redux idioms like middleware to further simplify your asynchronous code.

From Backbone

Backbone’s model layer is quite different from Redux, so we don’t suggest mixing them. If possible, it is best that you rewrite your app’s model layer from scratch instead of connecting Backbone to Redux. However, if a rewrite is not feasible, you may use [backbone-redux](#) to migrate gradually, and keep the Redux store in sync with Backbone models and collections.

If your Backbone codebase is too big for a quick rewrite or you don’t want to manage interactions between store and models, use [backbone-redux-migrator](#) to help your two codebases coexist while keeping healthy separation. Once your rewrite finishes, Backbone code can be discarded and your Redux application can work on its own once you configure router.

Using Object Spread Operator

Since one of the core tenets of Redux is to never mutate state, you'll often find yourself using `Object.assign()` to create copies of objects with new or updated values. For example, in the `todoApp` below `Object.assign()` is used to return a new `state` object with an updated `visibilityFilter` property:

```
function todoApp(state = initialState, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return Object.assign({}, state, {
        visibilityFilter: action.filter
      })
    default:
      return state
  }
}
```

While effective, using `Object.assign()` can quickly make simple reducers difficult to read given its rather verbose syntax.

An alternative approach is to use the [object spread syntax](#) proposed for the next versions of JavaScript which lets you use the spread (`...`) operator to copy enumerable properties from one object to another in a more succinct way. The object spread operator is conceptually similar to the ES6 [array spread operator](#). We can simplify the `todoApp` example above by using the object spread syntax:

```
function todoApp(state = initialState, action) {
  switch (action.type) {
    case SET_VISIBILITY_FILTER:
      return { ...state, visibilityFilter: action.filter }
    default:
      return state
  }
}
```

The advantage of using the object spread syntax becomes more apparent when you're composing complex objects. Below `getAddedIds` maps an array of `id` values to an array of objects with values returned from `getProduct` and `getQuantity`.

```
return getAddedIds(state.cart).map(id =>
  Object.assign({}, getProduct(state.products, id), {
    quantity: getQuantity(state.cart, id)
  })
)
```

Object spread lets us simplify the above `map` call to:

```
return getAddedIds(state.cart).map(id => ({
  ...getProduct(state.products, id),
  quantity: getQuantity(state.cart, id)
}))
```

Since the object spread syntax is still a [Stage 3](#) proposal for ECMAScript you'll need to use a transpiler such as [Babel](#) to use it in production. You can use your existing `es2015` preset, install `babel-plugin-transform-object-rest-spread` and add it individually to the `plugins` array in your `.babelrc`.

```
{
  "presets": ["es2015"],
```

```
  "plugins": ["transform-object-rest-spread"]  
}
```

Note that this is still an experimental language feature proposal so it may change in the future. Nevertheless some large projects such as [React Native](#) already use it extensively so it is safe to say that there will be a good automated migration path if it changes.

Reducing Boilerplate

Redux is in part [inspired by Flux](#), and the most common complaint about Flux is how it makes you write a lot of boilerplate. In this recipe, we will consider how Redux lets us choose how verbose we'd like our code to be, depending on personal style, team preferences, longer term maintainability, and so on.

Actions

Actions are plain objects describing what happened in the app, and serve as the sole way to describe an intention to mutate the data. It's important that **actions being objects you have to dispatch is not boilerplate, but one of the fundamental design choices of Redux**.

There are frameworks claiming to be similar to Flux, but without a concept of action objects. In terms of being predictable, this is a step backwards from Flux or Redux. If there are no serializable plain object actions, it is impossible to record and replay user sessions, or to implement [hot reloading with time travel](#). If you'd rather modify data directly, you don't need Redux.

Actions look like this:

```
{ type: 'ADD_TODO', text: 'Use Redux' }
{ type: 'REMOVE_TODO', id: 42 }
{ type: 'LOAD_ARTICLE', response: { ... } }
```

It is a common convention that actions have a constant type that helps reducers (or Stores in Flux) identify them. We recommend that you use strings and not [Symbols](#) for action types, because strings are serializable, and by using Symbols you make recording and replaying harder than it needs to be.

In Flux, it is traditionally thought that you would define every action type as a string constant:

```
const ADD_TODO = 'ADD_TODO'
const REMOVE_TODO = 'REMOVE_TODO'
const LOAD_ARTICLE = 'LOAD_ARTICLE'
```

Why is this beneficial? **It is often claimed that constants are unnecessary, and for small projects, this might be correct.** For larger projects, there are some benefits to defining action types as constants:

- It helps keep the naming consistent because all action types are gathered in a single place.
- Sometimes you want to see all existing actions before working on a new feature. It may be that the action you need was already added by somebody on the team, but you didn't know.
- The list of action types that were added, removed, and changed in a Pull Request helps everyone on the team keep track of scope and implementation of new features.
- If you make a typo when importing an action constant, you will get `undefined`. Redux will immediately throw when dispatching such an action, and you'll find the mistake sooner.

It is up to you to choose the conventions for your project. You may start by using inline strings, and later transition to constants, and maybe later group them into a single file. Redux does not have any opinion here, so use your best judgment.

Action Creators

It is another common convention that, instead of creating action objects inline in the places where you dispatch the actions, you would create functions generating them.

For example, instead of calling `dispatch` with an object literal:

```
// somewhere in an event handler
dispatch({
  type: 'ADD_TODO',
  text: 'Use Redux'
})
```

You might write an action creator in a separate file, and import it into your component:

actionCreators.js

```
export function addTodo(text) {
  return {
    type: 'ADD_TODO',
    text
  }
}
```

AddTodo.js

```
import { addTodo } from './actionCreators'

// somewhere in an event handler
dispatch(addTodo('Use Redux'))
```

Action creators have often been criticized as boilerplate. Well, you don't have to write them! **You can use object literals if you feel this better suits your project.** There are, however, some benefits for writing action creators you should know about.

Let's say a designer comes back to us after reviewing our prototype, and tells us that we need to allow three todos maximum. We can enforce this by rewriting our action creator to a callback form with `redux-thunk` middleware and adding an early exit:

```
function addTodoWithoutCheck(text) {
  return {
    type: 'ADD_TODO',
    text
  }
}

export function addTodo(text) {
  // This form is allowed by Redux Thunk middleware
  // described below in "Async Action Creators" section.
  return function (dispatch, getState) {
    if (getState().todos.length === 3) {
      // Exit early
      return
    }
    dispatch(addTodoWithoutCheck(text))
  }
}
```

We just modified how the `addTodo` action creator behaves, completely invisible to the calling code. **We don't have to worry about looking at each place where todos are being added, to make sure they have this check.** Action creators let you decouple additional logic around dispatching an action, from the actual components emitting those actions. It's very handy when the application is under heavy development, and the requirements change often.

Generating Action Creators

Some frameworks like [Flummox](#) generate action type constants automatically from the action creator function definitions. The idea is that you don't need to both define `ADD_TODO` constant and `addTodo()` action creator. Under the hood, such solutions still generate action type constants, but they're created implicitly so it's a level of indirection and can cause confusion. We recommend creating your action type constants explicitly.

Writing simple action creators can be tiresome and often ends up generating redundant boilerplate code:

```
export function addTodo(text) {
  return {
    type: 'ADD_TODO',
    text
  }
}

export function editTodo(id, text) {
  return {
    type: 'EDIT_TODO',
    id,
    text
  }
}

export function removeTodo(id) {
  return {
    type: 'REMOVE_TODO',
    id
  }
}
```

You can always write a function that generates an action creator:

```
function makeActionCreator(type, ...argNames) {
  return function (...args) {
    let action = { type }
    argNames.forEach((arg, index) => {
      action[argNames[index]] = args[index]
    })
    return action
  }
}

const ADD_TODO = 'ADD_TODO'
const EDIT_TODO = 'EDIT_TODO'
const REMOVE_TODO = 'REMOVE_TODO'

export const addTodo = makeActionCreator(ADD_TODO, 'text')
export const editTodo = makeActionCreator(EDIT_TODO, 'id', 'text')
export const removeTodo = makeActionCreator(REMOVE_TODO, 'id')
```

There are also utility libraries to aid in generating action creators, such as [redux-act](#) and [redux-actions](#). These can help reduce boilerplate code and enforce adherence to standards such as [Flux Standard Action \(FSA\)](#).

Async Action Creators

[Middleware](#) lets you inject custom logic that interprets every action object before it is dispatched. Async actions are the most common use case for middleware.

Without any middleware, `dispatch` only accepts a plain object, so we have to perform AJAX calls inside our components:

actionCreators.js

```

export function loadPostsSuccess(userId, response) {
  return {
    type: 'LOAD_POSTS_SUCCESS',
    userId,
    response
  }
}

export function loadPostsFailure(userId, error) {
  return {
    type: 'LOAD_POSTS_FAILURE',
    userId,
    error
  }
}

export function loadPostsRequest(userId) {
  return {
    type: 'LOAD_POSTS_REQUEST',
    userId
  }
}

```

UserInfo.js

```

import { Component } from 'react'
import { connect } from 'react-redux'
import {
  loadPostsRequest,
  loadPostsSuccess,
  loadPostsFailure
} from './actionCreators'

class Posts extends Component {
  loadData(userId) {
    // Injected into props by React Redux `connect()` call:
    let { dispatch, posts } = this.props

    if (posts[userId]) {
      // There is cached data! Don't do anything.
      return
    }

    // Reducer can react to this action by setting
    // `isFetching` and thus letting us show a spinner.
    dispatch(loadPostsRequest(userId))

    // Reducer can react to these actions by filling the `users`.
    fetch(`http://myapi.com/users/${userId}/posts`).then(
      response => dispatch(loadPostsSuccess(userId, response)),
      error => dispatch(loadPostsFailure(userId, error))
    )
  }

  componentDidMount() {
    this.loadData(this.props.userId)
  }

  componentWillReceiveProps(nextProps) {
    if (nextProps.userId !== this.props.userId) {
      this.loadData(nextProps.userId)
    }
  }

  render() {
    if (this.props.isFetching) {
      return <p>Loading...</p>
    }
  }
}

```

```

let posts = this.props.posts.map(post =>
  <Post post={post} key={post.id} />
)
return <div>{posts}</div>
}
}

export default connect(state => ({
  posts: state.posts
}))(Posts)

```

However, this quickly gets repetitive because different components request data from the same API endpoints. Moreover, we want to reuse some of this logic (e.g., early exit when there is cached data available) from many components.

Middleware lets us write more expressive, potentially async action creators. It lets us dispatch something other than plain objects, and interprets the values. For example, middleware can “catch” dispatched Promises and turn them into a pair of request and success/failure actions.

The simplest example of middleware is [redux-thunk](#). **“Thunk” middleware lets you write action creators as “thunks”, that is, functions returning functions.** This inverts the control: you will get `dispatch` as an argument, so you can write an action creator that dispatches many times.

Note

Thunk middleware is just one example of middleware. Middleware is not about “letting you dispatch functions”. It’s about letting you dispatch anything that the particular middleware you use knows how to handle. Thunk middleware adds a specific behavior when you dispatch functions, but it really depends on the middleware you use.

Consider the code above rewritten with [redux-thunk](#):

actionCreators.js

```

export function loadPosts(userId) {
  // Interpreted by the thunk middleware:
  return function (dispatch, getState) {
    let { posts } = getState()
    if (posts[userId]) {
      // There is cached data! Don't do anything.
      return
    }

    dispatch({
      type: 'LOAD_POSTS_REQUEST',
      userId
    })

    // Dispatch vanilla actions asynchronously
    fetch(`http://myapi.com/users/${userId}/posts`).then(
      response =>
        dispatch({
          type: 'LOAD_POSTS_SUCCESS',
          userId,
          response
        }),
      error =>
        dispatch({
          type: 'LOAD_POSTS_FAILURE',
          userId,
          error
        })
    )
  }
}

```

UserInfo.js

```

import { Component } from 'react'
import { connect } from 'react-redux'
import { loadPosts } from './actionCreators'

class Posts extends Component {
  componentDidMount() {
    this.props.dispatch(loadPosts(this.props.userId))
  }

  componentWillReceiveProps(nextProps) {
    if (nextProps.userId !== this.props.userId) {
      this.props.dispatch(loadPosts(nextProps.userId))
    }
  }

  render() {
    if (this.props.isFetching) {
      return <p>Loading...</p>
    }

    let posts = this.props.posts.map(post =>
      <Post post={post} key={post.id} />
    )

    return <div>{posts}</div>
  }
}

export default connect(state => ({
  posts: state.posts
}))(Posts)

```

This is much less typing! If you'd like, you can still have "vanilla" action creators like `loadPostsSuccess` which you'd use from a container `loadPosts` action creator.

Finally, you can write your own middleware. Let's say you want to generalize the pattern above and describe your async action creators like this instead:

```

export function loadPosts(userId) {
  return {
    // Types of actions to emit before and after
    types: ['LOAD_POSTS_REQUEST', 'LOAD_POSTS_SUCCESS', 'LOAD_POSTS_FAILURE'],
    // Check the cache (optional):
    shouldCallAPI: state => !state.posts[userId],
    // Perform the fetching:
    callAPI: () => fetch(`http://myapi.com/users/${userId}/posts`),
    // Arguments to inject in begin/end actions
    payload: { userId }
  }
}

```

The middleware that interprets such actions could look like this:

```

function callAPIMiddleware({ dispatch, getState }) {
  return next => action => {
    const {
      types,
      callAPI,
      shouldCallAPI = () => true,
      payload = {}
    } = action

    if (!types) {
      // Normal action: pass it on
    }
  }
}

```

```

        return next(action)
    }

    if (
        !Array.isArray(types) ||
        types.length !== 3 ||
        !types.every(type => typeof type === 'string')
    ) {
        throw new Error('Expected an array of three string types.')
    }

    if (typeof callAPI !== 'function') {
        throw new Error('Expected callAPI to be a function.')
    }

    if (!shouldCallAPI(getState())) {
        return
    }

    const [requestType, successType, failureType] = types

    dispatch(
        Object.assign({}, payload, {
            type: requestType
        })
    )

    return callAPI().then(
        response =>
        dispatch(
            Object.assign({}, payload, {
                response,
                type: successType
            })
        ),
        error =>
        dispatch(
            Object.assign({}, payload, {
                error,
                type: failureType
            })
        )
    )
}
}

```

After passing it once to `applyMiddleware(...middlewares)`, you can write all your API-calling action creators the same way:

```

export function loadPosts(userId) {
    return {
        types: ['LOAD_POSTS_REQUEST', 'LOAD_POSTS_SUCCESS', 'LOAD_POSTS_FAILURE'],
        shouldCallAPI: state => !state.posts[userId],
        callAPI: () => fetch(`http://myapi.com/users/${userId}/posts`),
        payload: { userId }
    }
}

export function loadComments(postId) {
    return {
        types: [
            'LOAD_COMMENTS_REQUEST',
            'LOAD_COMMENTS_SUCCESS',
            'LOAD_COMMENTS_FAILURE'
        ],
        shouldCallAPI: state => !state.comments[postId],
        callAPI: () => fetch(`http://myapi.com/posts/${postId}/comments`),
        payload: { postId }
    }
}

export function addComment(postId, message) {

```

```

return {
  types: [
    'ADD_COMMENT_REQUEST',
    'ADD_COMMENT_SUCCESS',
    'ADD_COMMENT_FAILURE'
  ],
  callAPI: () =>
    fetch(`http://myapi.com/posts/${postId}/comments`, {
      method: 'post',
      headers: {
        Accept: 'application/json',
        'Content-Type': 'application/json'
      },
      body: JSON.stringify({ message })
    }),
    payload: { postId, message }
}
}

```

Reducers

Redux reduces the boilerplate of Flux stores considerably by describing the update logic as a function. A function is simpler than an object, and much simpler than a class.

Consider this Flux store:

```

let _todos = []

const TodoStore = Object.assign({}, EventEmitter.prototype, {
  getAll() {
    return _todos
  }
})

AppDispatcher.register(function (action) {
  switch (action.type) {
    case ActionTypes.ADD_TODO:
      let text = action.text.trim()
      _todos.push(text)
      TodoStore.emitChange()
  }
})

export default TodoStore

```

With Redux, the same update logic can be described as a reducing function:

```

export function todos(state = [], action) {
  switch (action.type) {
    case ActionTypes.ADD_TODO:
      let text = action.text.trim()
      return [...state, text]
    default:
      return state
  }
}

```

The `switch` statement is *not* the real boilerplate. The real boilerplate of Flux is conceptual: the need to emit an update, the need to register the Store with a Dispatcher, the need for the Store to be an object (and the complications that arise when you want a universal app).

It's unfortunate that many still choose Flux framework based on whether it uses `switch` statements in the documentation. If you don't like `switch`, you can solve this with a single function, as we show below.

Generating Reducers

Let's write a function that lets us express reducers as an object mapping from action types to handlers. For example, if we want our `todos` reducers to be defined like this:

```
export const todos = createReducer([], {
  [ActionTypes.ADD_TODO](state, action) {
    let text = action.text.trim()
    return [...state, text]
  }
})
```

We can write the following helper to accomplish this:

```
function createReducer(initialState, handlers) {
  return function reducer(state = initialState, action) {
    if (handlers.hasOwnProperty(action.type)) {
      return handlers[action.type](state, action)
    } else {
      return state
    }
  }
}
```

This wasn't difficult, was it? Redux doesn't provide such a helper function by default because there are many ways to write it. Maybe you want it to automatically convert plain JS objects to Immutable objects to hydrate the server state. Maybe you want to merge the returned state with the current state. There may be different approaches to a "catch all" handler. All of this depends on the conventions you choose for your team on a specific project.

The Redux reducer API is `(state, action) => state`, but how you create those reducers is up to you.

Server Rendering

The most common use case for server-side rendering is to handle the *initial render* when a user (or search engine crawler) first requests our app. When the server receives the request, it renders the required component(s) into an HTML string, and then sends it as a response to the client. From that point on, the client takes over rendering duties.

We will use React in the examples below, but the same techniques can be used with other view frameworks that can render on the server.

Redux on the Server

When using Redux with server rendering, we must also send the state of our app along in our response, so the client can use it as the initial state. This is important because, if we preload any data before generating the HTML, we want the client to also have access to this data. Otherwise, the markup generated on the client won't match the server markup, and the client would have to load the data again.

To send the data down to the client, we need to:

- create a fresh, new Redux store instance on every request;
- optionally dispatch some actions;
- pull the state out of store;
- and then pass the state along to the client.

On the client side, a new Redux store will be created and initialized with the state provided from the server.

Redux's **only** job on the server side is to provide the **initial state** of our app.

Setting Up

In the following recipe, we are going to look at how to set up server-side rendering. We'll use the simplistic [Counter app](#) as a guide and show how the server can render state ahead of time based on the request.

Install Packages

For this example, we'll be using [Express](#) as a simple web server. We also need to install the React bindings for Redux, since they are not included in Redux by default.

```
npm install --save express react-redux
```

The Server Side

The following is the outline for what our server side is going to look like. We are going to set up an [Express middleware](#) using [app.use](#) to handle all requests that come in to our server. If you're unfamiliar with Express or middleware, just know that our `handleRender` function will be called every time the server receives a request.

Additionally, as we are using ES6 and JSX syntax, we will need to compile with [Babel](#) (see [this example of a Node Server with Babel](#)) and the [React preset](#).

```
server.js
```

```
import path from 'path'
import Express from 'express'
```

```

import React from 'react'
import { createStore } from 'redux'
import { Provider } from 'react-redux'
import counterApp from './reducers'
import App from './containers/App'

const app = Express()
const port = 3000

// Serve static files
app.use('/static', Express.static('static'))

// This is fired every time the server side receives a request
app.use(handleRender)

// We are going to fill these out in the sections to follow
function handleRender(req, res) { /* ... */ }
function renderFullPage(html, preloadedState) { /* ... */ }

app.listen(port)

```

Handling the Request

The first thing that we need to do on every request is create a new Redux store instance. The only purpose of this store instance is to provide the initial state of our application.

When rendering, we will wrap `<App />`, our root component, inside a `<Provider>` to make the store available to all components in the component tree, as we saw in [Usage with React](#).

The key step in server side rendering is to render the initial HTML of our component **before** we send it to the client side. To do this, we use `ReactDOMServer.renderToString()`.

We then get the initial state from our Redux store using `store.getState()`. We will see how this is passed along in our `renderFullPage` function.

```

import { renderToString } from 'react-dom/server'

function handleRender(req, res) {
  // Create a new Redux store instance
  const store = createStore(counterApp)

  // Render the component to a string
  const html = renderToString(
    <Provider store={store}>
      <App />
    </Provider>
  )

  // Grab the initial state from our Redux store
  const preloadedState = store.getState()

  // Send the rendered page back to the client
  res.send(renderFullPage(html, preloadedState))
}

```

Inject Initial Component HTML and State

The final step on the server side is to inject our initial component HTML and initial state into a template to be rendered on the client side. To pass along the state, we add a `<script>` tag that will attach `preloadedState` to `window.__PRELOADED_STATE__`.

The `preloadedState` will then be available on the client side by accessing `window.__PRELOADED_STATE__`.

We also include our bundle file for the client-side application via a script tag. This is whatever output your bundling tool provides for your client entry point. It may be a static file or a URL to a hot reloading development server.

```

function renderFullPage(html, preloadedState) {
  return `
    <!doctype html>
    <html>
      <head>
        <title>Redux Universal Example</title>
      </head>
      <body>
        <div id="root">${html}</div>
        <script>
          // WARNING: See the following for security issues around embedding JSON in HTML:
          // http://redux.js.org/docs/recipes/ServerRendering.html#security-considerations
          window.__PRELOADED_STATE__ = ${JSON.stringify(preloadedState).replace(/</g, '\\u003c')}
        </script>
        <script src="/static/bundle.js"></script>
      </body>
    </html>
  `
}

```

The Client Side

The client side is very straightforward. All we need to do is grab the initial state from `window.__PRELOADED_STATE__`, and pass it to our `createStore()` function as the initial state.

Let's take a look at our new client file:

client.js

```

import React from 'react'
import { render } from 'react-dom'
import { createStore } from 'redux'
import { Provider } from 'react-redux'
import App from './containers/App'
import counterApp from './reducers'

// Grab the state from a global variable injected into the server-generated HTML
const preloadedState = window.__PRELOADED_STATE__

// Allow the passed state to be garbage-collected
delete window.__PRELOADED_STATE__

// Create Redux store with initial state
const store = createStore(counterApp, preloadedState)

render(
  <Provider store={store}>
    <App />
  </Provider>,
  document.getElementById('root')
)

```

You can set up your build tool of choice (Webpack, Browserify, etc.) to compile a bundle file into `static/bundle.js`.

When the page loads, the bundle file will be started up and `ReactDOM.render()` will hook into the `data-react-id` attributes from the server-rendered HTML. This will connect our newly-started React instance to the virtual DOM used on the server. Since we have the same initial state for our Redux store and used the same code for all our view components, the result will be the same real DOM.

And that's it! That is all we need to do to implement server side rendering.

But the result is pretty vanilla. It essentially renders a static view from dynamic code. What we need to do next is build an initial state dynamically to allow that rendered view to be dynamic.

Preparing the Initial State

Because the client side executes ongoing code, it can start with an empty initial state and obtain any necessary state on demand and over time. On the server side, rendering is synchronous and we only get one shot to render our view. We need to be able to compile our initial state during the request, which will have to react to input and obtain external state (such as that from an API or database).

Processing Request Parameters

The only input for server side code is the request made when loading up a page in your app in your browser. You may choose to configure the server during its boot (such as when you are running in a development vs. production environment), but that configuration is static.

The request contains information about the URL requested, including any query parameters, which will be useful when using something like [React Router](#). It can also contain headers with inputs like cookies or authorization, or POST body data. Let's see how we can set the initial counter state based on a query parameter.

server.js

```
import qs from 'qs' // Add this at the top of the file
import { renderToString } from 'react-dom/server'

function handleRender(req, res) {
  // Read the counter from the request, if provided
  const params = qs.parse(req.query)
  const counter = parseInt(params.counter, 10) || 0

  // Compile an initial state
  let preloadedState = { counter }

  // Create a new Redux store instance
  const store = createStore(counterApp, preloadedState)

  // Render the component to a string
  const html = renderToString(
    <Provider store={store}>
      <App />
    </Provider>
  )

  // Grab the initial state from our Redux store
  const finalState = store.getState()

  // Send the rendered page back to the client
  res.send(renderFullPage(html, finalState))
}
```

The code reads from the Express `req` object passed into our server middleware. The parameter is parsed into a number and then set in the initial state. If you visit <http://localhost:3000/?counter=100> in your browser, you'll see the counter starts at 100. In the rendered HTML, you'll see the counter output as 100 and the `__PRELOADED_STATE__` variable has the counter set in it.

Async State Fetching

The most common issue with server side rendering is dealing with state that comes in asynchronously. Rendering on the server is synchronous by nature, so it's necessary to map any asynchronous fetches into a synchronous operation.

The easiest way to do this is to pass through some callback back to your synchronous code. In this case, that will be a function that will reference the response object and send back our rendered HTML to the client. Don't worry, it's not as hard as it may sound.

For our example, we'll imagine there is an external datastore that contains the counter's initial value (Counter As A Service, or CaaS). We'll make a mock call over to them and build our initial state from the result. We'll start by building out our API call:

api/counter.js

```
function getRandomInt(min, max) {
  return Math.floor(Math.random() * (max - min)) + min
}

export function fetchCounter(callback) {
  setTimeout(() => {
    callback(getRandomInt(1, 100))
  }, 500)
}
```

Again, this is just a mock API, so we use `setTimeout` to simulate a network request that takes 500 milliseconds to respond (this should be much faster with a real world API). We pass in a callback that returns a random number asynchronously. If you're using a Promise-based API client, then you would issue this callback in your `then` handler.

On the server side, we simply wrap our existing code in the `fetchCounter` and receive the result in the callback:

server.js

```
// Add this to our imports
import { fetchCounter } from './api/counter'
import { renderToString } from 'react-dom/server'

function handleRender(req, res) {
  // Query our mock API asynchronously
  fetchCounter(apiResult => {
    // Read the counter from the request, if provided
    const params = qs.parse(req.query)
    const counter = parseInt(params.counter, 10) || apiResult || 0

    // Compile an initial state
    let preloadedState = { counter }

    // Create a new Redux store instance
    const store = createStore(counterApp, preloadedState)

    // Render the component to a string
    const html = renderToString(
      <Provider store={store}>
        <App />
      </Provider>
    )

    // Grab the initial state from our Redux store
    const finalState = store.getState()

    // Send the rendered page back to the client
    res.send(renderFullPage(html, finalState))
  })
}
```

Because we call `res.send()` inside of the callback, the server will hold open the connection and won't send any data until that callback executes. You'll notice a 500ms delay is now added to each server request as a result of our new API call. A more advanced usage would handle errors in the API gracefully, such as a bad response or timeout.

Security Considerations

Because we have introduced more code that relies on user generated content (UGC) and input, we have increased our attack surface area for our application. It is important for any application that you ensure your input is properly sanitized to prevent things like cross-site scripting (XSS) attacks or code injections.

In our example, we take a rudimentary approach to security. When we obtain the parameters from the request, we use `parseInt` on the `counter` parameter to ensure this value is a number. If we did not do this, you could easily get dangerous data into the rendered HTML by providing a script tag in the request. That might look like this: `?counter=</script><script>doSomethingBad();</script>`

For our simplistic example, coercing our input into a number is sufficiently secure. If you're handling more complex input, such as freeform text, then you should run that input through an appropriate sanitization function, such as [validator.js](#).

Furthermore, you can add additional layers of security by sanitizing your state output. `JSON.stringify` can be subject to script injections. To counter this, you can scrub the JSON string of HTML tags and other dangerous characters. This can be done with either a simple text replacement on the string, e.g. `JSON.stringify(state).replace(/</g, '\\u003c')`, or via more sophisticated libraries such as [serialize-javascript](#).

Next Steps

You may want to read [Async Actions](#) to learn more about expressing asynchronous flow in Redux with async primitives such as Promises and thunks. Keep in mind that anything you learn there can also be applied to universal rendering.

If you use something like [React Router](#), you might also want to express your data fetching dependencies as static `fetchData()` methods on your route handler components. They may return [async actions](#), so that your `handleRender` function can match the route to the route handler component classes, dispatch `fetchData()` result for each of them, and render only after the Promises have resolved. This way the specific API calls required for different routes are colocated with the route handler component definitions. You can also use the same technique on the client side to prevent the router from switching the page until its data has been loaded.

Writing Tests

Because most of the Redux code you write are functions, and many of them are pure, they are easy to test without mocking.

Setting Up

We recommend [Jest](#) as the testing engine. Note that it runs in a Node environment, so you won't have access to the DOM.

```
npm install --save-dev jest
```

To use it together with [Babel](#), you will need to install `babel-jest`:

```
npm install --save-dev babel-jest
```

and configure it to use ES2015 features in `.babelrc`:

```
{
  "presets": ["es2015"]
}
```

Then, add this to `scripts` in your `package.json`:

```
{
  ...
  "scripts": {
    ...
    "test": "jest",
    "test:watch": "npm test -- --watch"
  },
  ...
}
```

and run `npm test` to run it once, or `npm run test:watch` to test on every file change.

Action Creators

In Redux, action creators are functions which return plain objects. When testing action creators we want to test whether the correct action creator was called and also whether the right action was returned.

Example

```
export function addTodo(text) {
  return {
    type: 'ADD_TODO',
    text
  }
}
```

can be tested like:

```
import * as actions from '../../../../../actions/TodoActions'
import * as types from '../../../../../constants/ActionTypes'
```

```

describe('actions', () => {
  it('should create an action to add a todo', () => {
    const text = 'Finish docs'
    const expectedAction = {
      type: types.ADD_TODO,
      text
    }
    expect(actions.addTodo(text)).toEqual(expectedAction)
  })
})

```

Async Action Creators

For async action creators using [Redux Thunk](#) or other middleware, it's best to completely mock the Redux store for tests. You can apply the middleware to a mock store using [redux-mock-store](#). You can also use [fetch-mock](#) to mock the HTTP requests.

Example

```

import fetch from 'isomorphic-fetch'

function fetchTodosRequest() {
  return {
    type: FETCH_TODOS_REQUEST
  }
}

function fetchTodosSuccess(body) {
  return {
    type: FETCH_TODOS_SUCCESS,
    body
  }
}

function fetchTodosFailure(ex) {
  return {
    type: FETCH_TODOS_FAILURE,
    ex
  }
}

export function fetchTodos() {
  return dispatch => {
    dispatch(fetchTodosRequest())
    return fetch('http://example.com/todos')
      .then(res => res.json())
      .then(json => dispatch(fetchTodosSuccess(json.body)))
      .catch(ex => dispatch(fetchTodosFailure(ex)))
  }
}

```

can be tested like:

```

import configureMockStore from 'redux-mock-store'
import thunk from 'redux-thunk'
import * as actions from '../../../../../actions/TodoActions'
import * as types from '../../../../../constants/ActionTypes'
import fetchMock from 'fetch-mock'
import expect from 'expect' // You can use any testing library

const middlewares = [thunk]
const mockStore = configureMockStore(middlewares)

describe('async actions', () => {
  afterEach(() => {
    fetchMock.reset()
  })
})

```

```

    fetchMock.restore()
  })

it('creates FETCH_TODOS_SUCCESS when fetching todos has been done', () => {
  fetchMock
    .getOnce('/todos', { body: { todos: ['do something'] }, headers: { 'content-type': 'application/json' } })

  const expectedActions = [
    { type: types.FETCH_TODOS_REQUEST },
    { type: types.FETCH_TODOS_SUCCESS, body: { todos: ['do something'] } }
  ]
  const store = mockStore({ todos: [] })

  return store.dispatch(actions.fetchTodos()).then(() => {
    // return of async actions
    expect(store.getActions()).toEqual(expectedActions)
  })
})
})
})
})

```

Reducers

A reducer should return the new state after applying the action to the previous state, and that's the behavior tested below.

Example

```

import { ADD_TODO } from '../constants/ActionTypes'

const initialState = [
  {
    text: 'Use Redux',
    completed: false,
    id: 0
  }
]

export default function todos(state = initialState, action) {
  switch (action.type) {
    case ADD_TODO:
      return [
        {
          id: state.reduce((maxId, todo) => Math.max(todo.id, maxId), -1) + 1,
          completed: false,
          text: action.text
        },
        ...state
      ]
    default:
      return state
  }
}

```

can be tested like:

```

import reducer from '../../../../../reducers/todos'
import * as types from '../../../../../constants/ActionTypes'

describe('todos reducer', () => {
  it('should return the initial state', () => {
    expect(reducer(undefined, {})).toEqual([
      {
        text: 'Use Redux',
        completed: false,
        id: 0
      }
    ])
  })
})

```

```
        completed: false,
        id: 0
    }
])
})
}

it('should handle ADD_TODO', () => {
  expect(
    reducer([], {
      type: types.ADD_TODO,
      text: 'Run the tests'
    })
  ).toEqual([
    {
      text: 'Run the tests',
      completed: false,
      id: 0
    }
  ])
}

expect(
  reducer(
    [
      {
        text: 'Use Redux',
        completed: false,
        id: 0
      }
    ],
    {
      type: types.ADD_TODO,
      text: 'Run the tests'
    }
  )
).toEqual([
  {
    text: 'Run the tests',
    completed: false,
    id: 1
  },
  {
    text: 'Use Redux',
    completed: false,
    id: 0
  }
])
})
```

Components

A nice thing about React components is that they are usually small and only rely on their props. That makes them easy to test.

First, we will install [Enzyme](#). Enzyme uses the [React Test Utilities](#) underneath, but is more convenient, readable, and powerful.

```
npm install --save-dev enzyme
```

To test the components we make a `setup()` helper that passes the stubbed callbacks as props and renders the component with [shallow rendering](#). This lets individual tests assert on whether the callbacks were called when expected.

Example

```
import React, { Component } from 'react'
```

```

import PropTypes from 'prop-types'
import TodoTextInput from './TodoTextInput'

class Header extends Component {
  handleSave(text) {
    if (text.length !== 0) {
      this.props.addTodo(text)
    }
  }

  render() {
    return (
      <header className="header">
        <h1>todos</h1>
        <TodoTextInput
          newTodo={true}
          onSave={this.handleSave.bind(this)}
          placeholder="What needs to be done?"
        />
      </header>
    )
  }
}

Header.propTypes = {
  addTodo: PropTypes.func.isRequired
}

export default Header

```

can be tested like:

```

import React from 'react'
import { mount } from 'enzyme'
import Header from '../../../../../components/Header'

function setup() {
  const props = {
    addTodo: jest.fn()
  }

  const enzymeWrapper = mount(<Header {...props} />)

  return {
    props,
    enzymeWrapper
  }
}

describe('components', () => {
  describe('Header', () => {
    it('should render self and subcomponents', () => {
      const { enzymeWrapper } = setup()

      expect(enzymeWrapper.find('header').hasClass('header')).toBe(true)

      expect(enzymeWrapper.find('h1').text()).toBe('todos')

      const todoInputProps = enzymeWrapper.find('TodoTextInput').props()
      expect(todoInputProps.newTodo).toBe(true)
      expect(todoInputProps.placeholder).toEqual('What needs to be done?')
    })

    it('should call addTodo if length of text is greater than 0', () => {
      const { enzymeWrapper, props } = setup()
      const input = enzymeWrapper.find('TodoTextInput')
      input.props().onSave('')
      expect(props.addTodo.mock.calls.length).toBe(0)
      input.props().onSave('Use Redux')
      expect(props.addTodo.mock.calls.length).toBe(1)
    })
  })
})

```

```
})
```

Connected Components

If you use a library like `React Redux`, you might be using higher-order components like `connect()`. This lets you inject Redux state into a regular React component.

Consider the following `App` component:

```
import { connect } from 'react-redux'

class App extends Component { /* ... */ }

export default connect(mapStateToProps)(App)
```

In a unit test, you would normally import the `App` component like this:

```
import App from './App'
```

However, when you import it, you're actually holding the wrapper component returned by `connect()`, and not the `App` component itself. If you want to test its interaction with Redux, this is good news: you can wrap it in a `<Provider>` with a store created specifically for this unit test. But sometimes you want to test just the rendering of the component, without a Redux store.

In order to be able to test the `App` component itself without having to deal with the decorator, we recommend you to also export the undecorated component:

```
import { connect } from 'react-redux'

// Use named export for unconnected component (for tests)
export class App extends Component { /* ... */ }

// Use default export for the connected component (for app)
export default connect(mapStateToProps)(App)
```

Since the default export is still the decorated component, the import statement pictured above will work as before so you won't have to change your application code. However, you can now import the undecorated `App` components in your test file like this:

```
// Note the curly braces: grab the named export instead of default export
import { App } from './App'
```

And if you need both:

```
import ConnectedApp, { App } from './App'
```

In the app itself, you would still import it normally:

```
import App from './App'
```

You would only use the named export for tests.

A Note on Mixing ES6 Modules and CommonJS

If you are using ES6 in your application source, but write your tests in ES5, you should know that Babel handles the interchangeable use of ES6 `import` and CommonJS `require` through its `interop` capability to run two module formats side-by-side, but the behavior is **slightly different**. If you add a second export beside your default export, you can no longer import the default using `require('./App')`. Instead you have to use `require('./App').default`.

Middleware

Middleware functions wrap behavior of `dispatch` calls in Redux, so to test this modified behavior we need to mock the behavior of the `dispatch` call.

Example

First, we'll need a middleware function. This is similar to the real [redux-thunk](#).

```
const thunk = ({ dispatch, getState }) => next => action => {
  if (typeof action === 'function') {
    return action(dispatch, getState)
  }

  return next(action)
}
```

We need to create a fake `getState`, `dispatch`, and `next` functions. We use `jest.fn()` to create stubs, but with other test frameworks you would likely use sinon.

The `invoke` function runs our middleware in the same way Redux does.

```
const create = () => {
  const store = {
    getState: jest.fn(() => ({ })),
    dispatch: jest.fn(),
  };
  const next = jest.fn()

  const invoke = (action) => thunk(store)(next)(action)

  return {store, next, invoke}
};
```

We test that our middleware is calling the `getState`, `dispatch`, and `next` functions at the right time.

```
it(`passes through non-function action`, () => {
  const { next, invoke } = create()
  const action = {type: 'TEST'}
  invoke(action)
  expect(next).toHaveBeenCalledWith(action)
})

it('calls the function', () => {
  const { invoke } = create()
  const fn = jest.fn()
  invoke(fn)
  expect(fn).toHaveBeenCalled()
});

it('passes dispatch and getState', () => {
  const { store, invoke } = create()
  invoke(({ dispatch, getState }) => {
    dispatch('TEST DISPATCH')
    getState();
  })
  expect(store.dispatch).toHaveBeenCalledWith('TEST DISPATCH')
})
```

```
    expect(store.getState()).toHaveBeenCalled()  
});
```

In some cases, you will need to modify the `create` function to use different mock implementations of `getState` and `next`.

Glossary

- [Enzyme](#): Enzyme is a JavaScript Testing utility for React that makes it easier to assert, manipulate, and traverse your React Components' output.
- [React Test Utils](#): Test Utilities for React. Used by Enzyme.
- [Shallow rendering](#): Shallow rendering lets you instantiate a component and effectively get the result of its `render` method just a single level deep instead of rendering components recursively to a DOM. Shallow rendering is useful for unit tests, where you test a particular component only, and importantly not its children. This also means that changing a child component won't affect the tests for the parent component. Testing a component and all its children can be accomplished with Enzyme's `mount()` method, aka full DOM rendering.

Computing Derived Data

[Reselect](#) is a simple library for creating memoized, composable **selector** functions. Reselect selectors can be used to efficiently compute derived data from the Redux store.

Motivation for Memoized Selectors

Let's revisit the [Todos List example](#):

containers/VisibleTodoList.js

```
import { connect } from 'react-redux'
import { toggleTodo } from '../actions'
import TodoList from '../components/TodoList'

const getVisibleTodos = (todos, filter) => {
  switch (filter) {
    case 'SHOW_ALL':
      return todos
    case 'SHOW_COMPLETED':
      return todos.filter(t => t.completed)
    case 'SHOW_ACTIVE':
      return todos.filter(t => !t.completed)
  }
}

const mapStateToProps = state => {
  return {
    todos: getVisibleTodos(state.todos, state.visibilityFilter)
  }
}

const mapDispatchToProps = dispatch => {
  return {
    onTodoClick: id => {
      dispatch(toggleTodo(id))
    }
  }
}

const VisibleTodoList = connect(
  mapStateToProps,
  mapDispatchToProps
)(TodoList)

export default VisibleTodoList
```

In the above example, `mapStateToProps` calls `getVisibleTodos` to calculate `todos`. This works great, but there is a drawback: `todos` is calculated every time the component is updated. If the state tree is large, or the calculation expensive, repeating the calculation on every update may cause performance problems. Reselect can help to avoid these unnecessary recalculations.

Creating a Memoized Selector

We would like to replace `getVisibleTodos` with a memoized selector that recalculates `todos` when the value of `state.todos` OR `state.visibilityFilter` changes, but not when changes occur in other (unrelated) parts of the state tree.

Reselect provides a function `createSelector` for creating memoized selectors. `createSelector` takes an array of input-selectors and a transform function as its arguments. If the Redux state tree is mutated in a way that causes the value of an input-selector to change, the selector will call its transform function with the values of the input-selectors as arguments and return the result. If the values of the input-selectors are the same as the previous call to the selector, it will return the previously computed value instead of calling the transform function.

Let's define a memoized selector named `getVisibleTodos` to replace the non-memoized version above:

selectors/index.js

```
import { createSelector } from 'reselect'

const getVisibilityFilter = state => state.visibilityFilter
const getTodos = state => state.todos

export const getVisibleTodos = createSelector(
  [getVisibilityFilter, getTodos],
  (visibilityFilter, todos) => {
    switch (visibilityFilter) {
      case 'SHOW_ALL':
        return todos
      case 'SHOW_COMPLETED':
        return todos.filter(t => t.completed)
      case 'SHOW_ACTIVE':
        return todos.filter(t => !t.completed)
    }
  }
)
```

In the example above, `getVisibilityFilter` and `getTodos` are input-selectors. They are created as ordinary non-memoized selector functions because they do not transform the data they select. `getVisibleTodos` on the other hand is a memoized selector. It takes `getVisibilityFilter` and `getTodos` as input-selectors, and a transform function that calculates the filtered todos list.

Composing Selectors

A memoized selector can itself be an input-selector to another memoized selector. Here is `getVisibleTodos` being used as an input-selector to a selector that further filters the todos by keyword:

```
const getKeyword = state => state.keyword

const getVisibleTodosFilteredByKeyword = createSelector(
  [getVisibleTodos, getKeyword],
  (visibleTodos, keyword) =>
    visibleTodos.filter(todo => todo.text.indexOf(keyword) > -1)
)
```

Connecting a Selector to the Redux Store

If you are using [React Redux](#), you can call selectors as regular functions inside `mapStateToProps()`:

containers/VisibleTodoList.js

```
import { connect } from 'react-redux'
import { toggleTodo } from '../actions'
import Todolist from '../components/TodoList'
import { getVisibleTodos } from '../selectors'

const mapStateToProps = state => {
  return {
    todos: getVisibleTodos(state)
  }
}
```

```

        }
    }

    const mapDispatchToProps = dispatch => {
        return {
            onTodoClick: id => {
                dispatch(toggleTodo(id))
            }
        }
    }

    const VisibleTodoList = connect(
        mapStateToProps,
        mapDispatchToProps
    )(TodoList)

    export default VisibleTodoList

```

Accessing React Props in Selectors

This section introduces a hypothetical extension to our app that allows it to support multiple Todo Lists. Please note that a full implementation of this extension requires changes to the reducers, components, actions etc. that aren't directly relevant to the topics discussed and have been omitted for brevity.

So far we have only seen selectors receive the Redux store state as an argument, but a selector can receive props too.

Here is an `App` component that renders three `VisibleTodoList` components, each of which has a `listId` prop:

components/App.js

```

import React from 'react'
import Footer from './Footer'
import AddTodo from '../containers/AddTodo'
import VisibleTodoList from '../containers/VisibleTodoList'

const App = () =>
<div>
    <VisibleTodoList listId="1" />
    <VisibleTodoList listId="2" />
    <VisibleTodoList listId="3" />
</div>
)

```

Each `VisibleTodoList` container should select a different slice of the state depending on the value of the `listId` prop, so let's modify `getVisibilityFilter` and `getTodos` to accept a `props` argument:

selectors/todoSelectors.js

```

import { createSelector } from 'reselect'

const getVisibilityFilter = (state, props) =>
    state.todoLists[props.listId].visibilityFilter

const getTodos = (state, props) => state.todoLists[props.listId].todos

const getVisibleTodos = createSelector(
    [getVisibilityFilter, getTodos],
    (visibilityFilter, todos) => {
        switch (visibilityFilter) {
            case 'SHOW_COMPLETED':
                return todos.filter(todo => todo.completed)
            case 'SHOW_ACTIVE':
                return todos.filter(todo => !todo.completed)
            default:

```

```

        return todos
    }
}

export default getVisibleTodos

```

`props` can be passed to `getVisibleTodos` from `mapStateToProps`:

```

const mapStateToProps = (state, props) => {
  return {
    todos: getVisibleTodos(state, props)
  }
}

```

So now `getVisibleTodos` has access to `props`, and everything seems to be working fine.

But there is a problem!

Using the `getVisibleTodos` selector with multiple instances of the `visibleTodoList` container will not correctly memoize:

`containers/VisibleTodoList.js`

```

import { connect } from 'react-redux'
import { toggleTodo } from '../actions'
import TodoList from '../components/TodoList'
import { getVisibleTodos } from '../selectors'

const mapStateToProps = (state, props) => {
  return {
    // WARNING: THE FOLLOWING SELECTOR DOES NOT CORRECTLY MEMOIZE
    todos: getVisibleTodos(state, props)
  }
}

const mapDispatchToProps = dispatch => {
  return {
    onTodoClick: id => {
      dispatch(toggleTodo(id))
    }
  }
}

const VisibleTodoList = connect(
  mapStateToProps,
  mapDispatchToProps
)(TodoList)

export default VisibleTodoList

```

A selector created with `createSelector` only returns the cached value when its set of arguments is the same as its previous set of arguments. If we alternate between rendering `<VisibleTodoList listId="1" />` and `<VisibleTodoList listId="2" />`, the shared selector will alternate between receiving `{listId: 1}` and `{listId: 2}` as its `props` argument. This will cause the arguments to be different on each call, so the selector will always recompute instead of returning the cached value. We'll see how to overcome this limitation in the next section.

Sharing Selectors Across Multiple Components

The examples in this section require React Redux v4.3.0 or greater

In order to share a selector across multiple `VisibleTodoList` components **and** retain memoization, each instance of the component needs its own private copy of the selector.

Let's create a function named `makeGetVisibleTodos` that returns a new copy of the `getVisibleTodos` selector each time it is called:

selectors/todoSelectors.js

```
import { createSelector } from 'reselect'

const getVisibilityFilter = (state, props) =>
  state.todoLists[props.listId].visibilityFilter

const getTodos = (state, props) => state.todoLists[props.listId].todos

const makeGetVisibleTodos = () => {
  return createSelector(
    [getVisibilityFilter, getTodos],
    (visibilityFilter, todos) => {
      switch (visibilityFilter) {
        case 'SHOW_COMPLETED':
          return todos.filter(todo => todo.completed)
        case 'SHOW_ACTIVE':
          return todos.filter(todo => !todo.completed)
        default:
          return todos
      }
    }
  )
}

export default makeGetVisibleTodos
```

We also need a way to give each instance of a container access to its own private selector. The `mapStateToProps` argument of `connect` can help with this.

If the `mapStateToProps` argument supplied to `connect` returns a function instead of an object, it will be used to create an individual `mapStateToProps` function for each instance of the container.

In the example below `makeMapStateToProps` creates a new `getVisibleTodos` selector, and returns a `mapStateToProps` function that has exclusive access to the new selector:

```
const makeMapStateToProps = () => {
  const getVisibleTodos = makeGetVisibleTodos()
  const mapStateToProps = (state, props) => {
    return {
      todos: getVisibleTodos(state, props)
    }
  }
  return mapStateToProps
}
```

If we pass `makeMapStateToProps` to `connect`, each instance of the `VisibleTodoList` container will get its own `mapStateToProps` function with a private `getVisibleTodos` selector. Memoization will now work correctly regardless of the render order of the `VisibleTodoList` containers.

containers/VisibleTodoList.js

```
import { connect } from 'react-redux'
import { toggleTodo } from '../actions'
import TodoList from '../components/TodoList'
import { makeGetVisibleTodos } from '../selectors'

const makeMapStateToProps = () => {
  const getVisibleTodos = makeGetVisibleTodos()
  const mapStateToProps = (state, props) => {
    return {
```

```
        todos: getVisibleTodos(state, props)
    }
}
return mapStateToProps
}

const mapDispatchToProps = dispatch => {
    return {
        onTodoClick: id => {
            dispatch(toggleTodo(id))
        }
    }
}

const VisibleTodoList = connect(
    makeMapStateToProps,
    mapDispatchToProps
)(TodoList)

export default VisibleTodoList
```

Next Steps

Check out the [official documentation](#) of Reselect as well as its [FAQ](#). Most Redux projects start using Reselect when they have performance problems because of too many derived computations and wasted re-renders, so make sure you are familiar with it before you build something big. It can also be useful to study [its source code](#) so you don't think it's magic.

Implementing Undo History

Building an Undo and Redo functionality into an app has traditionally required conscious effort from the developer. It is not an easy problem with classical MVC frameworks because you need to keep track of every past state by cloning all relevant models. In addition, you need to be mindful of the undo stack because the user-initiated changes should be undoable.

This means that implementing Undo and Redo in an MVC application usually forces you to rewrite parts of your application to use a specific data mutation pattern like [Command](#).

With Redux, however, implementing undo history is a breeze. There are three reasons for this:

- There are no multiple models—just a state subtree that you want to keep track of.
- The state is already immutable, and mutations are already described as discrete actions, which is close to the undo stack mental model.
- The reducer `(state, action) => state` signature makes it natural to implement generic “reducer enhancers” or “higher order reducers”. They are functions that take your reducer and enhance it with some additional functionality while preserving its signature. Undo history is exactly such a case.

Before proceeding, make sure you have worked through the [basics tutorial](#) and understand [reducer composition](#) well. This recipe will build on top of the example described in the [basics tutorial](#).

In the first part of this recipe, we will explain the underlying concepts that make Undo and Redo possible to implement in a generic way.

In the second part of this recipe, we will show how to use [Redux Undo](#) package that provides this functionality out of the box.



Understanding Undo History

Designing the State Shape

Undo history is also part of your app's state, and there is no reason why we should approach it differently. Regardless of the type of the state changing over time, when you implement Undo and Redo, you want to keep track of the *history* of this state at different points in time.

For example, the state shape of a counter app might look like this:

```
{  
  counter: 10  
}
```

If we wanted to implement Undo and Redo in such an app, we'd need to store more state so we can answer the following questions:

- Is there anything left to undo or redo?
- What is the current state?
- What are the past (and future) states in the undo stack?

It is reasonable to suggest that our state shape should change to answer these questions:

```
{
  counter: {
    past: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
    present: 10,
    future: []
  }
}
```

Now, if user presses “Undo”, we want it to change to move into the past:

```
{
  counter: {
    past: [0, 1, 2, 3, 4, 5, 6, 7, 8],
    present: 9,
    future: [10]
  }
}
```

And further yet:

```
{
  counter: {
    past: [0, 1, 2, 3, 4, 5, 6, 7],
    present: 8,
    future: [9, 10]
  }
}
```

When the user presses “Redo”, we want to move one step back into the future:

```
{
  counter: {
    past: [0, 1, 2, 3, 4, 5, 6, 7, 8],
    present: 9,
    future: [10]
  }
}
```

Finally, if the user performs an action (e.g. decrement the counter) while we're in the middle of the undo stack, we're going to discard the existing future:

```
{
  counter: {
    past: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9],
    present: 8,
    future: []
  }
}
```

The interesting part here is that it does not matter whether we want to keep an undo stack of numbers, strings, arrays, or objects. The structure will always be the same:

```
{
  counter: {
    past: [0, 1, 2],
    present: 3,
    future: [4]
  }
}
```

```
{
  todos: {
    past: [
      [],
      [{ text: 'Use Redux' }],
      [{ text: 'Use Redux', complete: true }]
    ],
    present: [
      { text: 'Use Redux', complete: true },
      { text: 'Implement Undo' }
    ],
    future: [
      [
        { text: 'Use Redux', complete: true },
        { text: 'Implement Undo', complete: true }
      ]
    ]
  }
}
```

In general, it looks like this:

```
{
  past: Array<T>,
  present: T,
  future: Array<T>
}
```

It is also up to us whether to keep a single top-level history:

```
{
  past: [
    { counterA: 1, counterB: 1 },
    { counterA: 1, counterB: 0 },
    { counterA: 0, counterB: 0 }
  ],
  present: { counterA: 2, counterB: 1 },
  future: []
}
```

Or many granular histories so user can undo and redo actions in them independently:

```
{
  counterA: {
    past: [1, 0],
    present: 2,
    future: []
  },
  counterB: {
    past: [0],
    present: 1,
    future: []
  }
}
```

We will see later how the approach we take lets us choose how granular Undo and Redo need to be.

Designing the Algorithm

Regardless of the specific data type, the shape of the undo history state is the same:

```
{
  past: Array<T>,
  present: T,
  future: Array<T>
}
```

Let's talk through the algorithm to manipulate the state shape described above. We can define two actions to operate on this state: `UNDO` and `REDO`. In our reducer, we will do the following steps to handle these actions:

Handling Undo

- Remove the *last* element from the `past`.
- Set the `present` to the element we removed in the previous step.
- Insert the old `present` state at the *beginning* of the `future`.

Handling Redo

- Remove the *first* element from the `future`.
- Set the `present` to the element we removed in the previous step.
- Insert the old `present` state at the *end* of the `past`.

Handling Other Actions

- Insert the `present` at the end of the `past`.
- Set the `present` to the new state after handling the action.
- Clear the `future`.

First Attempt: Writing a Reducer

```
const initialState = {
  past: [],
  present: null, // (?) How do we initialize the present?
  future: []
}

function undoable(state = initialState, action) {
  const { past, present, future } = state

  switch (action.type) {
    case 'UNDO':
      const previous = past[past.length - 1]
      const newPast = past.slice(0, past.length - 1)
      return {
        past: newPast,
        present: previous,
        future: [present, ...future]
      }
    case 'REDO':
      const next = future[0]
      const newFuture = future.slice(1)
      return {
        past: [...past, present],
        present: next,
        future: newFuture
      }
    default:
      // (?) How do we handle other actions?
  }
}
```

```

        return state
    }
}

```

This implementation isn't usable because it leaves out three important questions:

- Where do we get the initial `present` state from? We don't seem to know it beforehand.
- Where do we react to the external actions to save the `present` to the `past`?
- How do we actually delegate the control over the `present` state to a custom reducer?

It seems that reducer isn't the right abstraction, but we're very close.

Meet Reducer Enhancers

You might be familiar with [higher order functions](#). If you use React, you might be familiar with [higher order components](#). Here is a variation on the same pattern, applied to reducers.

A *reducer enhancer* (or a *higher order reducer*) is a function that takes a reducer, and returns a new reducer that is able to handle new actions, or to hold more state, delegating control to the inner reducer for the actions it doesn't understand. This isn't a new pattern—technically, `combineReducers()` is also a reducer enhancer because it takes reducers and returns a new reducer.

A reducer enhancer that doesn't do anything looks like this:

```

function doNothingWith(reducer) {
  return function (state, action) {
    // Just call the passed reducer
    return reducer(state, action)
  }
}

```

A reducer enhancer that combines other reducers might look like this:

```

function combineReducers(reducers) {
  return function (state = {}, action) {
    return Object.keys(reducers).reduce((nextState, key) => {
      // Call every reducer with the part of the state it manages
      nextState[key] = reducers[key](state[key], action)
      return nextState
    }, {})
  }
}

```

Second Attempt: Writing a Reducer Enhancer

Now that we have a better understanding of reducer enhancers, we can see that this is exactly what `undoable` should have been:

```

function undoable(reducer) {
  // Call the reducer with empty action to populate the initial state
  const initialState = {
    past: [],
    present: reducer(undefined, {}),
    future: []
  }

  // Return a reducer that handles undo and redo
  return function (state = initialState, action) {
    const { past, present, future } = state

    switch (action.type) {
      case 'UNDO':

```

```

        const previous = past[past.length - 1]
        const newPast = past.slice(0, past.length - 1)
        return {
          past: newPast,
          present: previous,
          future: [present, ...future]
        }
      case 'REDO':
        const next = future[0]
        const newFuture = future.slice(1)
        return {
          past: [...past, present],
          present: next,
          future: newFuture
        }
      default:
        // Delegate handling the action to the passed reducer
        const newPresent = reducer(present, action)
        if (present === newPresent) {
          return state
        }
        return {
          past: [...past, present],
          present: newPresent,
          future: []
        }
      }
    }
}

```

We can now wrap any reducer into `undoable` reducer enhancer to teach it to react to `UNDO` and `REDO` actions.

```

// This is a reducer
function todos(state = [], action) {
  /* ... */
}

// This is also a reducer!
const undoableTodos = undoable(todos)

import { createStore } from 'redux'
const store = createStore(undoableTodos)

store.dispatch({
  type: 'ADD_TODO',
  text: 'Use Redux'
})

store.dispatch({
  type: 'ADD_TODO',
  text: 'Implement Undo'
})

store.dispatch({
  type: 'UNDO'
})

```

There is an important gotcha: you need to remember to append `.present` to the current state when you retrieve it. You may also check `.past.length` and `.future.length` to determine whether to enable or to disable the Undo and Redo buttons, respectively.

You might have heard that Redux was influenced by [Elm Architecture](#). It shouldn't come as a surprise that this example is very similar to [elm-undo-redo package](#).

Using Redux Undo

This was all very informative, but can't we just drop a library and use it instead of implementing `undoable` ourselves? Sure, we can! Meet [Redux Undo](#), a library that provides simple Undo and Redo functionality for any part of your Redux tree.

In this part of the recipe, you will learn how to make the [Todo List example](#) undoable. You can find the full source of this recipe in the [todos-with-undo example that comes with Redux](#).

Installation

First of all, you need to run

```
npm install --save redux-undo
```

This installs the package that provides the `undoable` reducer enhancer.

Wrapping the Reducer

You will need to wrap the reducer you wish to enhance with `undoable` function. For example, if you exported a `todos` reducer from a dedicated file, you will want to change it to export the result of calling `undoable()` with the reducer you wrote:

reducers/todos.js

```
import undoable, { distinctState } from 'redux-undo'

/* ... */

const todos = (state = [], action) => {
  /* ... */
}

const undoableTodos = undoable(todos, {
  filter: distinctState()
})

export default undoableTodos
```

The `distinctState()` filter serves to ignore the actions that didn't result in a state change. There are [many other options](#) to configure your undoable reducer, like setting the action type for Undo and Redo actions.

Note that your `combineReducers()` call will stay exactly as it was, but the `todos` reducer will now refer to the reducer enhanced with Redux Undo:

reducers/index.js

```
import { combineReducers } from 'redux'
import todos from './todos'
import visibilityFilter from './visibilityFilter'

const todoApp = combineReducers({
  todos,
  visibilityFilter
})

export default todoApp
```

You may wrap one or more reducers in `undoable` at any level of the reducer composition hierarchy. We choose to wrap `todos` instead of the top-level combined reducer so that changes to `visibilityFilter` are not reflected in the undo history.

Updating the Selectors

Now the `todos` part of the state looks like this:

```
{
  visibilityFilter: 'SHOW_ALL',
  todos: {
    past: [
      [],
      [{ text: 'Use Redux' }],
      [{ text: 'Use Redux', complete: true }]
    ],
    present: [
      { text: 'Use Redux', complete: true },
      { text: 'Implement Undo' }
    ],
    future: [
      [
        { text: 'Use Redux', complete: true },
        { text: 'Implement Undo', complete: true }
      ]
    ]
  }
}
```

This means you need to access your state with `state.todos.present` instead of just `state.todos`:

`containers/VisibleTodoList.js`

```
const mapStateToProps = state => {
  return {
    todos: getVisibleTodos(state.todos.present, state.visibilityFilter)
  }
}
```

Adding the Buttons

Now all you need to do is add the buttons for the Undo and Redo actions.

First, create a new container component called `UndoRedo` for these buttons. We won't bother to split the presentational part into a separate file because it is very small:

`containers/UndoRedo.js`

```
import React from 'react'

/* ... */

let UndoRedo = ({ canUndo, canRedo, onUndo, onredo }) => (
  <p>
    <button onClick={onUndo} disabled={!canUndo}>
      Undo
    </button>
    <button onClick={onRedo} disabled={!canRedo}>
      Redo
    </button>
  </p>
)
```

You will use `connect()` from [React Redux](#) to generate a container component. To determine whether to enable Undo and Redo buttons, you can check `state.todos.past.length` and `state.todos.future.length`. You won't need to write action creators for performing undo and redo because Redux Undo already provides them:

containers/UndoRedo.js

```
/* ... */

import { ActionCreators as UndoActionCreators } from 'redux-undo'
import { connect } from 'react-redux'

/* ... */

const mapStateToProps = state => {
  return {
    canUndo: state.todos.past.length > 0,
    canRedo: state.todos.future.length > 0
  }
}

const mapDispatchToProps = dispatch => {
  return {
    onUndo: () => dispatch(UndoActionCreators.undo()),
    onRedo: () => dispatch(UndoActionCreators.redo())
  }
}

UndoRedo = connect(
  mapStateToProps,
  mapDispatchToProps
)(UndoRedo)

export default UndoRedo
```

Now you can add `UndoRedo` component to the `App` component:

components/App.js

```
import React from 'react'
import Footer from './Footer'
import AddTodo from '../containers/AddTodo'
import VisibleTodoList from '../containers/VisibleTodoList'
import UndoRedo from '../containers/UndoRedo'

const App = () =>
<div>
  <AddTodo />
  <VisibleTodoList />
  <Footer />
  <UndoRedo />
</div>

export default App
```

This is it! Run `npm install` and `npm start` in the [example folder](#) and try it out!

Isolating Redux Sub-Apps

Consider the case of a “big” app (contained in a `<BigApp>` component) that embeds smaller “sub-apps” (contained in `<SubApp>` components):

```
import React, { Component } from 'react'
import SubApp from './subapp'

class BigApp extends Component {
  render() {
    return (
      <div>
        <SubApp />
        <SubApp />
        <SubApp />
      </div>
    )
  }
}
```

These `<SubApp>`s will be completely independent. They won’t share data or actions, and won’t see or communicate with each other.

It’s best not to mix this approach with standard Redux reducer composition. For typical web apps, stick with reducer composition. For “product hubs”, “dashboards”, or enterprise software that groups disparate tools into a unified package, give the sub-app approach a try.

The sub-app approach is also useful for large teams that are divided by product or feature verticals. These teams can ship sub-apps independently or in combination with an enclosing “app shell”.

Below is a sub-app’s root connected component. As usual, it can render more components, connected or not, as children. Usually we’d render it in `<Provider>` and be done with it.

```
class App extends Component { ... }
export default connect(mapStateToProps)(App)
```

However, we don’t have to call `ReactDOM.render(<Provider><App /></Provider>)` if we’re interested in hiding the fact that the sub-app component is a Redux app.

Maybe we want to be able to run multiple instances of it in the same “bigger” app and keep it as a complete black box, with Redux being an implementation detail.

To hide Redux behind a React API, we can wrap it in a special component that initializes the store in the constructor:

```
import React, { Component } from 'react'
import { Provider } from 'react-redux'
import { createStore } from 'redux'
import reducer from './reducers'
import App from './App'

class SubApp extends Component {
  constructor(props) {
    super(props)
    this.store = createStore(reducer)
  }

  render() {
    return (
      <Provider store={this.store}>
        <App />
      </Provider>
    )
  }
}
```

```
    )  
  }  
}
```

This way every instance will be independent.

This pattern is *not* recommended for parts of the same app that share data. However, it can be useful when the bigger app has zero access to the smaller apps' internals, and we'd like to keep the fact that they are implemented with Redux as an implementation detail. Each component instance will have its own store, so they won't "know" about each other.

Structuring Reducers

At its core, Redux is really a fairly simple design pattern: all your "write" logic goes into a single function, and the only way to run that logic is to give Redux a plain object that describes something that has happened. The Redux store calls that write logic function and passes in the current state tree and the descriptive object, the write logic function returns some new state tree, and the Redux store notifies any subscribers that the state tree has changed.

Redux puts some basic constraints on how that write logic function should work. As described in [Reducers](#), it has to have a signature of `(previousState, action) => newState`, is known as a **reducer function**, and must be *pure* and predictable.

Beyond that, Redux does not really care how you actually structure your logic inside that reducer function, as long as it obeys those basic rules. This is both a source of freedom and a source of confusion. However, there are a number of common patterns that are widely used when writing reducers, as well as a number of related topics and concepts to be aware of. As an application grows, these patterns play a crucial role in managing reducer code complexity, handling real-world data, and optimizing UI performance.

Prerequisite Concepts for Writing Reducers

Some of these concepts are already described elsewhere in the Redux documentation. Others are generic and applicable outside of Redux itself, and there are numerous existing articles that cover these concepts in detail. These concepts and techniques form the foundation of writing solid Redux reducer logic.

It is vital that these Prerequisite Concepts are **thoroughly understood** before moving on to more advanced and Redux-specific techniques. A recommended reading list is available at:

Prerequisite Concepts

It's also important to note that some of these suggestions may or may not be directly applicable based on architectural decisions in a specific application. For example, an application using Immutable.js Maps to store data would likely have its reducer logic structured at least somewhat differently than an application using plain Javascript objects. This documentation primarily assumes use of plain Javascript objects, but many of the principles would still apply if using other tools.

Reducer Concepts and Techniques

- [Basic Reducer Structure](#)
- [Splitting Reducer Logic](#)
- [Refactoring Reducers Example](#)
- [Using `combineReducers`](#)
- [Beyond `combineReducers`](#)
- [Normalizing State Shape](#)
- [Updating Normalized Data](#)
- [Reusing Reducer Logic](#)
- [Immutable Update Patterns](#)
- [Initializing State](#)

Prerequisite Reducer Concepts

As described in [Reducers](#), a Redux reducer function:

- Should have a signature of `(previousState, action) => newState`, similar to the type of function you would pass to `Array.prototype.reduce(reducer, ?initialValue)`
- Should be "pure", which means the reducer:
 - Does not *perform side effects* (such as calling API's or modifying non-local objects or variables).
 - Does not *call non-pure functions* (like `Date.now` OR `Math.random`).
 - Does not *mutate* its arguments. If the reducer updates state, it should not *modify* the **existing** state object in-place. Instead, it should generate a **new** object containing the necessary changes. The same approach should be used for any sub-objects within state that the reducer updates.

Note on immutability, side effects, and mutation

Mutation is discouraged because it generally breaks time-travel debugging, and React Redux's `connect` function:

- For time traveling, the Redux DevTools expect that replaying recorded actions would output a state value, but not change anything else. **Side effects like mutation or asynchronous behavior will cause time travel to alter behavior between steps, breaking the application.**
- For React Redux, `connect` checks to see if the props returned from a `mapStateToProps` function have changed in order to determine if a component needs to update. To improve performance, `connect` takes some shortcuts that rely on the state being immutable, and uses shallow reference equality checks to detect changes. This means that **changes made to objects and arrays by direct mutation will not be detected, and components will not re-render.**

Other side effects like generating unique IDs or timestamps in a reducer also make the code unpredictable and harder to debug and test.

Because of these rules, it's important that the following core concepts are fully understood before moving on to other specific techniques for organizing Redux reducers:

Redux Reducer Basics

Key concepts:

- Thinking in terms of state and state shape
- Delegating update responsibility by slice of state (*reducer composition*)
- Higher order reducers
- Defining reducer initial state

Reading list:

- [Redux Docs: Reducers](#)
- [Redux Docs: Reducing Boilerplate](#)
- [Redux Docs: Implementing Undo History](#)
- [Redux DOCS: combineReducers](#)
- [The Power of Higher-Order Reducers](#)
- [Stack Overflow: Store initial state and combineReducers](#)
- [Stack Overflow: State key names and combineReducers](#)

Pure Functions and Side Effects

Key Concepts:

- Side effects
- Pure functions
- How to think in terms of combining functions

Reading List:

- [The Little Idea of Functional Programming](#)
- [Understanding Programmatic Side-Effects](#)
- [Learning Functional Programming in Javascript](#)
- [An Introduction to Reasonably Pure Functional Programming](#)

Immutable Data Management

Key Concepts:

- Mutability vs immutability
- Immutably updating objects and arrays safely
- Avoiding functions and statements that mutate state

Reading List:

- [Pros and Cons of Using Immutability With React](#)
- [Javascript and Immutability](#)
- [Immutable Data using ES6 and Beyond](#)
- [Immutable Data from Scratch](#)
- [Redux Docs: Using the Object Spread Operator](#)

Normalizing Data

Key Concepts:

- Database structure and organization
- Splitting relational/nested data up into separate tables
- Storing a single definition for a given item
- Referring to items by IDs
- Using objects keyed by item IDs as lookup tables, and arrays of IDs to track ordering
- Associating items in relationships

Reading List:

- [Database Normalization in Simple English](#)
- [Idiomatic Redux: Normalizing the State Shape](#)
- [Normalizr Documentation](#)
- [Redux Without Profanity: Normalizr](#)
- [Querying a Redux Store](#)
- [Wikipedia: Associative Entity](#)
- [Database Design: Many-to-Many](#)
- [Avoiding Accidental Complexity When Structuring Your App State](#)

Basic Reducer Structure and State Shape

Basic Reducer Structure

First and foremost, it's important to understand that your entire application really only has **one single reducer function**: the function that you've passed into `createStore` as the first argument. That one single reducer function ultimately needs to do several things:

- The first time the reducer is called, the `state` value will be `undefined`. The reducer needs to handle this case by supplying a default state value before handling the incoming action.
- It needs to look at the previous state and the dispatched action, and determine what kind of work needs to be done
- Assuming actual changes need to occur, it needs to create new objects and arrays with the updated data and return those
- If no changes are needed, it should return the existing state as-is.

The simplest possible approach to writing reducer logic is to put everything into a single function declaration, like this:

```
function counter(state, action) {
  if (typeof state === 'undefined') {
    state = 0; // If state is undefined, initialize it with a default value
  }

  if (action.type === 'INCREMENT') {
    return state + 1;
  }
  else if (action.type === 'DECREMENT') {
    return state - 1;
  }
  else {
    return state; // In case an action is passed in we don't understand
  }
}
```

Notice that this simple function fulfills all the basic requirements. It returns a default value if none exists, initializing the store; it determines what sort of update needs to be done based on the type of the action, and returns new values; and it returns the previous state if no work needs to be done.

There are some simple tweaks that can be made to this reducer. First, repeated `if / else` statements quickly grow tiresome, so it's very common to use `switch` statements instead. Second, we can use ES6's default parameter values to handle the initial "no existing data" case. With those changes, the reducer would look like:

```
function counter(state = 0, action) {
  switch (action.type) {
    case 'INCREMENT':
      return state + 1;
    case 'DECREMENT':
      return state - 1;
    default:
      return state;
  }
}
```

This is the basic structure that a typical Redux reducer function uses.

Basic State Shape

Redux encourages you to think about your application in terms of the data you need to manage. The data at any given point in time is the "*state*" of your application, and the structure and organization of that state is typically referred to as its "*shape*". The shape of your state plays a major role in how you structure your reducer logic.

A Redux state usually has a plain Javascript object as the top of the state tree. (It is certainly possible to have another type of data instead, such as a single number, an array, or a specialized data structure, but most libraries assume that the top-level value is a plain object.) The most common way to organize data within that top-level object is to further divide data into sub-trees, where each top-level key represents some "domain" or "slice" of related data. For example, a basic Todo app's state might look like:

```
{
  visibilityFilter: 'SHOW_ALL',
  todos: [
    {
      text: 'Consider using Redux',
      completed: true,
    },
    {
      text: 'Keep all state in a single tree',
      completed: false
    }
  ]
}
```

In this example, `todos` and `visibilityFilter` are both top-level keys in the state, and each represents a "slice" of data for some particular concept.

Most applications deal with multiple types of data, which can be broadly divided into three categories:

- *Domain data*: data that the application needs to show, use, or modify (such as "all of the Todos retrieved from the server")
- *App state*: data that is specific to the application's behavior (such as "Todo #5 is currently selected", or "there is a request in progress to fetch Todos")
- *UI state*: data that represents how the UI is currently displayed (such as "The EditTodo modal dialog is currently open")

Because the store represents the core of your application, you should **define your state shape in terms of your domain data and app state, not your UI component tree**. As an example, a shape of

`state.leftPane.todoList.todos` would be a bad idea, because the idea of "todos" is central to the whole application, not just a single part of the UI. The `todos` slice should be at the top of the state tree instead.

There will *rarely* be a 1-to-1 correspondence between your UI tree and your state shape. The exception to that might be if you are explicitly tracking various aspects of UI data in your Redux store as well, but even then the shape of the UI data and the shape of the domain data would likely be different.

A typical app's state shape might look roughly like:

```
{
  domainData1 : {},
  domainData2 : {},
  appState1 : {},
  appState2 : {},
  ui : {
    uiState1 : {},
    uiState2 : {}
  }
}
```


Splitting Up Reducer Logic

For any meaningful application, putting *all* your update logic into a single reducer function is quickly going to become unmaintainable. While there's no single rule for how long a function should be, it's generally agreed that functions should be relatively short and ideally only do one specific thing. Because of this, it's good programming practice to take pieces of code that are very long or do many different things, and break them into smaller pieces that are easier to understand.

Since a Redux reducer is *just* a function, the same concept applies. You can split some of your reducer logic out into another function, and call that new function from the parent function.

These new functions would typically fall into one of three categories:

1. Small utility functions containing some reusable chunk of logic that is needed in multiple places (which may or may not be actually related to the specific business logic)
2. Functions for handling a specific update case, which often need parameters other than the typical `(state, action)` pair
3. Functions which handle *all* updates for a given slice of state. These functions do generally have the typical `(state, action)` parameter signature

For clarity, these terms will be used to distinguish between different types of functions and different use cases:

- **reducer**: any function with the signature `(state, action) -> newState` (ie, any function that *could* be used as an argument to `Array.prototype.reduce`)
- **root reducer**: the reducer function that is actually passed as the first argument to `createStore`. This is the only part of the reducer logic that *must* have the `(state, action) -> newState` signature.
- **slice reducer**: a reducer that is being used to handle updates to one specific slice of the state tree, usually done by passing it to `combineReducers`
- **case function**: a function that is being used to handle the update logic for a specific action. This may actually be a reducer function, or it may require other parameters to do its work properly.
- **higher-order reducer**: a function that takes a reducer function as an argument, and/or returns a new reducer function as a result (such as `combineReducers`, or `redux-undo`)

The term "*sub-reducer*" has also been used in various discussions to mean any function that is not the root reducer, although the term is not very precise. Some people may also refer to some functions as "*business logic*" (functions that relate to application-specific behavior) or "*utility functions*" (generic functions that are not application-specific).

Breaking down a complex process into smaller, more understandable parts is usually described with the term **functional decomposition**. This term and concept can be applied generically to any code. However, in Redux it is *very* common to structure reducer logic using approach #3, where update logic is delegated to other functions based on slice of state. Redux refers to this concept as **reducer composition**, and it is by far the most widely-used approach to structuring reducer logic. In fact, it's so common that Redux includes a utility function called `combineReducers()`, which specifically abstracts the process of delegating work to other reducer functions based on slices of state. However, it's important to note that it is not the *only* pattern that can be used. In fact, it's entirely possible to use all three approaches for splitting up logic into functions, and usually a good idea as well. The [Refactoring Reducers](#) section shows some examples of this in action.

Refactoring Reducer Logic Using Functional Decomposition and Reducer Composition

It may be helpful to see examples of what the different types of sub-reducer functions look like and how they fit together. Let's look at a demonstration of how a large single reducer function can be refactored into a composition of several smaller functions.

Note: this example is deliberately written in a verbose style in order to illustrate the concepts and the process of refactoring, rather than perfectly concise code.

Initial Reducer

Let's say that our initial reducer looks like this:

```
const initialState = {
  visibilityFilter : 'SHOW_ALL',
  todos : []
};

function appReducer(state = initialState, action) {
  switch(action.type) {
    case 'SET_VISIBILITY_FILTER' : {
      return Object.assign({}, state, {
        visibilityFilter : action.filter
      });
    }
    case 'ADD_TODO' : {
      return Object.assign({}, state, {
        todos : state.todos.concat({
          id: action.id,
          text: action.text,
          completed: false
        })
      });
    }
    case 'TOGGLE_TODO' : {
      return Object.assign({}, state, {
        todos : state.todos.map(todo => {
          if (todo.id !== action.id) {
            return todo;
          }

          return Object.assign({}, todo, {
            completed : !todo.completed
          })
        })
      });
    }
    case 'EDIT_TODO' : {
      return Object.assign({}, state, {
        todos : state.todos.map(todo => {
          if (todo.id !== action.id) {
            return todo;
          }

          return Object.assign({}, todo, {
            text : action.text
          })
        })
      });
    }
    default : return state;
  }
}
```

That function is fairly short, but already becoming overly complex. We're dealing with two different areas of concern (filtering vs managing our list of todos), the nesting is making the update logic harder to read, and it's not exactly clear what's going on everywhere.

Extracting Utility Functions

A good first step might be to break out a utility function to return a new object with updated fields. There's also a repeated pattern with trying to update a specific item in an array that we could extract to a function:

```
function updateObject(oldObject, newValues) {
  // Encapsulate the idea of passing a new object as the first parameter
  // to Object.assign to ensure we correctly copy data instead of mutating
  return Object.assign({}, oldObject, newValues);
}

function updateItemInArray(array, itemId, updateItemCallback) {
  const updatedItems = array.map(item => {
    if(item.id !== itemId) {
      // Since we only want to update one item, preserve all others as they are now
      return item;
    }

    // Use the provided callback to create an updated item
    const updatedItem = updateItemCallback(item);
    return updatedItem;
  });

  return updatedItems;
}

function appReducer(state = initialState, action) {
  switch(action.type) {
    case 'SET_VISIBILITY_FILTER' : {
      return updateObject(state, {visibilityFilter : action.filter});
    }
    case 'ADD_TODO' : {
      const newTodos = state.todos.concat({
        id: action.id,
        text: action.text,
        completed: false
      });

      return updateObject(state, {todos : newTodos});
    }
    case 'TOGGLE_TODO' : {
      const newTodos = updateItemInArray(state.todos, action.id, todo => {
        return updateObject(todo, {completed : !todo.completed});
      });

      return updateObject(state, {todos : newTodos});
    }
    case 'EDIT_TODO' : {
      const newTodos = updateItemInArray(state.todos, action.id, todo => {
        return updateObject(todo, {text : action.text});
      });

      return updateObject(state, {todos : newTodos});
    }
    default : return state;
  }
}
```

That reduced the duplication and made things a bit easier to read.

Extracting Case Reducers

Next, we can split each specific case into its own function:

```
// Omitted
function updateObject(oldObject, newValues) {}
function updateItemInArray(array, itemId, updateItemCallback) {}

function setVisibilityFilter(state, action) {
  return updateObject(state, {visibilityFilter : action.filter });
}

function addTodo(state, action) {
  const newTodos = state.todos.concat({
    id: action.id,
    text: action.text,
    completed: false
  });
  return updateObject(state, {todos : newTodos});
}

function toggleTodo(state, action) {
  const newTodos = updateItemInArray(state.todos, action.id, todo => {
    return updateObject(todo, {completed : !todo.completed});
  });
  return updateObject(state, {todos : newTodos});
}

function editTodo(state, action) {
  const newTodos = updateItemInArray(state.todos, action.id, todo => {
    return updateObject(todo, {text : action.text});
  });
  return updateObject(state, {todos : newTodos});
}

function appReducer(state = initialState, action) {
  switch(action.type) {
    case 'SET_VISIBILITY_FILTER' : return setVisibilityFilter(state, action);
    case 'ADD_TODO' : return addTodo(state, action);
    case 'TOGGLE_TODO' : return toggleTodo(state, action);
    case 'EDIT_TODO' : return editTodo(state, action);
    default : return state;
  }
}
```

Now it's very clear what's happening in each case. We can also start to see some patterns emerging.

Separating Data Handling by Domain

Our app reducer is still aware of all the different cases for our application. Let's try splitting things up so that the filter logic and the todo logic are separated:

```
// Omitted
function updateObject(oldObject, newValues) {}
function updateItemInArray(array, itemId, updateItemCallback) {}

function setVisibilityFilter(visiblityState, action) {
  // Technically, we don't even care about the previous state
  return action.filter;
}

function visibilityReducer(visiblityState = 'SHOW_ALL', action) {
  switch(action.type) {
    case 'SET_VISIBILITY_FILTER' : return setVisibilityFilter(visiblityState, action);
    default : return visiblityState;
  }
}
```

```

    }

};

function addTodo(todosState, action) {
  const newTodos = todosState.concat({
    id: action.id,
    text: action.text,
    completed: false
  });

  return newTodos;
}

function toggleTodo(todosState, action) {
  const newTodos = updateItemInArray(todosState, action.id, todo => {
    return updateObject(todo, {completed: !todo.completed});
  });

  return newTodos;
}

function editTodo(todosState, action) {
  const newTodos = updateItemInArray(todosState, action.id, todo => {
    return updateObject(todo, {text: action.text});
  });

  return newTodos;
}

function todosReducer(todosState = [], action) {
  switch(action.type) {
    case 'ADD_TODO': return addTodo(todosState, action);
    case 'TOGGLE_TODO': return toggleTodo(todosState, action);
    case 'EDIT_TODO': return editTodo(todosState, action);
    default: return todosState;
  }
}

function appReducer(state = initialState, action) {
  return {
    todos: todosReducer(state.todos, action),
    visibilityFilter: visibilityReducer(state.visibilityFilter, action)
  };
}

```

Notice that because the two "slice of state" reducers are now getting only their own part of the whole state as arguments, they no longer need to return complex nested state objects, and are now simpler as a result.

Reducing Boilerplate

We're almost done. Since many people don't like switch statements, it's very common to use a function that creates a lookup table of action types to case functions. We'll use the `createReducer` function described in [Reducing Boilerplate](#):

```

// Omitted
function updateObject(oldObject, newValue) {}
function updateItemInArray(array, itemID, updateItemCallback) {}

function createReducer(initialState, handlers) {
  return function reducer(state = initialState, action) {
    if (handlers.hasOwnProperty(action.type)) {
      return handlers[action.type](state, action)
    } else {
      return state
    }
  }
}

```

```

// Omitted
function setVisibilityFilter(visibilityState, action) {}

const visibilityReducer = createReducer('SHOW_ALL', {
  'SET_VISIBILITY_FILTER' : setVisibilityFilter
});

// Omitted
function addTodo(todosState, action) {}
function toggleTodo(todosState, action) {}
function editTodo(todosState, action) {}

const todosReducer = createReducer([], {
  'ADD_TODO' : addTodo,
  'TOGGLE_TODO' : toggleTodo,
  'EDIT_TODO' : editTodo
});

function appReducer(state = initialState, action) {
  return {
    todos : todosReducer(state.todos, action),
    visibilityFilter : visibilityReducer(state.visibilityFilter, action)
  };
}

```

Combining Reducers by Slice

As our last step, we can now use Redux's built-in `combineReducers` utility to handle the "slice-of-state" logic for our top-level app reducer. Here's the final result:

```

// Reusable utility functions

function updateObject(oldObject, newValues) {
  // Encapsulate the idea of passing a new object as the first parameter
  // to Object.assign to ensure we correctly copy data instead of mutating
  return Object.assign({}, oldObject, newValues);
}

function updateItemInArray(array, itemId, updateItemCallback) {
  const updatedItems = array.map(item => {
    if(item.id !== itemId) {
      // Since we only want to update one item, preserve all others as they are now
      return item;
    }

    // Use the provided callback to create an updated item
    const updatedItem = updateItemCallback(item);
    return updatedItem;
  });

  return updatedItems;
}

function createReducer(initialState, handlers) {
  return function reducer(state = initialState, action) {
    if (handlers.hasOwnProperty(action.type)) {
      return handlers[action.type](state, action)
    } else {
      return state
    }
  }
}

// Handler for a specific case ("case reducer")
function setVisibilityFilter(visibilityState, action) {
  // Technically, we don't even care about the previous state
  return action.filter;
}

```

```

// Handler for an entire slice of state ("slice reducer")
const visibilityReducer = createReducer('SHOW_ALL', {
  'SET_VISIBILITY_FILTER' : setVisibilityFilter
});

// Case reducer
function addTodo(todosState, action) {
  const newTodos = todosState.concat({
    id: action.id,
    text: action.text,
    completed: false
  });

  return newTodos;
}

// Case reducer
function toggleTodo(todosState, action) {
  const newTodos = updateItemInArray(todosState, action.id, todo => {
    return updateObject(todo, {completed : !todo.completed});
  });

  return newTodos;
}

// Case reducer
function editTodo(todosState, action) {
  const newTodos = updateItemInArray(todosState, action.id, todo => {
    return updateObject(todo, {text : action.text});
  });

  return newTodos;
}

// Slice reducer
const todosReducer = createReducer([], {
  'ADD_TODO' : addTodo,
  'TOGGLE_TODO' : toggleTodo,
  'EDIT_TODO' : editTodo
});

// "Root reducer"
const appReducer = combineReducers({
  visibilityFilter : visibilityReducer,
  todos : todosReducer
});

```

We now have examples of several kinds of split-up reducer functions: helper utilities like `updateObject` and `createReducer`, handlers for specific cases like `setVisibilityFilter` and `addTodo`, and slice-of-state handlers like `visibilityReducer` and `todosReducer`. We also can see that `appReducer` is an example of a "root reducer".

Although the final result in this example is noticeably longer than the original version, this is primarily due to the extraction of the utility functions, the addition of comments, and some deliberate verbosity for the sake of clarity, such as separate return statements. Looking at each function individually, the amount of responsibility is now smaller, and the intent is hopefully clearer. Also, in a real application, these functions would probably then be split into separate files such as `reducerUtilities.js`, `visibilityReducer.js`, `todosReducer.js`, and `rootReducer.js`.

Using combineReducers

Core Concepts

The most common state shape for a Redux app is a plain Javascript object containing "slices" of domain-specific data at each top-level key. Similarly, the most common approach to writing reducer logic for that state shape is to have "slice reducer" functions, each with the same `(state, action)` signature, and each responsible for managing all updates to that specific slice of state. Multiple slice reducers can respond to the same action, independently update their own slice as needed, and the updated slices are combined into the new state object.

Because this pattern is so common, Redux provides the `combineReducers` utility to implement that behavior. It is an example of a *higher-order reducer*, which takes an object full of slice reducer functions, and returns a new reducer function.

There are several important ideas to be aware of when using `combineReducers`:

- First and foremost, `combineReducers` is simply a **utility function to simplify the most common use case when writing Redux reducers**. You are *not* required to use it in your own application, and it does *not* handle every possible scenario. It is entirely possible to write reducer logic without using it, and it is quite common to need to write custom reducer logic for cases that `combineReducer` does not handle. (See [Beyond combineReducers](#) for examples and suggestions.)
- While Redux itself is not opinionated about how your state is organized, `combineReducers` enforces several rules to help users avoid common errors. (See [combineReducers](#) for details.)
- One frequently asked question is whether Redux "calls all reducers" when dispatching an action. Since there really is only one root reducer function, the default answer is "no, it does not". However, `combineReducers` has specific behavior that *does* work that way. In order to assemble the new state tree, `combineReducers` will call each slice reducer with its current slice of state and the current action, giving the slice reducer a chance to respond and update its slice of state if needed. So, in that sense, using `combineReducers` *does* "call all reducers", or at least all of the slice reducers it is wrapping.
- You can use it at all levels of your reducer structure, not just to create the root reducer. It's very common to have multiple combined reducers in various places, which are composed together to create the root reducer.

Defining State Shape

There are two ways to define the initial shape and contents of your store's state. First, the `createStore` function can take `preloadedState` as its second argument. This is primarily intended for initializing the store with state that was previously persisted elsewhere, such as the browser's localStorage. The other way is for the root reducer to return the initial state value when the `state` argument is `undefined`. These two approaches are described in more detail in [Initializing State](#), but there are some additional concerns to be aware of when using `combineReducers`.

`combineReducers` takes an object full of slice reducer functions, and creates a function that outputs a corresponding state object with the same keys. This means that if no preloaded state is provided to `createStore`, the naming of the keys in the input slice reducer object will define the naming of the keys in the output state object. The correlation between these names is not always apparent, especially when using ES6 features such as default module exports and object literal shorthands.

Here's an example of how use of ES6 object literal shorthand with `combineReducers` can define the state shape:

```
// reducers.js
export default theDefaultReducer = (state = 0, action) => state;
```

```

export const firstNamedReducer = (state = 1, action) => state;

export const secondNamedReducer = (state = 2, action) => state;

// rootReducer.js
import {combineReducers, createStore} from "redux";

import theDefaultReducer, {firstNamedReducer, secondNamedReducer} from "./reducers";

// Use ES6 object literal shorthand syntax to define the object shape
const rootReducer = combineReducers({
  theDefaultReducer,
  firstNamedReducer,
  secondNamedReducer
});

const store = createStore(rootReducer);
console.log(store.getState());
// {theDefaultReducer : 0, firstNamedReducer : 1, secondNamedReducer : 2}

```

Notice that because we used the ES6 shorthand for defining an object literal, the key names in the resulting state are the same as the variable names from the imports. This may not always be the desired behavior, and is often a cause of confusion for those who aren't as familiar with ES6 syntax.

Also, the resulting names are a bit odd. It's generally not a good practice to actually include words like "reducer" in your state key names - the keys should simply reflect the domain or type of data they hold. This means we should either explicitly specify the names of the keys in the slice reducer object to define the keys in the output state object, or carefully rename the variables for the imported slice reducers to set up the keys when using the shorthand object literal syntax.

A better usage might look like:

```

import {combineReducers, createStore} from "redux";

// Rename the default import to whatever name we want. We can also rename a named import.
import defaultState, {firstNamedReducer, secondNamedReducer as secondState} from "./reducers";

const rootReducer = combineReducers({
  defaultState, // key name same as the carefully renamed default export
  firstState : firstNamedReducer, // specific key name instead of the variable name
  secondState, // key name same as the carefully renamed named export
});

const reducerInitializedStore = createStore(rootReducer);
console.log(reducerInitializedStore.getState());
// {defaultState : 0, firstState : 1, secondState : 2}

```

This state shape better reflects the data involved, because we took care to set up the keys we passed to `combineReducers`.

Beyond combineReducers

The `combineReducers` utility included with Redux is very useful, but is deliberately limited to handle a single common use case: updating a state tree that is a plain Javascript object, by delegating the work of updating each slice of state to a specific slice reducer. It does *not* handle other use cases, such as a state tree made up of Immutable.js Maps, trying to pass other portions of the state tree as an additional argument to a slice reducer, or performing "ordering" of slice reducer calls. It also does not care how a given slice reducer does its work.

The common question, then, is "How can I use `combineReducers` to handle these other use cases?". The answer to that is simply: "you don't - you probably need to use something else". **Once you go past the core use case for `combineReducers`, it's time to use more "custom" reducer logic**, whether it be specific logic for a one-off use case, or a reusable function that could be widely shared. Here's some suggestions for dealing with a couple of these typical use cases, but feel free to come up with your own approaches.

Using slice reducers with Immutable.js objects

Since `combineReducers` currently only works with plain Javascript objects, an application that uses an Immutable.js Map object for the top of its state tree could not use `combineReducers` to manage that Map. Since many developers do use Immutable.js, there are a number of published utilities that provide equivalent functionality, such as [redux-immutable](#). This package provides its own implementation of `combineReducers` that knows how to iterate over an Immutable Map instead of a plain Javascript object.

Sharing data between slice reducers

Similarly, if `sliceReducerA` happens to need some data from `sliceReducerB`'s slice of state in order to handle a particular action, or `sliceReducerB` happens to need the entire state as an argument, `combineReducers` does not handle that itself. This could be resolved by writing a custom function that knows to pass the needed data as an additional argument in those specific cases, such as:

```
function combinedReducer(state, action) {
  switch(action.type) {
    case "A_TYPICAL_ACTION" : {
      return {
        a : sliceReducerA(state.a, action),
        b : sliceReducerB(state.b, action)
      };
    }
    case "SOME_SPECIAL_ACTION" : {
      return {
        // specifically pass state.b as an additional argument
        a : sliceReducerA(state.a, action, state.b),
        b : sliceReducerB(state.b, action)
      };
    }
    case "ANOTHER_SPECIAL_ACTION" : {
      return {
        a : sliceReducerA(state.a, action),
        // specifically pass the entire state as an additional argument
        b : sliceReducerB(state.b, action, state)
      };
    }
    default: return state;
  }
}
```

Another alternative to the "shared-slice updates" issue would be to simply put more data into the action. This is easily accomplished using thunk functions or a similar approach, per this example:

```
function someSpecialActionCreator() {
  return (dispatch, getState) => {
    const state = getState();
    const dataFromB = selectImportantDataFromB(state);

    dispatch({
      type : "SOME_SPECIAL_ACTION",
      payload : {
        dataFromB
      }
    });
  }
}
```

Because the data from B's slice is already in the action, the parent reducer doesn't have to do anything special to make that data available to `sliceReducerA`.

A third approach would be to use the reducer generated by `combineReducers` to handle the "simple" cases where each slice reducer can update itself independently, but also use another reducer to handle the "special" cases where data needs to be shared across slices. Then, a wrapping function could call both of those reducers in turn to generate the final result:

```
const combinedReducer = combineReducers({
  a : sliceReducerA,
  b : sliceReducerB
});

function crossSliceReducer(state, action) {
  switch(action.type) {
    case "SOME_SPECIAL_ACTION" : {
      return {
        // specifically pass state.b as an additional argument
        a : handleSpecialCaseForA(state.a, action, state.b),
        b : sliceReducerB(state.b, action)
      }
    }
    default : return state;
  }
}

function rootReducer(state, action) {
  const intermediateState = combinedReducer(state, action);
  const finalState = crossSliceReducer(intermediateState, action);
  return finalState;
}
```

As it turns out, there's a useful utility called `reduce-reducers` that can make that process easier. It simply takes multiple reducers and runs `reduce()` on them, passing the intermediate state values to the next reducer in line:

```
// Same as the "manual" rootReducer above
const rootReducer = reduceReducers(combinedReducers, crossSliceReducer);
```

Note that if you use `reduceReducers`, you should make sure that the first reducer in the list is able to define the initial state, since the later reducers will generally assume that the entire state already exists and not try to provide defaults.

Further Suggestions

Again, it's important to understand that Redux reducers are *just* functions. While `combineReducers` is useful, it's just one tool in the toolbox. Functions can contain conditional logic other than switch statements, functions can be composed to wrap each other, and functions can call other functions. Maybe you need one of your slice reducers to be able to reset its state, and to only respond to specific actions overall. You could do:

```
const undoableFilteredSliceA = compose(undoReducer, filterReducer("ACTION_1", "ACTION_2"), sliceReducerA);
const rootReducer = combineReducers({
  a : undoableFilteredSliceA,
  b : normalSliceReducerB
});
```

Note that `combineReducers` doesn't know or care that there's anything special about the reducer function that's responsible for managing `a`. We didn't need to modify `combineReducers` to specifically know how to undo things - we just built up the pieces we needed into a new composed function.

Also, while `combineReducers` is the one reducer utility function that's built into Redux, there's a wide variety of third-party reducer utilities that have published for reuse. The [Redux Addons Catalog](#) lists many of the third-party utilities that are available. Or, if none of the published utilities solve your use case, you can always write a function yourself that does just exactly what you need.

Normalizing State Shape

Many applications deal with data that is nested or relational in nature. For example, a blog editor could have many Posts, each Post could have many Comments, and both Posts and Comments would be written by a User. Data for this kind of application might look like:

```
const blogPosts = [
  {
    id : "post1",
    author : {username : "user1", name : "User 1"},
    body : ".....",
    comments : [
      {
        id : "comment1",
        author : {username : "user2", name : "User 2"},
        comment : ".....",
      },
      {
        id : "comment2",
        author : {username : "user3", name : "User 3"},
        comment : ".....",
      }
    ]
  },
  {
    id : "post2",
    author : {username : "user2", name : "User 2"},
    body : ".....",
    comments : [
      {
        id : "comment3",
        author : {username : "user3", name : "User 3"},
        comment : ".....",
      },
      {
        id : "comment4",
        author : {username : "user1", name : "User 1"},
        comment : ".....",
      },
      {
        id : "comment5",
        author : {username : "user3", name : "User 3"},
        comment : ".....",
      }
    ]
  }
  // and repeat many times
]
```

Notice that the structure of the data is a bit complex, and some of the data is repeated. This is a concern for several reasons:

- When a piece of data is duplicated in several places, it becomes harder to make sure that it is updated appropriately.
- Nested data means that the corresponding reducer logic has to be more nested and therefore more complex. In particular, trying to update a deeply nested field can become very ugly very fast.
- Since immutable data updates require all ancestors in the state tree to be copied and updated as well, and new object references will cause connected UI components to re-render, an update to a deeply nested data object could force totally unrelated UI components to re-render even if the data they're displaying hasn't actually changed.

Because of this, the recommended approach to managing relational or nested data in a Redux store is to treat a portion of your store as if it were a database, and keep that data in a *normalized* form.

Designing a Normalized State

The basic concepts of normalizing data are:

- Each type of data gets its own "table" in the state.
- Each "data table" should store the individual items in an object, with the IDs of the items as keys and the items themselves as the values.
- Any references to individual items should be done by storing the item's ID.
- Arrays of IDs should be used to indicate ordering.

An example of a normalized state structure for the blog example above might look like:

```
{
  posts : {
   .byId : {
      "post1" : {
        id : "post1",
        author : "user1",
        body : ".....",
        comments : ["comment1", "comment2"]
      },
      "post2" : {
        id : "post2",
        author : "user2",
        body : ".....",
        comments : ["comment3", "comment4", "comment5"]
      }
    },
    allIds : ["post1", "post2"]
  },
  comments : {
   .byId : {
      "comment1" : {
        id : "comment1",
        author : "user2",
        comment : ".....",
      },
      "comment2" : {
        id : "comment2",
        author : "user3",
        comment : ".....",
      },
      "comment3" : {
        id : "comment3",
        author : "user3",
        comment : ".....",
      },
      "comment4" : {
        id : "comment4",
        author : "user1",
        comment : ".....",
      },
      "comment5" : {
        id : "comment5",
        author : "user3",
        comment : ".....",
      }
    },
    allIds : ["comment1", "comment2", "comment3", "comment4", "comment5"]
  },
  users : {
   .byId : {
      "user1" : {
        username : "user1",
        name : "User 1",
      }
      "user2" : {
        username : "user2",
        name : "User 2",
      }
    }
  }
}
```

```

    "user3" : {
      username : "user3",
      name : "User 3",
    },
  },
  allIds : ["user1", "user2", "user3"]
}

```

This state structure is much flatter overall. Compared to the original nested format, this is an improvement in several ways:

- Because each item is only defined in one place, we don't have to try to make changes in multiple places if that item is updated.
- The reducer logic doesn't have to deal with deep levels of nesting, so it will probably be much simpler.
- The logic for retrieving or updating a given item is now fairly simple and consistent. Given an item's type and its ID, we can directly look it up in a couple simple steps, without having to dig through other objects to find it.
- Since each data type is separated, an update like changing the text of a comment would only require new copies of the "comments > byId > comment" portion of the tree. This will generally mean fewer portions of the UI that need to update because their data has changed. In contrast, updating a comment in the original nested shape would have required updating the comment object, the parent post object, the array of all post objects, and likely have caused *all* of the Post components and Comment components in the UI to re-render themselves.

Note that a normalized state structure generally implies that more components are connected and each component is responsible for looking up its own data, as opposed to a few connected components looking up large amounts of data and passing all that data downwards. As it turns out, having connected parent components simply pass item IDs to connected children is a good pattern for optimizing UI performance in a React Redux application, so keeping state normalized plays a key role in improving performance.

Organizing Normalized Data in State

A typical application will likely have a mixture of relational data and non-relational data. While there is no single rule for exactly how those different types of data should be organized, one common pattern is to put the relational "tables" under a common parent key, such as "entities". A state structure using this approach might look like:

```

{
  simpleDomainData1: {...},
  simpleDomainData2: {...}
  entities : {
    entityType1 : {...},
    entityType2 : {...}
  }
  ui : {
    uiSection1 : {...},
    uiSection2 : {...}
  }
}

```

This could be expanded in a number of ways. For example, an application that does a lot of editing of entities might want to keep two sets of "tables" in the state, one for the "current" item values and one for the "work-in-progress" item values. When an item is edited, its values could be copied into the "work-in-progress" section, and any actions that update it would be applied to the "work-in-progress" copy, allowing the editing form to be controlled by that set of data while another part of the UI still refers to the original version. "Resetting" the edit form would simply require removing the item from the "work-in-progress" section and re-copying the original data from "current" to "work-in-progress", while "applying" the edits would involve copying the values from the "work-in-progress" section to the "current" section.

Relationships and Tables

Because we're treating a portion of our Redux store as a "database", many of the principles of database design also apply here as well. For example, if we have a many-to-many relationship, we can model that using an intermediate table that stores the IDs of the corresponding items (often known as a "join table" or an "associative table"). For consistency, we would probably also want to use the same `byId` and `allIds` approach that we used for the actual item tables, like this:

```
{
  entities: {
    authors : { byId : {}, allIds : [] },
    books : { byId : {}, allIds : [] },
    authorBook : {
      byId : {
        1 : {
          id : 1,
          authorId : 5,
          bookId : 22
        },
        2 : {
          id : 2,
          authorId : 5,
          bookId : 15,
        }
        3 : {
          id : 3,
          authorId : 42,
          bookId : 12
        }
      },
      allIds : [1, 2, 3]
    }
  }
}
```

Operations like "Look up all books by this author", can then be accomplished easily with a single loop over the join table. Given the typical amounts of data in a client application and the speed of Javascript engines, this kind of operation is likely to have sufficiently fast performance for most use cases.

Normalizing Nested Data

Because APIs frequently send back data in a nested form, that data needs to be transformed into a normalized shape before it can be included in the state tree. The [Normalizr](#) library is usually used for this task. You can define schema types and relations, feed the schema and the response data to Normalizr, and it will output a normalized transformation of the response. That output can then be included in an action and used to update the store. See the Normalizr documentation for more details on its usage.

Managing Normalized Data

As mentioned in [Normalizing State Shape](#), the Normalizr library is frequently used to transform nested response data into a normalized shape suitable for integration into the store. However, that doesn't address the issue of executing further updates to that normalized data as it's being used elsewhere in the application. There are a variety of different approaches that you can use, based on your own preference. We'll use the example of adding a new Comment to a Post.

Standard Approaches

Simple Merging

One approach is to merge the contents of the action into the existing state. In this case, we need to do a deep recursive merge, not just a shallow copy. The Lodash `merge` function can handle this for us:

```
import merge from "lodash/merge";

function commentsById(state = {}, action) {
  switch(action.type) {
    default : {
      if(action.entities && action.entities.comments) {
        return merge({}, state, action.entities.comments.byId);
      }
      return state;
    }
  }
}
```

This requires the least amount of work on the reducer side, but does require that the action creator potentially do a fair amount of work to organize the data into the correct shape before the action is dispatched. It also doesn't handle trying to delete an item.

Slice Reducer Composition

If we have a nested tree of slice reducers, each slice reducer will need to know how to respond to this action appropriately. We will need to include all the relevant data in the action. We need to update the correct Post object with the comment's ID, create a new Comment object using that ID as a key, and include the Comment's ID in the list of all Comment IDs. Here's how the pieces for this might fit together:

```
// actions.js
function addComment(postId, commentText) {
  // Generate a unique ID for this comment
  const commentId = generateId("comment");

  return {
    type : "ADD_COMMENT",
    payload : {
      postId,
      commentId,
      commentText
    }
};

// reducers/posts.js
function addComment(state, action) {
  const {payload} = action;
```

```

const {postId, commentId} = payload;

// Look up the correct post, to simplify the rest of the code
const post = state[postId];

return {
  ...state,
  // Update our Post object with a new "comments" array
  [postId] : {
    ...post,
    comments : post.comments.concat(commentId)
  }
};

function postsById(state = {}, action) {
  switch(action.type) {
    case "ADD_COMMENT" : return addComment(state, action);
    default : return state;
  }
}

function allPosts(state = [], action) {
  // omitted - no work to be done for this example
}

const postsReducer = combineReducers({
  byId : postsById,
  allIds : allPosts
});

// reducers/comments.js
function addCommentEntry(state, action) {
  const {payload} = action;
  const {commentId, commentText} = payload;

  // Create our new Comment object
  const comment = {id : commentId, text : commentText};

  // Insert the new Comment object into the updated lookup table
  return {
    ...state,
    [commentId] : comment
  };
}

function commentsById(state = {}, action) {
  switch(action.type) {
    case "ADD_COMMENT" : return addCommentEntry(state, action);
    default : return state;
  }
}

function addCommentId(state, action) {
  const {payload} = action;
  const {commentId} = payload;
  // Just append the new Comment's ID to the list of all IDs
  return state.concat(commentId);
}

function allComments(state = [], action) {
  switch(action.type) {
    case "ADD_COMMENT" : return addCommentId(state, action);
    default : return state;
  }
}

const commentsReducer = combineReducers({
  byId : commentsById,
  allIds : allComments
});

```

The example is a bit long, because it's showing how all the different slice reducers and case reducers fit together. Note the delegation involved here. The `postsById` slice reducer delegates the work for this case to `addComment`, which inserts the new Comment's ID into the correct Post item. Meanwhile, both the `commentsById` and `allComments` slice reducers have their own case reducers, which update the Comments lookup table and list of all Comment IDs appropriately.

Other Approaches

Task-Based Updates

Since reducers are just functions, there's an infinite number of ways to split up this logic. While using slice reducers is obviously the most common, it's also possible to organize behavior in a more task-oriented structure. Because this will often involve more nested updates, you may want to use an immutable update utility library like [dot-prop-immutable](#) or [object-path-immutable](#) to simplify the update statements. Here's an example of what that might look like:

```
import posts from "./postsReducer";
import comments from "./commentsReducer";
import dotProp from "dot-prop-immutable";
import {combineReducers} from "redux";
import reduceReducers from "reduce-reducers";

const combinedReducer = combineReducers({
  posts,
  comments
});

function addComment(state, action) {
  const {payload} = action;
  const {postId, commentId, commentText} = payload;

  // State here is the entire combined state
  const updatedWithPostState = dotProp.set(
    state,
    `posts.byId.${postId}.comments`,
    comments => comments.concat(commentId)
  );

  const updatedWithCommentsTable = dotProp.set(
    updatedWithPostState,
    `comments.byId.${commentId}`,
    {id: commentId, text: commentText}
  );

  const updatedWithCommentsList = dotProp.set(
    updatedWithCommentsTable,
    `comments.allIds`,
    allIds => allIds.concat(commentId);
  );

  return updatedWithCommentsList;
}

const featureReducers = createReducer({}, {
  ADD_COMMENT : addComment,
});

const rootReducer = reduceReducers(
  combinedReducer,
  featureReducers
);
```

This approach makes it very clear what's happening for the `"ADD_COMMENTS"` case, but it does require nested updating logic, and some specific knowledge of the state tree shape. Depending on how you want to compose your reducer logic, this may or may not be desired.

Redux-ORM

The [Redux-ORM](#) library provides a very useful abstraction layer for managing normalized data in a Redux store. It allows you to declare Model classes and define relations between them. It can then generate the empty "tables" for your data types, act as a specialized selector tool for looking up the data, and perform immutable updates on that data.

There's a couple ways Redux-ORM can be used to perform updates. First, the Redux-ORM docs suggest defining reducer functions on each Model subclass, then including the auto-generated combined reducer function into your store:

```
// models.js
import {Model, many, Schema} from "redux-orm";

export class Post extends Model {
  static get fields() {
    return [
      // Define a many-sided relation - one Post can have many Comments,
      // at a field named "comments"
      comments : many("Comment")
    ];
  }

  static reducer(state, action, Post) {
    switch(action.type) {
      case "CREATE_POST" : {
        // Queue up the creation of a Post instance
        Post.create(action.payload);
        break;
      }
      case "ADD_COMMENT" : {
        const {payload} = action;
        const {postId, commentId} = payload;
        // Queue up the addition of a relation between this Comment ID
        // and this Post instance
        Post.withId(postId).comments.add(commentId);
        break;
      }
    }
    // Redux-ORM will automatically apply queued updates after this returns
  }
}
Post.modelName = "Post";

export class Comment extends Model {
  static get fields() {
    return {};
  }

  static reducer(state, action, Comment) {
    switch(action.type) {
      case "ADD_COMMENT" : {
        const {payload} = action;
        const {commentId, commentText} = payload;

        // Queue up the creation of a Comment instance
        Comment.create({id : commentId, text : commentText});
        break;
      }
    }
    // Redux-ORM will automatically apply queued updates after this returns
  }
}
```

```

}

Comment modelName = "Comment";

// Create a Schema instance, and hook up the Post and Comment models
export const schema = new Schema();
schema.register(Post, Comment);

// main.js
import { createStore, combineReducers } from 'redux'
import {schema} from "./models";

const rootReducer = combineReducers({
  // Insert the auto-generated Redux-ORM reducer. This will
  // initialize our model "tables", and hook up the reducer
  // logic we defined on each Model subclass
  entities : schema.reducer()
});

// Dispatch an action to create a Post instance
store.dispatch({
  type : "CREATE_POST",
  payload : {
    id : 1,
    name : "Test Post Please Ignore"
  }
});

// Dispatch an action to create a Comment instance as a child of that Post
store.dispatch({
  type : "ADD_COMMENT",
  payload : {
    postId : 1,
    commentId : 123,
    commentText : "This is a comment"
  }
});

```

The Redux-ORM library maintains an internal queue of updates to be applied. Those updates are then applied immutably, simplifying the update process.

Another variation on this is to use Redux-ORM as an abstraction layer within a single case reducer:

```

import {schema} from "./models";

// Assume this case reducer is being used in our "entities" slice reducer,
// and we do not have reducers defined on our Redux-ORM Model subclasses
function addComment(entitiesState, action) {
  const session = schema.from(entitiesState);
  const {Post, Comment} = session;
  const {payload} = action;
  const {postId, commentId, commentText} = payload;

  const post = Post.withId(postId);
  post.comments.add(commentId);

  Comment.create({id : commentId, text : commentText});

  return session.reduce();
}

```

Overall, Redux-ORM provides a very useful set of abstractions for defining relations between data types, creating the "tables" in our state, retrieving and denormalizing relational data, and applying immutable updates to relational data.

Reusing Reducer Logic

As an application grows, common patterns in reducer logic will start to emerge. You may find several parts of your reducer logic doing the same kinds of work for different types of data, and want to reduce duplication by reusing the same common logic for each data type. Or, you may want to have multiple "instances" of a certain type of data being handled in the store. However, the global structure of a Redux store comes with some trade-offs: it makes it easy to track the overall state of an application, but can also make it harder to "target" actions that need to update a specific piece of state, particularly if you are using `combineReducers`.

As an example, let's say that we want to track multiple counters in our application, named A, B, and C. We define our initial `counter` reducer, and we use `combineReducers` to set up our state:

```
function counter(state = 0, action) {
  switch (action.type) {
    case 'INCREMENT':
      return state + 1;
    case 'DECREMENT':
      return state - 1;
    default:
      return state;
  }
}

const rootReducer = combineReducers({
  counterA: counter,
  counterB: counter,
  counterC: counter
});
```

Unfortunately, this setup has a problem. Because `combineReducers` will call each slice reducer with the same action, dispatching `{type : 'INCREMENT'}` will actually cause *all three* counter values to be incremented, not just one of them. We need some way to wrap the `counter` logic so that we can ensure that only the counter we care about is updated.

Customizing Behavior with Higher-Order Reducers

As defined in [Splitting Reducer Logic](#), a *higher-order reducer* is a function that takes a reducer function as an argument, and/or returns a new reducer function as a result. It can also be viewed as a "reducer factory".

`combineReducers` is one example of a higher-order reducer. We can use this pattern to create specialized versions of our own reducer functions, with each version only responding to specific actions.

The two most common ways to specialize a reducer are to generate new action constants with a given prefix or suffix, or to attach additional info inside the action object. Here's what those might look like:

```
function createCounterWithNamedType(counterName = '') {
  return function counter(state = 0, action) {
    switch (action.type) {
      case `INCREMENT_${counterName}`:
        return state + 1;
      case `DECREMENT_${counterName}`:
        return state - 1;
      default:
        return state;
    }
  }
}

function createCounterWithNameData(counterName = '') {
  return function counter(state = 0, action) {
    const {name} = action;
```

```

        if(name !== counterName) return state;

        switch (action.type) {
            case `INCREMENT`:
                return state + 1;
            case `DECREMENT`:
                return state - 1;
            default:
                return state;
        }
    }
}

```

We should now be able to use either of these to generate our specialized counter reducers, and then dispatch actions that will affect the portion of the state that we care about:

```

const rootReducer = combineReducers({
    counterA : createCounterWithNamedType('A'),
    counterB : createCounterWithNamedType('B'),
    counterC : createCounterWithNamedType('C'),
});

store.dispatch({type : 'INCREMENT_B'});
console.log(store.getState());
// {counterA : 0, counterB : 1, counterC : 0}

```

We could also vary the approach somewhat, and create a more generic higher-order reducer that accepts both a given reducer function and a name or identifier:

```

function counter(state = 0, action) {
    switch (action.type) {
        case 'INCREMENT':
            return state + 1;
        case 'DECREMENT':
            return state - 1;
        default:
            return state;
    }
}

function createNamedWrapperReducer(reducerFunction, reducerName) {
    return (state, action) => {
        const {name} = action;
        const isInitializationCall = state === undefined;
        if(name !== reducerName && !isInitializationCall) return state;

        return reducerFunction(state, action);
    }
}

const rootReducer = combineReducers({
    counterA : createNamedWrapperReducer(counter, 'A'),
    counterB : createNamedWrapperReducer(counter, 'B'),
    counterC : createNamedWrapperReducer(counter, 'C'),
});

```

You could even go as far as to make a generic filtering higher-order reducer:

```

function createFilteredReducer(reducerFunction, reducerPredicate) {
    return (state, action) => {
        const isInitializationCall = state === undefined;
        const shouldRunWrappedReducer = reducerPredicate(action) || isInitializationCall;
        return shouldRunWrappedReducer ? reducerFunction(state, action) : state;
    }
}

const rootReducer = combineReducers({
    // check for suffixed strings
}

```

```
counterA : createFilteredReducer(counter, action => action.type.endsWith('_A')),
// check for extra data in the action
counterB : createFilteredReducer(counter, action => action.name === 'B'),
// respond to all 'INCREMENT' actions, but never 'DECREMENT'
counterC : createFilteredReducer(counter, action => action.type === 'INCREMENT')
};
```

These basic patterns allow you to do things like having multiple instances of a smart connected component within the UI, or reuse common logic for generic capabilities such as pagination or sorting.

In addition to generating reducers this way, you might also want to generate action creators using the same approach, and could generate them both at the same time with helper functions. See [Action/Reducer Generators](#) and [Reducers](#) libraries for action/reducer utilities.

Immutable Update Patterns

The articles listed in [Prerequisite Concepts#Immutable Data Management](#) give a number of good examples for how to perform basic update operations immutably, such as updating a field in an object or adding an item to the end of an array. However, reducers will often need to use those basic operations in combination to perform more complicated tasks. Here are some examples for some of the more common tasks you might have to implement.

Updating Nested Objects

The key to updating nested data is **that every level of nesting must be copied and updated appropriately**. This is often a difficult concept for those learning Redux, and there are some specific problems that frequently occur when trying to update nested objects. These lead to accidental direct mutation, and should be avoided.

Common Mistake #1: New variables that point to the same objects

Defining a new variable does *not* create a new actual object - it only creates another reference to the same object. An example of this error would be:

```
function updateNestedState(state, action) {
  let nestedState = state.nestedState;
  // ERROR: this directly modifies the existing object reference - don't do this!
  nestedState.nestedField = action.data;

  return {
    ...state,
    nestedState
  };
}
```

This function does correctly return a shallow copy of the top-level state object, but because the `nestedState` variable was still pointing at the existing object, the state was directly mutated.

Common Mistake #2: Only making a shallow copy of one level

Another common version of this error looks like this:

```
function updateNestedState(state, action) {
  // Problem: this only does a shallow copy!
  let newState = { ...state };

  // ERROR: nestedState is still the same object!
  newState.nestedState.nestedField = action.data;

  return newState;
}
```

Doing a shallow copy of the top level is *not* sufficient - the `nestedState` object should be copied as well.

Correct Approach: Copying All Levels of Nested Data

Unfortunately, the process of correctly applying immutable updates to deeply nested state can easily become verbose and hard to read. Here's what an example of updating `state.first.second[someId].fourth` might look like:

```
function updateVeryNestedField(state, action) {
  return {
    ...state,
    first: {
```

```

    ...state.first,
    second : [
      ...state.first.second,
      [action.someId] : {
        ...state.first.second[action.someId],
        fourth : action.someValue
      }
    ]
}
]
}
}

```

Obviously, each layer of nesting makes this harder to read, and gives more chances to make mistakes. This is one of several reasons why you are encouraged to keep your state flattened, and compose reducers as much as possible.

Inserting and Removing Items in Arrays

Normally, a Javascript array's contents are modified using mutative functions like `push`, `unshift`, and `splice`. Since we don't want to mutate state directly in reducers, those should normally be avoided. Because of that, you might see "insert" or "remove" behavior written like this:

```

function insertItem(array, action) {
  return [
    ...array.slice(0, action.index),
    action.item,
    ...array.slice(action.index)
  ]
}

function removeItem(array, action) {
  return [
    ...array.slice(0, action.index),
    ...array.slice(action.index + 1)
  ];
}

```

However, remember that the key is that the *original in-memory reference* is not modified. **As long as we make a copy first, we can safely mutate the copy.** Note that this is true for both arrays and objects, but nested values still must be updated using the same rules.

This means that we could also write the insert and remove functions like this:

```

function insertItem(array, action) {
  let newArray = array.slice();
  newArray.splice(action.index, 0, action.item);
  return newArray;
}

function removeItem(array, action) {
  let newArray = array.slice();
  newArray.splice(action.index, 1);
  return newArray;
}

```

The remove function could also be implemented as:

```

function removeItem(array, action) {
  return array.filter( (item, index) => index !== action.index);
}

```

Updating an Item in an Array

Updating one item in an array can be accomplished by using `Array.map`, returning a new value for the item we want to update, and returning the existing values for all other items:

```
function updateObjectInArray(array, action) {
  return array.map( (item, index) => {
    if(index !== action.index) {
      // This isn't the item we care about - keep it as-is
      return item;
    }

    // Otherwise, this is the one we want - return an updated value
    return {
      ...item,
      ...action.item
    };
  });
}
```

Immutable Update Utility Libraries

Because writing immutable update code can become tedious, there are a number of utility libraries that try to abstract out the process. These libraries vary in APIs and usage, but all try to provide a shorter and more succinct way of writing these updates. Some, like [dot-prop-immutable](#), take string paths for commands:

```
state = dotProp.set(state, `todos.${index}.complete`, true)
```

Others, like [immutability-helper](#) (a fork of the now-deprecated React Immutability Helpers addon), use nested values and helper functions:

```
var collection = [1, 2, {a: [12, 17, 15]}];
var newCollection = update(collection, {2: {a: {$splice: [[1, 1, 13, 14]]}}});
```

They can provide a useful alternative to writing manual immutable update logic.

A list of many immutable update utilities can be found in the [Immutable Data#Immutable Update Utilities](#) section of the [Redux Addons Catalog](#).

Initializing State

There are two main ways to initialize state for your application. The `createStore` method can accept an optional `preloadedState` value as its second argument. Reducers can also specify an initial value by looking for an incoming `state` argument that is `undefined`, and returning the value they'd like to use as a default. This can either be done with an explicit check inside the reducer, or by using the ES6 default argument value syntax: `function myReducer(state = someDefaultValue, action)`.

It's not always immediately clear how these two approaches interact. Fortunately, the process does follow some predictable rules. Here's how the pieces fit together.

Summary

Without `combineReducers()` or similar manual code, `preloadedState` always wins over `state = ...` in the reducer because the `state` passed to the reducer is `preloadedState` and is not `undefined`, so the ES6 argument syntax doesn't apply.

With `combineReducers()` the behavior is more nuanced. Those reducers whose state is specified in `preloadedState` will receive that state. Other reducers will receive `undefined` and because of that will fall back to the `state = ...` default argument they specify.

In general, `preloadedState` wins over the state specified by the reducer. This lets reducers specify initial data that makes sense to them as default arguments, but also allows loading existing data (fully or partially) when you're hydrating the store from some persistent storage or the server.

Note: Reducers whose initial state is populated using `preloadedState` will still need to provide a default value to handle when passed a `state` of `undefined`. All reducers are passed `undefined` on initialization, so they should be written such that when given `undefined`, some value should be returned. This can be any non-`undefined` value; there's no need to duplicate the section of `preloadedState` here as the default.

In Depth

Single Simple Reducer

First let's consider a case where you have a single reducer. Say you don't use `combineReducers()`.

Then your reducer might look like this:

```
function counter(state = 0, action) {
  switch (action.type) {
    case 'INCREMENT': return state + 1;
    case 'DECREMENT': return state - 1;
    default: return state;
  }
}
```

Now let's say you create a store with it.

```
import { createStore } from 'redux';
let store = createStore(counter);
console.log(store.getState()); // 0
```

The initial state is zero. Why? Because the second argument to `createStore` was `undefined`. This is the `state` passed to your reducer the first time. When Redux initializes it dispatches a "dummy" action to fill the state. So your `counter` reducer was called with `state` equal to `undefined`. **This is exactly the case that "activates" the default argument.** Therefore, `state` is now `0` as per the default `state` value (`state = 0`). This state (`0`) will be returned.

Let's consider a different scenario:

```
import { createStore } from 'redux';
let store = createStore(counter, 42);
console.log(store.getState()); // 42
```

Why is it `42`, and not `0`, this time? Because `createStore` was called with `42` as the second argument. This argument becomes the `state` passed to your reducer along with the dummy action. **This time, state is not undefined (it's 42 !), so ES6 default argument syntax has no effect.** The `state` is `42`, and `42` is returned from the reducer.

Combined Reducers

Now let's consider a case where you use `combineReducers()`.

You have two reducers:

```
function a(state = 'lol', action) {
  return state;
}

function b(state = 'wat', action) {
  return state;
}
```

The reducer generated by `combineReducers({ a, b })` looks like this:

```
// const combined = combineReducers({ a, b })
function combined(state = {}, action) {
  return {
    a: a(state.a, action),
    b: b(state.b, action)
  };
}
```

If we call `createStore` without the `preloadedState`, it's going to initialize the `state` to `{}`. Therefore, `state.a` and `state.b` will be `undefined` by the time it calls `a` and `b` reducers. **Both a and b reducers will receive undefined as their state arguments, and if they specify default state values, those will be returned.** This is how the combined reducer returns a `{ a: 'lol', b: 'wat' }` state object on the first invocation.

```
import { createStore } from 'redux';
let store = createStore(combined);
console.log(store.getState()); // { a: 'lol', b: 'wat' }
```

Let's consider a different scenario:

```
import { createStore } from 'redux';
let store = createStore(combined, { a: 'horse' });
console.log(store.getState()); // { a: 'horse', b: 'wat' }
```

Now I specified the `preloadedState` as the argument to `createStore()`. The state returned from the combined reducer *combines* the initial state I specified for the `a` reducer with the `'wat'` default argument specified that `b` reducer chose itself.

Let's recall what the combined reducer does:

```
// const combined = combineReducers({ a, b })
function combined(state = {}, action) {
  return {
    a: a(state.a, action),
    b: b(state.b, action)
  };
}
```

In this case, `state` was specified so it didn't fall back to `{}`. It was an object with `a` field equal to `'horse'`, but without the `b` field. This is why the `a` reducer received `'horse'` as its `state` and gladly returned it, but the `b` reducer received `undefined` as its `state` and thus returned *its idea* of the default `state` (in our example, `'wat'`). This is how we get `{ a: 'horse', b: 'wat' }` in return.

Recap

To sum this up, if you stick to Redux conventions and return the initial state from reducers when they're called with `undefined` as the `state` argument (the easiest way to implement this is to specify the `state` ES6 default argument value), you're going to have a nice useful behavior for combined reducers. **They will prefer the corresponding value in the `preloadedState` object you pass to the `createStore()` function, but if you didn't pass any, or if the corresponding field is not set, the default `state` argument specified by the reducer is chosen instead.** This approach works well because it provides both initialization and hydration of existing data, but lets individual reducers reset their state if their data was not preserved. Of course you can apply this pattern recursively, as you can use `combineReducers()` on many levels, or even compose reducers manually by calling reducers and giving them the relevant part of the state tree.

Using Immutable.JS with Redux

Table of Contents

- Why should I use an immutable-focused library such as Immutable.JS?
- Why should I choose Immutable.JS as an immutable library?
- What are the issues with using Immutable.JS?
- Is Immutable.JS worth the effort?
- What are some opinionated Best Practices for using Immutable.JS with Redux?

Why should I use an immutable-focused library such as Immutable.JS?

Immutable-focused libraries such as Immutable.JS have been designed to overcome the issues with immutability inherent within JavaScript, providing all the benefits of immutability with the performance your app requires.

Whether you choose to use such a library, or stick with plain JavaScript, depends on how comfortable you are with adding another dependency to your app, or how sure you are that you can avoid the pitfalls inherent within JavaScript's approach to immutability.

Whichever option you choose, make sure you're familiar with the concepts of [immutability](#), [side effects](#) and [mutation](#). In particular, ensure you have a deep understanding of what JavaScript does when updating and copying values in order to guard against accidental mutations that will degrade your app's performance, or break it altogether.

Further Information

Documentation

- [Recipes: immutability, side effects and mutation](#)

Articles

- [Introduction to Immutable.js and Functional Programming Concepts](#)
- [Pros and Cons of using immutability with React.js](#)

Why should I choose Immutable.JS as an immutable library?

Immutable.JS was designed to provide immutability in a performant manner in an effort to overcome the limitations of immutability with JavaScript. Its principle advantages include:

Guaranteed immutability

Data encapsulated in an Immutable.JS object is never mutated. A new copy is always returned. This contrasts with JavaScript, in which some operations do not mutate your data (e.g. some Array methods, including map, filter, concat, forEach, etc.), but some do (Array's pop, push, splice, etc.).

Rich API

Immutable.JS provides a rich set of immutable objects to encapsulate your data (e.g. Maps, Lists, Sets, Records, etc.), and an extensive set of methods to manipulate it, including methods to sort, filter, and group the data, reverse it, flatten it, and create subsets.

Performance

Immutable.JS does a lot of work behind the scenes to optimize performance. This is the key to its power, as using immutable data structures can involve a lot of expensive copying. In particular, immutably manipulating large, complex data sets, such as a nested Redux state tree, can generate many intermediate copies of objects, which consume memory and slow down performance as the browser's garbage collector fights to clean things up.

Immutable.JS avoids this by [cleverly sharing data structures](#) under the surface, minimizing the need to copy data. It also enables complex chains of operations to be carried out without creating unnecessary (and costly) cloned intermediate data that will quickly be thrown away.

You never see this, of course - the data you give to an Immutable.JS object is never mutated. Rather, it's the *intermediate* data generated within Immutable.JS from a chained sequence of method calls that is free to be mutated. You therefore get all the benefits of immutable data structures with none (or very little) of the potential performance hits.

Further Information

Articles

- [Immutable.js, persistent data structures and structural sharing](#)
- [PDF: JavaScript Immutability - Don't go changing](#)

Libraries

- [Immutable.js](#)

What are the issues with using Immutable.JS?

Although powerful, Immutable.JS needs to be used carefully, as it comes with issues of its own. Note, however, that all of these issues can be overcome quite easily with careful coding.

Difficult to interoperate with

JavaScript does not provide immutable data structures. As such, for Immutable.JS to provide its immutable guarantees, your data must be encapsulated within an Immutable.JS object (such as a `Map` or a `List`, etc.). Once it's contained in this way, it's hard for that data to then interoperate with other, plain JavaScript objects.

For example, you will no longer be able to reference an object's properties through standard JavaScript dot or bracket notation. Instead, you must reference them via Immutable.JS's `get()` or `getIn()` methods, which use an awkward syntax that accesses properties via an array of strings, each of which represents a property key.

For example, instead of `myObj.prop1.prop2.prop3`, you would use `myImmutableMap.getIn(['prop1', 'prop2', 'prop3'])`.

This makes it awkward to interoperate not just with your own code, but also with other libraries, such as lodash or ramda, that expect plain JavaScript objects.

Note that Immutable.JS objects do have a `toJS()` method, which returns the data as a plain JavaScript data structure, but this method is extremely slow, and using it extensively will negate the performance benefits that Immutable.JS provides

Once used, Immutable.JS will spread throughout your codebase

Once you encapsulate your data with Immutable.JS, you have to use Immutable.JS's `get()` or `getIn()` property accessors to access it.

This has the effect of spreading Immutable.JS across your entire codebase, including potentially your components, where you may prefer not to have such external dependencies. Your entire codebase must know what is, and what is not, an Immutable.JS object. It also makes removing Immutable.JS from your app difficult in the future, should you ever need to.

This issue can be avoided by [uncoupling your application logic from your data structures](#), as outlined in the [best practices section](#) below.

No Destructuring or Spread Operators

Because you must access your data via Immutable.JS's own `get()` and `getIn()` methods, you can no longer use JavaScript's destructuring operator (or the proposed Object spread operator), making your code more verbose.

Not suitable for small values that change often

Immutable.JS works best for collections of data, and the larger the better. It can be slow when your data comprises lots of small, simple JavaScript objects, with each comprising a few keys of primitive values.

Note, however, that this does not apply to the Redux state tree, which is (usually) represented as a large collection of data.

Difficult to Debug

Immutable.JS objects, such as `Map`, `List`, etc., can be difficult to debug, as inspecting such an object will reveal an entire nested hierarchy of Immutable.JS-specific properties that you don't care about, while your actual data that you do care about is encapsulated several layers deep.

To resolve this issue, use a browser extension such as the [Immutable.js Object Formatter](#), which surfaces your data in Chrome Dev Tools, and hides Immutable.JS's properties when inspecting your data.

Breaks object references, causing poor performance

One of the key advantages of immutability is that it enables shallow equality checking, which dramatically improves performance.

If two different variables reference the same immutable object, then a simple equality check of the two variables is enough to determine that they are equal, and that the object they both reference is unchanged. The equality check never has to check the values of any of the object's properties, as it is, of course, immutable.

However, shallow checking will not work if your data encapsulated within an Immutable.JS object is itself an object. This is because Immutable.JS's `toJS()` method, which returns the data contained within an Immutable.JS object as a JavaScript value, will create a new object every time it's called, and so break the reference with the encapsulated data.

Accordingly, calling `toJS()` twice, for example, and assigning the result to two different variables will cause an equality check on those two variables to fail, even though the object values themselves haven't changed.

This is a particular issue if you use `toJS()` in a wrapped component's `mapStateToProps` function, as React-Redux shallowly compares each value in the returned props object. For example, the value referenced by the `todos` prop returned from `mapStateToProps` below will always be a different object, and so will fail a shallow equality check.

```
// AVOID .toJS() in mapStateToProps
function mapStateToProps(state) {
  return {
    todos: state.get('todos').toJS() // Always a new object
  }
}
```

When the shallow check fails, React-Redux will cause the component to re-render. Using `.toJS()` in `mapStateToProps` in this way, therefore, will always cause the component to re-render, even if the value never changes, impacting heavily on performance.

This can be prevented by using `.toJS()` in a Higher Order Component, as discussed in the [Best Practices](#) section below.

Further Information

Articles

- [Immutable.js, persistent data structures and structural sharing](#)
- [Immutable Data Structures and JavaScript](#)
- [React.js pure render performance anti-pattern](#)
- [Building Efficient UI with React and Redux](#)

Chrome Extension

- [Immutable Object Formatter](#)

Is Using Immutable.JS worth the effort?

Frequently, yes. There are various tradeoffs and opinions to consider, but there are many good reasons to use Immutable.JS. Do not underestimate the difficulty of trying to track down a property of your state tree that has been inadvertently mutated.

Components will both re-render when they shouldn't, and refuse to render when they should, and tracking down the bug causing the rendering issue is hard, as the component rendering incorrectly is not necessarily the one whose properties are being accidentally mutated.

This problem is caused predominantly by returning a mutated state object from a Redux reducer. With Immutable.JS, this problem simply does not exist, thereby removing a whole class of bugs from your app.

This, together with its performance and rich API for data manipulation, is why Immutable.JS is worth the effort.

Further Information

Documentation

- [Troubleshooting: Nothing happens when I dispatch an action](#)

What are some opinionated Best Practices for using Immutable.JS with Redux?

Immutable.JS can provide significant reliability and performance improvements to your app, but it must be used correctly. If you choose to use Immutable.JS (and remember, you are not required to, and there are other immutable libraries you can use), follow these opinionated best practices, and you'll be able to get the most out of it, without tripping up on any of the issues it can potentially cause.

Never mix plain JavaScript objects with Immutable.JS

Never let a plain JavaScript object contain Immutable.JS properties. Equally, never let an Immutable.JS object contain a plain JavaScript object.

Further Information

Articles

- [Immutable Data Structures and JavaScript](#)

Make your entire Redux state tree an Immutable.JS object

For a Redux app, your entire state tree should be an Immutable.JS object, with no plain JavaScript objects used at all.

- Create the tree using Immutable.JS's `fromJS()` function.
- Use an Immutable.JS-aware version of the `combineReducers` function, such as the one in [redux-immutable](#), as Redux itself expects the state tree to be a plain JavaScript object.
- When adding JavaScript objects to an Immutable.JS Map or List using Immutable.JS's `update`, `merge` or `set` methods, ensure that the object being added is first converted to an Immutable object using `fromJS()`.

Example

```
// avoid
const newObj = { key: value }
const newState = state.setIn(['prop1'], newObj)
// newObj has been added as a plain JavaScript object, NOT as an Immutable.JS Map

// recommended
const newObj = { key: value }
const newState = state.setIn(['prop1'], fromJS(newObj))
// newObj is now an Immutable.JS Map
```

Further Information

Articles

- [Immutable Data Structures and JavaScript](#)

Libraries

- [redux-immutable](#)

Use Immutable.JS everywhere except your dumb components

Using Immutable.JS everywhere keeps your code performant. Use it in your smart components, your selectors, your sagas or thunks, action creators, and especially your reducers.

Do not, however, use Immutable.JS in your dumb components.

Further Information

Articles

- [Immutable Data Structures and JavaScript](#)
- [Smart and Dumb Components in React](#)

Limit your use of `toJS()`

`toJS()` is an expensive function and negates the purpose of using Immutable.JS. Avoid its use.

Further Information

Discussions

- [Lee Byron on Twitter: "Perf tip for #immutablejs..."](#)

Your selectors should return Immutable.JS objects

Always.

Use Immutable.JS objects in your Smart Components

Smart components that access the store via React Redux's `connect` function must use the Immutable.JS values returned by your selectors. Make sure you avoid the potential issues this can cause with unnecessary component re-rendering. Memoize your selectors using a library such as `reselect` if necessary.

Further Information

Documentation

- [Recipes: Computing Derived Data](#)
- [FAQ: Immutable Data](#)
- [Reselect Documentation: How do I use Reselect with Immutable.js?](#)

Articles

- [Redux Patterns and Anti-Patterns](#)

Libraries

- [Reselect: Selector library for Redux](#)

Never use `toJS()` in `mapStateToProps`

Converting an Immutable.JS object to a JavaScript object using `toJS()` will return a new object every time. If you do this in `mapStateToProps`, you will cause the component to believe that the object has changed every time the state tree changes, and so trigger an unnecessary re-render.

Further Information

Documentation

- [FAQ: Immutable Data](#)

Never use Immutable.JS in your Dumb Components

Your dumb components should be pure; that is, they should produce the same output given the same input, and have no external dependencies. If you pass such a component an Immutable.JS object as a prop, you make it dependent upon Immutable.JS to extract the prop's value and otherwise manipulate it.

Such a dependency renders the component impure, makes testing the component more difficult, and makes reusing and refactoring the component unnecessarily difficult.

Further Information

Articles

- [Immutable Data Structures and JavaScript](#)
- [Smart and Dumb Components in React](#)
- [Tips For a Better Redux Architecture: Lessons for Enterprise Scale](#)

Use a Higher Order Component to convert your Smart Component's Immutable.JS props to your Dumb Component's JavaScript props

Something needs to map the Immutable.JS props in your Smart Component to the pure JavaScript props used in your Dumb Component. That something is a Higher Order Component (HOC) that simply takes the Immutable.JS props from your Smart Component, and converts them using `toJS()` to plain JavaScript props, which are then passed to your Dumb Component.

Here is an example of such a HOC:

```
import React from 'react'
import { Iterable } from 'immutable'

export const toJS = WrappedComponent => wrappedComponentProps => {
  const KEY = 0
  const VALUE = 1

  const propsJS = Object.entries(
    wrappedComponentProps
  ).reduce((newProps, wrappedComponentProp) => {
    newProps[wrappedComponentProp[KEY]] = Iterable.isIterable(
      wrappedComponentProp[VALUE]
    )
    ? wrappedComponentProp[VALUE].toJS()
    : wrappedComponentProp[VALUE]
    return newProps
  }, {})

  return <WrappedComponent {...propsJS} />
}
```

And this is how you would use it in your Smart Component:

```
import { connect } from 'react-redux'

import { toJS } from './to-js'
import DumbComponent from './dumb.component'

const mapStateToProps = state => {
  return {
    // obj is an Immutable object in Smart Component, but it's converted to a plain
    // JavaScript object by toJS, and so passed to DumbComponent as a pure JavaScript
    // object. Because it's still an Immutable.JS object here in mapStateToProps, though,
    // there is no issue with errant re-renders.
    obj: getImmutableObjectFromStateTree(state)
  }
}
export default connect(mapStateToProps)(toJS(DumbComponent))
```

By converting Immutable.JS objects to plain JavaScript values within a HOC, we achieve Dumb Component portability, but without the performance hits of using `toJS()` in the Smart Component.

Note: if your app requires high performance, you may need to avoid `toJS()` altogether, and so will have to use Immutable.JS in your dumb components. However, for most apps this will not be the case, and the benefits of keeping Immutable.JS out of your dumb components (maintainability, portability and easier testing) will far outweigh any

perceived performance improvements of keeping it in.

In addition, using `toJS` in a Higher Order Component should not cause much, if any, performance degradation, as the component will only be called when the connected component's props change. As with any performance issue, conduct performance checks first before deciding what to optimise.

Further Information

Documentation

- [React: Higher-Order Components](#)

Articles

- [React Higher Order Components in depth](#)

Discussions

- [Reddit: acemarke and cpsubrian comments on Dan Abramov: Redux is not an architecture or design pattern, it is just a library.](#)

Gists

- [cbsubrian: React decorators for redux/react-router/immutable 'smart' components](#)

Use the Immutable Object Formatter Chrome Extension to Aid Debugging

Install the [Immutable Object Formatter](#), and inspect your Immutable.JS data without seeing the noise of Immutable.JS's own object properties.

Further Information

Chrome Extension

- [Immutable Object Formatter](#)

Redux FAQ

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- Why is my component re-rendering too often?
- How can I speed up my `mapStateToProps`?
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- How can I implement authentication in Redux?

Redux FAQ: General

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- [Can Redux only be used with React?](#)
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General

When should I learn Redux?

What to learn can be an overwhelming question for a JavaScript developer. It helps to narrow the range of options by learning one thing at a time and focusing on problems you find in your work. Redux is a pattern for managing application state. If you do not have problems with state management, you might find the benefits of Redux harder to understand. Some UI libraries (like React) have their own state management system. If you are using one of these libraries, especially if you are just learning to use them, we encourage you to learn the capabilities of that built-in system first. It might be all you need to build your application. If your application becomes so complex that you are confused about where state is stored or how state changes, then it is a good time to learn Redux. Experiencing the complexity that Redux seeks to abstract is the best preparation for effectively applying that abstraction to your work.

Further information

Articles

- [Deciding What Not To Learn](#)
- [How to learn web frameworks](#)
- [Redux vs MobX vs Flux vs... Do you even need that?](#)

Discussions

- [Ask HN: Overwhelmed with learning front-end, how do I proceed?](#)
- [Twitter: If you want to teach someone to use an abstraction...](#)
- [Twitter: it was never intended to be learned before...](#)
- [Twitter: Learning Redux before React?](#)
- [Twitter: The first time I used React, people told me I needed Redux...](#)
- [Twitter: This was my experience with Redux...](#)

When should I use Redux?

The need to use Redux should not be taken for granted.

As Pete Hunt, one of the early contributors to React, says:

You'll know when you need Flux. If you aren't sure if you need it, you don't need it.

Similarly, Dan Abramov, one of the creators of Redux, says:

I would like to amend this: don't use Redux until you have problems with vanilla React.

In general, use Redux when you have reasonable amounts of data changing over time, you need a single source of truth, and you find that approaches like keeping everything in a top-level React component's state are no longer sufficient.

However, it's also important to understand that using Redux comes with tradeoffs. It's not designed to be the shortest or fastest way to write code. It's intended to help answer the question "When did a certain slice of state change, and where did the data come from?", with predictable behavior. It does so by asking you to follow specific constraints in your application: store your application's state as plain data, describe changes as plain objects, and handle those changes with pure functions that apply updates immutably. This is often the source of complaints about "boilerplate". These constraints require effort on the part of a developer, but also open up a number of additional possibilities (such as store persistence and synchronization).

In the end, Redux is just a tool. It's a great tool, and there's some great reasons to use it, but there's also reasons you might not want to use it. Make informed decisions about your tools, and understand the tradeoffs involved in each decision.

Further information

Documentation

- [Introduction: Motivation](#)

Articles

- [React How-To](#)
- [You Might Not Need Redux](#)
- [The Case for Flux](#)
- [Some Reasons Why Redux is Useful in a React App](#)

Discussions

- [Twitter: Don't use Redux until...](#)
- [Twitter: Redux is designed to be predictable, not concise](#)
- [Twitter: Redux is useful to eliminate deep prop passing](#)
- [Twitter: Don't use Redux unless you're unhappy with local component state](#)
- [Twitter: You don't need Redux if your data never changes](#)
- [Twitter: If your reducer looks boring, don't use redux](#)
- [Reddit: You don't need Redux if your app just fetches something on a single page](#)
- [Stack Overflow: Why use Redux over Facebook Flux?](#)
- [Stack Overflow: Why should I use Redux in this example?](#)
- [Stack Overflow: What could be the downsides of using Redux instead of Flux?](#)
- [Stack Overflow: When should I add Redux to a React app?](#)
- [Stack Overflow: Redux vs plain React?](#)
- [Twitter: Redux is a platform for developers to build customized state management with reusable things](#)

Can Redux only be used with React?

Redux can be used as a data store for any UI layer. The most common usage is with React and React Native, but there are bindings available for Angular, Angular 2, Vue, Mithril, and more. Redux simply provides a subscription mechanism which can be used by any other code. That said, it is most useful when combined with a declarative view implementation that can infer the UI updates from the state changes, such as React or one of the similar libraries available.

Do I need to have a particular build tool to use Redux?

Redux is originally written in ES6 and transpiled for production into ES5 with Webpack and Babel. You should be able to use it regardless of your JavaScript build process. Redux also offers a UMD build that can be used directly without any build process at all. The [counter-vanilla](#) example demonstrates basic ES5 usage with Redux included as a `<script>` tag. As the relevant pull request says:

The new Counter Vanilla example is aimed to dispel the myth that Redux requires Webpack, React, hot reloading, sagas, action creators, constants, Babel, npm, CSS modules, decorators, fluent Latin, an Egghead subscription, a PhD, or an Exceeds Expectations O.W.L. level.

Nope, it's just HTML, some artisanal `<script>` tags, and plain old DOM manipulation. Enjoy!

Redux FAQ: Reducers

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- [How do I share state between two reducers? Do I have to use combineReducers?](#)
- [Do I have to use the switch statement to handle actions?](#)

Reducers

How do I share state between two reducers? Do I have to use combineReducers ?

The suggested structure for a Redux store is to split the state object into multiple “slices” or “domains” by key, and provide a separate reducer function to manage each individual data slice. This is similar to how the standard Flux pattern has multiple independent stores, and Redux provides the `combineReducers` utility function to make this pattern easier. However, it’s important to note that `combineReducers` is *not* required—it is simply a utility function for the common use case of having a single reducer function per state slice, with plain JavaScript objects for the data.

Many users later want to try to share data between two reducers, but find that `combineReducers` does not allow them to do so. There are several approaches that can be used:

- If a reducer needs to know data from another slice of state, the state tree shape may need to be reorganized so that a single reducer is handling more of the data.
- You may need to write some custom functions for handling some of these actions. This may require replacing `combineReducers` with your own top-level reducer function. You can also use a utility such as [reduce-reducers](#) to run `combineReducers` to handle most actions, but also run a more specialized reducer for specific actions that cross state slices.
- [Async action creators](#) such as [redux-thunk](#) have access to the entire state through `getState()`. An action creator can retrieve additional data from the state and put it in an action, so that each reducer has enough information to update its own state slice.

In general, remember that reducers are just functions—you can organize them and subdivide them any way you want, and you are encouraged to break them down into smaller, reusable functions (“reducer composition”). While you do so, you may pass a custom third argument from a parent reducer if a child reducer needs additional data to calculate its next state. You just need to make sure that together they follow the basic rules of reducers: `(state, action) => newState`, and update state immutably rather than mutating it directly.

Further information

Documentation

- [API: combineReducers](#)
- [Recipes: Structuring Reducers](#)

Discussions

- [#601: A concern on combineReducers, when an action is related to multiple reducers](#)
- [#1400: Is passing top-level state object to branch reducer an anti-pattern?](#)
- [Stack Overflow: Accessing other parts of the state when using combined reducers?](#)
- [Stack Overflow: Reducing an entire subtree with redux combineReducers](#)

- [Sharing State Between Redux Reducers](#)

Do I have to use the `switch` statement to handle actions?

No. You are welcome to use any approach you'd like to respond to an action in a reducer. The `switch` statement is the most common approach, but it's fine to use `if` statements, a lookup table of functions, or to create a function that abstracts this away. In fact, while Redux does require that action objects contain a `type` field, your reducer logic doesn't even have to rely on that to handle the action. That said, the standard approach is definitely using a `switch` statement or a lookup table based on `type`.

Further information

Documentation

- [Recipes: Reducing Boilerplate](#)
- [Recipes: Structuring Reducers - Splitting Reducer Logic](#)

Discussions

- [#883: take away the huge switch block](#)
- [#1167: Reducer without switch](#)

Redux FAQ: Organizing State

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- Do I have to put all my state into Redux? Should I ever use React's `useState()`?
- Can I put functions, promises, or other non-serializable items in my store state?
- How do I organize nested or duplicate data in my state?

Organizing State

Do I have to put all my state into Redux? Should I ever use React's `useState()` ?

There is no “right” answer for this. Some users prefer to keep every single piece of data in Redux, to maintain a fully serializable and controlled version of their application at all times. Others prefer to keep non-critical or UI state, such as “is this dropdown currently open”, inside a component’s internal state.

Using local component state is fine. As a developer, it is *your* job to determine what kinds of state make up your application, and where each piece of state should live. Find a balance that works for you, and go with it.

Some common rules of thumb for determining what kind of data should be put into Redux:

- Do other parts of the application care about this data?
- Do you need to be able to create further derived data based on this original data?
- Is the same data being used to drive multiple components?
- Is there value to you in being able to restore this state to a given point in time (ie, time travel debugging)?
- Do you want to cache the data (ie, use what’s in state if it’s already there instead of re-requesting it)?

There are a number of community packages that implement various approaches for storing per-component state in a Redux store instead, such as `redux-ui`, `redux-component`, `redux-react-local`, and more. It’s also possible to apply Redux’s principles and concept of reducers to the task of updating local component state as well, along the lines of `this.setState(previousState) => reducer(previousState, someAction) .`

Further information

Articles

- You Might Not Need Redux
- Finding `state` 's place with React and Redux
- A Case for `useState`
- How to handle state in React: the missing FAQ
- Where to Hold React Component Data: state, store, static, and this
- The 5 Types of React Application State

Discussions

- #159: Investigate using Redux for pseudo-local component state
- #1098: Using Redux in reusable React component
- #1287: How to choose between Redux’s store and React’s state?
- #1385: What are the disadvantages of storing all your state in a single immutable atom?
- Twitter: Should I keep something in React component state?

- Twitter: Using a reducer to update a component
- React Forums: Redux and global state vs local state
- Reddit: "When should I put something into my Redux store?"
- Stack Overflow: Why is state all in one place, even state that isn't global?
- Stack Overflow: Should all component state be kept in Redux store?

Libraries

- [Redux Addons Catalog: Component State](#)

Can I put functions, promises, or other non-serializable items in my store state?

It is highly recommended that you only put plain serializable objects, arrays, and primitives into your store. It's *technically* possible to insert non-serializable items into the store, but doing so can break the ability to persist and rehydrate the contents of a store, as well as interfere with time-travel debugging.

If you are okay with things like persistence and time-travel debugging potentially not working as intended, then you are totally welcome to put non-serializable items into your Redux store. Ultimately, it's *your* application, and how you implement it is up to you. As with many other things about Redux, just be sure you understand what tradeoffs are involved.

Further information

Discussions

- [#1248: Is it ok and possible to store a react component in a reducer?](#)
- [#1279: Have any suggestions for where to put a Map Component in Flux?](#)
- [#1390: Component Loading](#)
- [#1407: Just sharing a great base class](#)
- [#1793: React Elements in Redux State](#)

How do I organize nested or duplicate data in my state?

Data with IDs, nesting, or relationships should generally be stored in a "normalized" fashion: each object should be stored once, keyed by ID, and other objects that reference it should only store the ID rather than a copy of the entire object. It may help to think of parts of your store as a database, with individual "tables" per item type. Libraries such as [normalizr](#) and [redux-form](#) can provide help and abstractions in managing normalized data.

Further information

Documentation

- [Advanced: Async Actions](#)
- [Examples: Real World example](#)
- [Recipes: Structuring Reducers - Prerequisite Concepts](#)
- [Recipes: Structuring Reducers - Normalizing State Shape](#)
- [Examples: Tree View](#)

Articles

- [High-Performance Redux](#)
- [Querying a Redux Store](#)

Discussions

- #316: How to create nested reducers?
- #815: Working with Data Structures
- #946: Best way to update related state fields with split reducers?
- #994: How to cut the boilerplate when updating nested entities?
- #1255: Normalizr usage with nested objects in React/Redux
- #1269: Add tree view example
- #1824: Normalising state and garbage collection
- Twitter: state shape should be normalized
- Stack Overflow: How to handle tree-shaped entities in Redux reducers?
- Stack Overflow: How to optimize small updates to props of nested components in React + Redux?

Redux FAQ: Store Setup

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- Can or should I create multiple stores? Can I import my store directly, and use it in components myself?
- Is it OK to have more than one middleware chain in my store enhancer? What is the difference between next and dispatch in a middleware function?
- How do I subscribe to only a portion of the state? Can I get the dispatched action as part of the subscription?

Store Setup

Can or should I create multiple stores? Can I import my store directly, and use it in components myself?

The original Flux pattern describes having multiple “stores” in an app, each one holding a different area of domain data. This can introduce issues such as needing to have one store “`waitFor`” another store to update. This is not necessary in Redux because the separation between data domains is already achieved by splitting a single reducer into smaller reducers.

As with several other questions, it is *possible* to create multiple distinct Redux stores in a page, but the intended pattern is to have only a single store. Having a single store enables using the Redux DevTools, makes persisting and rehydrating data simpler, and simplifies the subscription logic.

Some valid reasons for using multiple stores in Redux might include:

- Solving a performance issue caused by too frequent updates of some part of the state, when confirmed by profiling the app.
- Isolating a Redux app as a component in a bigger application, in which case you might want to create a store per root component instance.

However, creating new stores shouldn't be your first instinct, especially if you come from a Flux background. Try reducer composition first, and only use multiple stores if it doesn't solve your problem.

Similarly, while you *can* reference your store instance by importing it directly, this is not a recommended pattern in Redux. If you create a store instance and export it from a module, it will become a singleton. This means it will be harder to isolate a Redux app as a component of a larger app, if this is ever necessary, or to enable server rendering, because on the server you want to create separate store instances for every request.

With [React Redux](#), the wrapper classes generated by the `connect()` function do actually look for `props.store` if it exists, but it's best if you wrap your root component in `<Provider store={store}>` and let React Redux worry about passing the store down. This way components don't need to worry about importing a store module, and isolating a Redux app or enabling server rendering is much easier to do later.

Further information

Documentation

- [API: Store](#)

Discussions

- [#1346: Is it bad practice to just have a 'stores' directory?](#)

- Stack Overflow: Redux multiple stores, why not?
- Stack Overflow: Accessing Redux state in an action creator
- Gist: Breaking out of Redux paradigm to isolate apps

Is it OK to have more than one middleware chain in my store enhancer? What is the difference between `next` and `dispatch` in a middleware function?

Redux middleware act like a linked list. Each middleware function can either call `next(action)` to pass an action along to the next middleware in line, call `dispatch(action)` to restart the processing at the beginning of the list, or do nothing at all to stop the action from being processed further.

This chain of middleware is defined by the arguments passed to the `applyMiddleware` function used when creating a store. Defining multiple chains will not work correctly, as they would have distinctly different `dispatch` references and the different chains would effectively be disconnected.

Further information

Documentation

- Advanced: Middleware
- API: `applyMiddleware`

Discussions

- #1051: Shortcomings of the current `applyMiddleware` and composing `createStore`
- Understanding Redux Middleware
- Exploring Redux Middleware

How do I subscribe to only a portion of the state? Can I get the dispatched action as part of the subscription?

Redux provides a single `store.subscribe` method for notifying listeners that the store has updated. Listener callbacks do not receive the current state as an argument—it is simply an indication that *something* has changed. The subscriber logic can then call `getState()` to get the current state value.

This API is intended as a low-level primitive with no dependencies or complications, and can be used to build higher-level subscription logic. UI bindings such as React Redux can create a subscription for each connected component. It is also possible to write functions that can intelligently compare the old state vs the new state, and execute additional logic if certain pieces have changed. Examples include `redux-watch`, `redux-subscribe` and `redux-subscriber` which offer different approaches to specifying subscriptions and handling changes.

The new state is not passed to the listeners in order to simplify implementing store enhancers such as the Redux DevTools. In addition, subscribers are intended to react to the state value itself, not the action. Middleware can be used if the action is important and needs to be handled specifically.

Further information

Documentation

- Basics: Store
- API: Store

Discussions

- #303: subscribe API with state as an argument
- #580: Is it possible to get action and state in `store.subscribe`?

- #922: Proposal: add subscribe to middleware API
- #1057: subscribe listener can get action param?
- #1300: Redux is great but major feature is missing

Libraries

- [Redux Addons Catalog: Store Change Subscriptions](#)

Redux FAQ: Actions

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- Why should `type` be a string, or at least serializable? Why should my action types be constants?
- Is there always a one-to-one mapping between reducers and actions?
- How can I represent “side effects” such as AJAX calls? Why do we need things like “action creators”, “thunks”, and “middleware” to do async behavior?
- Should I dispatch multiple actions in a row from one action creator?

Actions

Why should `type` be a string, or at least serializable? Why should my action types be constants?

As with state, serializable actions enable several of Redux's defining features, such as time travel debugging, and recording and replaying actions. Using something like a `Symbol` for the `type` value or using `instanceof` checks for actions themselves would break that. Strings are serializable and easily self-descriptive, and so are a better choice. Note that it *is* okay to use `Symbols`, `Promises`, or other non-serializable values in an action if the action is intended for use by middleware. Actions only need to be serializable by the time they actually reach the store and are passed to the reducers.

We can't reliably enforce serializable actions for performance reasons, so Redux only checks that every action is a plain object, and that the `type` is defined. The rest is up to you, but you might find that keeping everything serializable helps debug and reproduce issues.

Encapsulating and centralizing commonly used pieces of code is a key concept in programming. While it is certainly possible to manually create action objects everywhere, and write each `type` value by hand, defining reusable constants makes maintaining code easier. If you put constants in a separate file, you can [check your `import` statements against typos](#) so you can't accidentally use the wrong string.

Further information

Documentation

- [Reducing Boilerplate](#)

Discussion

- [#384: Recommend that Action constants be named in the past tense](#)
- [#628: Solution for simple action creation with less boilerplate](#)
- [#1024: Proposal: Declarative reducers](#)
- [#1167: Reducer without switch](#)
- [Stack Overflow: Why do you need 'Actions' as data in Redux?](#)
- [Stack Overflow: What is the point of the constants in Redux?](#)

Is there always a one-to-one mapping between reducers and actions?

No. We suggest you write independent small reducer functions that are each responsible for updates to a specific slice of state. We call this pattern “reducer composition”. A given action could be handled by all, some, or none of them. This keeps components decoupled from the actual data changes, as one action may affect different parts of the state tree, and there is no need for the component to be aware of this. Some users do choose to bind them more tightly together, such as the “ducks” file structure, but there is definitely no one-to-one mapping by default, and you should break out of such a paradigm any time you feel you want to handle an action in many reducers.

Further information

Documentation

- [Basics: Reducers](#)
- [Recipes: Structuring Reducers](#)

Discussions

- [Twitter: most common Redux misconception](#)
- [#1167: Reducer without switch](#)
- [Reduxible #8: Reducers and action creators aren't a one-to-one mapping](#)
- [Stack Overflow: Can I dispatch multiple actions without Redux Thunk middleware?](#)

How can I represent “side effects” such as AJAX calls? Why do we need things like “action creators”, “thunks”, and “middleware” to do async behavior?

This is a long and complex topic, with a wide variety of opinions on how code should be organized and what approaches should be used.

Any meaningful web app needs to execute complex logic, usually including asynchronous work such as making AJAX requests. That code is no longer purely a function of its inputs, and the interactions with the outside world are known as “[side effects](#)”

Redux is inspired by functional programming, and out of the box, has no place for side effects to be executed. In particular, reducer functions *must* always be pure functions of `(state, action) => newState`. However, Redux’s middleware makes it possible to intercept dispatched actions and add additional complex behavior around them, including side effects.

In general, Redux suggests that code with side effects should be part of the action creation process. While that logic *can* be performed inside of a UI component, it generally makes sense to extract that logic into a reusable function so that the same logic can be called from multiple places—in other words, an action creator function.

The simplest and most common way to do this is to add the [Redux Thunk](#) middleware that lets you write action creators with more complex and asynchronous logic. Another widely-used method is [Redux Saga](#) which lets you write more synchronous-looking code using generators, and can act like “background threads” or “daemons” in a Redux app. Yet another approach is [Redux Loop](#), which inverts the process by allowing your reducers to declare side effects in response to state changes and have them executed separately. Beyond that, there are *many* other community-developed libraries and ideas, each with their own take on how side effects should be managed.

Further information

Documentation

- [Advanced: Async Actions](#)
- [Advanced: Async Flow](#)
- [Advanced: Middleware](#)

Articles

- [Redux Side-Effects and You](#)
- [Pure functionality and side effects in Redux](#)
- [From Flux to Redux: Async Actions the easy way](#)
- [React/Redux Links: "Redux Side Effects" category](#)
- [Gist: Redux-Thunk examples](#)

Discussions

- [#291: Trying to put API calls in the right place](#)
- [#455: Modeling side effects](#)
- [#533: Simpler introduction to async action creators](#)
- [#569: Proposal: API for explicit side effects](#)
- [#1139: An alternative side effect model based on generators and sagas](#)
- [Stack Overflow: Why do we need middleware for async flow in Redux?](#)
- [Stack Overflow: How to dispatch a Redux action with a timeout?](#)
- [Stack Overflow: Where should I put synchronous side effects linked to actions in redux?](#)
- [Stack Overflow: How to handle complex side-effects in Redux?](#)
- [Stack Overflow: How to unit test async Redux actions to mock ajax response](#)
- [Stack Overflow: How to fire AJAX calls in response to the state changes with Redux?](#)
- [Reddit: Help performing Async API calls with Redux-Promise Middleware.](#)
- [Twitter: possible comparison between sagas, loops, and other approaches](#)

Should I dispatch multiple actions in a row from one action creator?

There's no specific rule for how you should structure your actions. Using an async middleware like Redux Thunk certainly enables scenarios such as dispatching multiple distinct but related actions in a row, dispatching actions to represent progression of an AJAX request, dispatching actions conditionally based on state, or even dispatching an action and checking the updated state immediately afterwards.

In general, ask if these actions are related but independent, or should actually be represented as one action. Do what makes sense for your own situation but try to balance the readability of reducers with readability of the action log. For example, an action that includes the whole new state tree would make your reducer a one-liner, but the downside is now you have no history of *why* the changes are happening, so debugging gets really difficult. On the other hand, if you emit actions in a loop to keep them granular, it's a sign that you might want to introduce a new action type that is handled in a different way.

Try to avoid dispatching several times synchronously in a row in the places where you're concerned about performance. There are a number of addons and approaches that can batch up dispatches as well.

Further information

Documentation

- [FAQ: Performance - Reducing Update Events](#)

Articles

- [Idiomatic Redux: Thoughts on Thunks, Sagas, Abstraction, and Reusability](#)

Discussions

- [#597: Valid to dispatch multiple actions from an event handler?](#)
- [#959: Multiple actions one dispatch?](#)
- [Stack Overflow: Should I use one or several action types to represent this async action?](#)

- Stack Overflow: Do events and actions have a 1:1 relationship in Redux?
- Stack Overflow: Should actions be handled by reducers to related actions or generated by action creators themselves?
- Twitter: "Good thread on the problems with Redux Thunk..."

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- [Why is immutability required by Redux?](#)
- [Why does Redux's use of shallow equality checking require immutability?](#)
 - [How do Shallow and Deep Equality Checking differ?](#)
 - [How does Redux use shallow equality checking?](#)
 - [How does `combineReducers` use shallow equality checking?](#)
 - [How does React-Redux use shallow equality checking?](#)
 - [How does React-Redux use shallow equality checking to determine whether a component needs re-rendering?](#)
 - [Why will shallow equality checking not work with mutable objects?](#)
 - [Does shallow equality checking with a mutable object cause problems with Redux?](#)
 - [Why does a reducer mutating the state prevent React-Redux from re-rendering a wrapped component?](#)
 - [Why does a selector mutating and returning a persistent object to `mapStateToProps` prevent React-Redux from re-rendering a wrapped component?](#)
 - [How does immutability enable a shallow check to detect object mutations?](#)
- [How can immutability in your reducers cause components to render unnecessarily?](#)
- [How can immutability in `mapStateToProps` cause components to render unnecessarily?](#)
- [What approaches are there for handling data immutably? Do I have to use Immutable.js?](#)
- [What are the issues with using JavaScript for immutable operations?](#)

What are the benefits of immutability?

Immutability can bring increased performance to your app, and leads to simpler programming and debugging, as data that never changes is easier to reason about than data that is free to be changed arbitrarily throughout your app.

In particular, immutability in the context of a Web app enables sophisticated change detection techniques to be implemented simply and cheaply, ensuring the computationally expensive process of updating the DOM occurs only when it absolutely has to (a cornerstone of React's performance improvements over other libraries).

Further information

Articles

- [Introduction to Immutable.js and Functional Programming Concepts](#)
- [JavaScript Immutability presentation \(PDF - see slide 12 for benefits\)](#)
- [Immutable.js - Immutable Collections for JavaScript](#)
- [React: Optimizing Performance](#)
- [JavaScript Application Architecture On The Road To 2015](#)

Why is immutability required by Redux?

- Both Redux and React-Redux employ [shallow equality checking](#). In particular:
 - Redux's `combineReducers` utility [shallowly checks for reference changes](#) caused by the reducers that it calls.
 - React-Redux's `connect` method generates components that [shallowly check reference changes to the root](#)

`state`, and the return values from the `mapStateToProps` function to see if the wrapped components actually need to re-render. Such [shallow checking requires immutability](#) to function correctly.

- Immutable data management ultimately makes data handling safer.
- Time-travel debugging requires that reducers be pure functions with no side effects, so that you can correctly jump between different states.

Further Information

Documentation

- [Recipes: Prerequisite Reducer Concepts](#)

Discussions

- [Reddit: Why Redux Needs Reducers To Be Pure Functions](#)

Why does Redux's use of shallow equality checking require immutability?

Redux's use of shallow equality checking requires immutability if any connected components are to be updated correctly. To see why, we need to understand the difference between shallow and deep equality checking in JavaScript.

How do shallow and deep equality checking differ?

Shallow equality checking (or *reference equality*) simply checks that two different *variables* reference the same object; in contrast, deep equality checking (or *value equality*) must check every *value* of two objects' properties.

A shallow equality check is therefore as simple (and as fast) as `a === b`, whereas a deep equality check involves a recursive traversal through the properties of two objects, comparing the value of each property at each step.

It's for this improvement in performance that Redux uses shallow equality checking.

Further Information

Articles

- [Pros and Cons of using immutability with React.js](#)

How does Redux use shallow equality checking?

Redux uses shallow equality checking in its `combineReducers` function to return either a new mutated copy of the root state object, or, if no mutations have been made, the current root state object.

Further Information

Documentation

- [API: combineReducers](#)

How does `combineReducers` use shallow equality checking?

The [suggested structure](#) for a Redux store is to split the state object into multiple "slices" or "domains" by key, and provide a separate reducer function to manage each individual data slice.

`combineReducers` makes working with this style of structure easier by taking a `reducers` argument that's defined as a hash table comprising a set of key/value pairs, where each key is the name of a state slice, and the corresponding value is the reducer function that will act on it.

So, for example, if your state shape is `{ todos, counter }`, the call to `combineReducers` would be:

```
combineReducers({ todos: myTodosReducer, counter: myCounterReducer })
```

where:

- the keys `todos` and `counter` each refer to a separate state slice;
- the values `myTodosReducer` and `myCounterReducer` are reducer functions, with each acting on the state slice identified by the respective key.

`combineReducers` iterates through each of these key/value pairs. For each iteration, it:

- creates a reference to the current state slice referred to by each key;
- calls the appropriate reducer and passes it the slice;
- creates a reference to the possibly-mutated state slice that's returned by the reducer.

As it continues through the iterations, `combineReducers` will construct a new state object with the state slices returned from each reducer. This new state object may or may not be different from the current state object. It is here that `combineReducers` uses shallow equality checking to determine whether the state has changed.

Specifically, at each stage of the iteration, `combineReducers` performs a shallow equality check on the current state slice and the state slice returned from the reducer. If the reducer returns a new object, the shallow equality check will fail, and `combineReducers` will set a `hasChanged` flag to true.

After the iterations have completed, `combineReducers` will check the state of the `hasChanged` flag. If it's true, the newly-constructed state object will be returned. If it's false, the *current* state object is returned.

This is worth emphasising: *If the reducers all return the same state object passed to them, then `combineReducers` will return the current root state object, not the newly updated one.*

Further Information

Documentation

- [API: combineReducers](#)
- [Redux FAQ - How do I share state between two reducers? do I have to use `combineReducers`?](#)

Video

- [Egghead.io: Redux: Implementing combineReducers\(\) from Scratch](#)

How does React-Redux use shallow equality checking?

React-Redux uses shallow equality checking to determine whether the component it's wrapping needs to be re-rendered.

To do this, it assumes that the wrapped component is pure; that is, that the component will produce the [same results given the same props and state](#).

By assuming the wrapped component is pure, it need only check whether the root state object or the values returned from `mapStateToProps` have changed. If they haven't, the wrapped component does not need re-rendering.

It detects a change by keeping a reference to the root state object, and a reference to *each value* in the props object that's returned from the `mapStateToProps` function.

It then runs a shallow equality check on its reference to the root state object and the state object passed to it, and a separate series of shallow checks on each reference to the props object's values and those that are returned from running the `mapStateToProps` function again.

Further Information

Documentation

- [React-Redux Bindings](#)

Articles

- [API: React-Redux's connect function and `mapStateToProps`](#)
- [Troubleshooting: My views aren't updating when something changes outside of Redux](#)

Why does React-Redux shallowly check each value within the props object returned from `mapStateToProps` ?

React-Redux performs a shallow equality check on each *value* within the props object, not on the props object itself.

It does so because the props object is actually a hash of prop names and their values (or selector functions that are used to retrieve or generate the values), such as in this example:

```
function mapStateToProps(state) {
  return {
    todos: state.todos, // prop value
    visibleTodos: getVisibleTodos(state) // selector
  }
}

export default connect(mapStateToProps)(TodoApp)
```

As such, a shallow equality check of the props object returned from repeated calls to `mapStateToProps` would always fail, as a new object would be returned each time.

React-Redux therefore maintains separate references to each *value* in the returned props object.

Further Information

Articles

- [React.js pure render performance anti-pattern](#)

How does React-Redux use shallow equality checking to determine whether a component needs re-rendering?

Each time React-Redux's `connect` function is called, it will perform a shallow equality check on its stored reference to the root state object, and the current root state object passed to it from the store. If the check passes, the root state object has not been updated, and so there is no need to re-render the component, or even call `mapStateToProps`.

If the check fails, however, the root state object *has* been updated, and so `connect` will call `mapStateToProps` to see if the props for the wrapped component have been updated.

It does this by performing a shallow equality check on each value within the object individually, and will only trigger a re-render if one of those checks fails.

In the example below, if `state.todos` and the value returned from `getVisibleTodos()` do not change on successive calls to `connect`, then the component will not re-render .

```

function mapStateToProps(state) {
  return {
    todos: state.todos, // prop value
    visibleTodos: getVisibleTodos(state) // selector
  }
}

export default connect(mapStateToProps)(TodoApp)

```

Conversely, in this next example (below), the component will *always* re-render, as the value of `todos` is always a new object, regardless of whether or not its values change:

```

// AVOID - will always cause a re-render
function mapStateToProps(state) {
  return {
    // todos always references a newly-created object
    todos: {
      all: state.todos,
      visibleTodos: getVisibleTodos(state)
    }
  }
}

export default connect(mapStateToProps)(TodoApp)

```

If the shallow equality check fails between the new values returned from `mapStateToProps` and the previous values that React-Redux kept a reference to, then a re-rendering of the component will be triggered.

Further Information

Articles

- [Practical Redux, Part 6: Connected Lists, Forms, and Performance](#)
- [React.js Pure Render Performance Anti-Pattern](#)
- [High Performance Redux Apps](#)

Discussions

- [#1816: Component connected to state with `mapStateToProps`](#)
- [#300: Potential `connect\(\)` optimization](#)

Why will shallow equality checking not work with mutable objects?

Shallow equality checking cannot be used to detect if a function mutates an object passed into it if that object is mutable.

This is because two variables that reference the same object will *always* be equal, regardless of whether the object's values changes or not, as they're both referencing the same object. Thus, the following will always return true:

```

function mutateObj(obj) {
  obj.key = 'newValue'
  return obj
}

const param = { key: 'originalValue' }
const returnVal = mutateObj(param)

param === returnVal
//> true

```

The shallow check of `param` and `returnValue` simply checks whether both variables reference the same object, which they do. `mutateObj()` may return a mutated version of `obj`, but it's still the same object as that passed in. The fact that its values have been changed within `mutateObj` matters not at all to a shallow check.

Further Information

Articles

- [Pros and Cons of using immutability with React.js](#)

Does shallow equality checking with a mutable object cause problems with Redux?

Shallow equality checking with a mutable object will not cause problems with Redux, but [it will cause problems with libraries that depend on the store, such as React-Redux](#).

Specifically, if the state slice passed to a reducer by `combineReducers` is a mutable object, the reducer can modify it directly and return it.

If it does, the shallow equality check that `combineReducers` performs will always pass, as the values of the state slice returned by the reducer may have been mutated, but the object itself has not - it's still the same object that was passed to the reducer.

Accordingly, `combineReducers` will not set its `hasChanged` flag, even though the state has changed. If none of the other reducers return a new, updated state slice, the `hasChanged` flag will remain set to false, causing `combineReducers` to return the *existing* root state object.

The store will still be updated with the new values for the root state, but because the root state object itself is still the same object, libraries that bind to Redux, such as React-Redux, will not be aware of the state's mutation, and so will not trigger a wrapped component's re-rendering.

Further Information

Documentation

- [Recipes: Immutable Update Patterns](#)
- [Troubleshooting: Never mutate reducer arguments](#)

Why does a reducer mutating the state prevent React-Redux from re-rendering a wrapped component?

If a Redux reducer directly mutates, and returns, the state object passed into it, the values of the root state object will change, but the object itself will not.

Because React-Redux performs a shallow check on the root state object to determine if its wrapped components need re-rendering or not, it will not be able to detect the state mutation, and so will not trigger a re-rendering.

Further Information

Documentation

- [Troubleshooting: My views aren't updating when something changes outside of Redux](#)

Why does a selector mutating and returning a persistent object to `mapStateToProps` prevent React-Redux from re-rendering a wrapped component?

If one of the values of the props object returned from `mapStateToProps` is an object that persists across calls to `connect` (such as, potentially, the root state object), yet is directly mutated and returned by a selector function, React-Redux will not be able to detect the mutation, and so will not trigger a re-render of the wrapped component.

As we've seen, the values in the mutable object returned by the selector function may have changed, but the object itself has not, and shallow equality checking only compares the objects themselves, not their values.

For example, the following `mapStateToProps` function will never trigger a re-render:

```
// State object held in the Redux store
const state = {
  user: {
    accessCount: 0,
    name: 'keith'
  }
}

// Selector function
const getUser = state => {
  ++state.user.accessCount // mutate the state object
  return state
}

// mapStateToProps
const mapStateToProps = state => ({
  // The object returned from getUser() is always
  // the same object, so this wrapped
  // component will never re-render, even though it's been
  // mutated
  userRecord: getUser(state)
})

const a = mapStateToProps(state)
const b = mapStateToProps(state)

a.userRecord === b.userRecord
//> true
```

Note that, conversely, if an *immutable* object is used, the component may re-render when it should not.

Further Information

Articles

- [Practical Redux, Part 6: Connected Lists, Forms, and Performance](#)

Discussions

- [#1948: Is `getMAPPEDItems` an anti-pattern in `mapStateToProps`?](#)

How does immutability enable a shallow check to detect object mutations?

If an object is immutable, any changes that need to be made to it within a function must be made to a *copy* of the object.

This mutated copy is a *separate* object from that passed into the function, and so when it is returned, a shallow check will identify it as being a different object from that passed in, and so will fail.

Further Information

Articles

- [Pros and Cons of using immutability with React.js](#)

How can immutability in your reducers cause components to render unnecessarily?

You cannot mutate an immutable object; instead, you must mutate a copy of it, leaving the original intact.

That's perfectly OK when you mutate the copy, but in the context of a reducer, if you return a copy that *hasn't* been mutated, Redux's `combineReducers` function will still think that the state needs to be updated, as you're returning an entirely different object from the state slice object that was passed in.

`combineReducers` will then return this new root state object to the store. The new object will have the same values as the current root state object, but because it's a different object, it will cause the store to be updated, which will ultimately cause all connected components to be re-rendered unnecessarily.

To prevent this from happening, you must *always return the state slice object that's passed into a reducer if the reducer does not mutate the state*.

Further Information

Articles

- [React.js pure render performance anti-pattern](#)
- [Building Efficient UI with React and Redux](#)

How can immutability in `mapStateToProps` cause components to render unnecessarily?

Certain immutable operations, such as an Array filter, will always return a new object, even if the values themselves have not changed.

If such an operation is used as a selector function in `mapStateToProps`, the shallow equality check that React-Redux performs on each value in the props object that's returned will always fail, as the selector is returning a new object each time.

As such, even though the values of that new object have not changed, the wrapped component will always be re-rendered,

For example, the following will always trigger a re-render:

```
// A JavaScript array's 'filter' method treats the array as immutable,
// and returns a filtered copy of the array.
const getVisibleTodos = todos => todos.filter(t => !t.completed)

const state = {
  todos: [
    {
      text: 'do todo 1',
      completed: false
    },
    {
      text: 'do todo 2',
      completed: true
    }
  ]
}
```

```
const mapStateToProps = state => ({
  // getVisibleTodos() always returns a new array, and so the
  // 'visibleTodos' prop will always reference a different array,
  // causing the wrapped component to re-render, even if the array's
  // values haven't changed
  visibleTodos: getVisibleTodos(state.todos)
})

const a = mapStateToProps(state)
// Call mapStateToProps(state) again with exactly the same arguments
const b = mapStateToProps(state)

a.visibleTodos
//> { "completed": false, "text": "do todo 1" }

b.visibleTodos
//> { "completed": false, "text": "do todo 1" }

a.visibleTodos === b.visibleTodos
//> false
```

Note that, conversely, if the values in your props object refer to mutable objects, your component may not render when it should.

Further Information

Articles

- [React.js pure render performance anti-pattern](#)
- [Building Efficient UI with React and Redux](#)
- [ImmutableJS: worth the price?](#)

What approaches are there for handling data immutably? Do I have to use Immutable.JS?

You do not need to use Immutable.JS with Redux. Plain JavaScript, if written correctly, is perfectly capable of providing immutability without having to use an immutable-focused library.

However, guaranteeing immutability with JavaScript is difficult, and it can be easy to mutate an object accidentally, causing bugs in your app that are extremely difficult to locate. For this reason, using an immutable update utility library such as Immutable.JS can significantly improve the reliability of your app, and make your app's development much easier.

Further Information

Discussions

- [#1185: Question: Should I use immutable data structures?](#)
- [Introduction to Immutable.js and Functional Programming Concepts](#)

What are the issues with using plain JavaScript for immutable operations?

JavaScript was never designed to provide guaranteed immutable operations. Accordingly, there are several issues you need to be aware of if you choose to use it for your immutable operations in your Redux app.

Accidental Object Mutation

With JavaScript, you can accidentally mutate an object (such as the Redux state tree) quite easily without realising it. For example, updating deeply nested properties, creating a new *reference* to an object instead of a new object, or performing a shallow copy rather than a deep copy, can all lead to inadvertent object mutations, and can trip up even the most experienced JavaScript coder.

To avoid these issues, ensure you follow the recommended [immutable update patterns for ES6](#).

Verbose Code

Updating complex nested state trees can lead to verbose code that is tedious to write and difficult to debug.

Poor Performance

Operating on JavaScript objects and arrays in an immutable way can be slow, particularly as your state tree grows larger.

Remember, to change an immutable object, you must mutate a *copy* of it, and copying large objects can be slow as every property must be copied.

In contrast, immutable libraries such as Immutable.JS can employ sophisticated optimization techniques such as [structural sharing](#), which effectively returns a new object that reuses much of the existing object being copied from.

For copying very large objects, [plain JavaScript can be over 100 times slower](#) than an optimized immutable library.

Further Information

Documentation

- [Immutable Update Patterns for ES6](#)

Articles

- [Immutable.js, persistent data structures and structural sharing](#)
- [A deep dive into Clojure's data structures](#)
- [Introduction to Immutable.js and Functional Programming Concepts](#)
- [JavaScript and Immutability](#)
- [Immutable Javascript using ES6 and beyond](#)
- [Pros and Cons of using immutability with React.js - React Kung Fu](#)

Redux FAQ: Code Structure

Table of Contents

- What should my file structure look like? How should I group my action creators and reducers in my project?
Where should my selectors go?
- How should I split my logic between reducers and action creators? Where should my “business logic” go?
- Why should I use action creators?

Code Structure

What should my file structure look like? How should I group my action creators and reducers in my project? Where should my selectors go?

Since Redux is just a data store library, it has no direct opinion on how your project should be structured. However, there are a few common patterns that most Redux developers tend to use:

- Rails-style: separate folders for “actions”, “constants”, “reducers”, “containers”, and “components”
- Domain-style: separate folders per feature or domain, possibly with sub-folders per file type
- “Ducks”: similar to domain style, but explicitly tying together actions and reducers, often by defining them in the same file

It's generally suggested that selectors are defined alongside reducers and exported, and then reused elsewhere (such as in `mapStateToProps` functions, in async action creators, or sagas) to colocate all the code that knows about the actual shape of the state tree in the reducer files.

While it ultimately doesn't matter how you lay out your code on disk, it's important to remember that actions and reducers shouldn't be considered in isolation. It's entirely possible (and encouraged) for a reducer defined in one folder to respond to an action defined in another folder.

Further information

Documentation

- [FAQ: Actions - "1:1 mapping between reducers and actions?"](#)

Articles

- [How to Scale React Applications](#) (accompanying talk: [Scaling React Applications](#))
- [Redux Best Practices](#)
- [Rules For Structuring \(Redux\) Applications](#)
- [A Better File Structure for React/Redux Applications](#)
- [Organizing Large React Applications](#)
- [Four Strategies for Organizing Code](#)
- [Encapsulating the Redux State Tree](#)
- [Redux Reducer/Selector Asymmetry](#)
- [Modular Reducers and Selectors](#)
- [My journey towards a maintainable project structure for React/Redux](#)
- [React/Redux Links: Architecture - Project File Structure](#)

Discussions

- #839: Emphasize defining selectors alongside reducers
- #943: Reducer querying
- React Boilerplate #27: Application Structure
- Stack Overflow: How to structure Redux components/containers
- Twitter: There is no ultimate file structure for Redux

How should I split my logic between reducers and action creators? Where should my “business logic” go?

There's no single clear answer to exactly what pieces of logic should go in a reducer or an action creator. Some developers prefer to have “fat” action creators, with “thin” reducers that simply take the data in an action and blindly merge it into the corresponding state. Others try to emphasize keeping actions as small as possible, and minimize the usage of `getState()` in an action creator. (For purposes of this question, other async approaches such as sagas and observables fall in the “action creator” category.)

There are some potential benefits from putting more logic into your reducers. It's likely that the action types would be more semantic and more meaningful (such as `"USER_UPDATED"` instead of `"SET_STATE"`). In addition, having more logic in reducers means that more functionality will be affected by time travel debugging.

This comment sums up the dichotomy nicely:

Now, the problem is what to put in the action creator and what in the reducer, the choice between fat and thin action objects. If you put all the logic in the action creator, you end up with fat action objects that basically declare the updates to the state. Reducers become pure, dumb, add-this, remove that, update these functions. They will be easy to compose. But not much of your business logic will be there. If you put more logic in the reducer, you end up with nice, thin action objects, most of your data logic in one place, but your reducers are harder to compose since you might need info from other branches. You end up with large reducers or reducers that take additional arguments from higher up in the state.

Find the balance between these two extremes, and you will master Redux.

Further information

Articles

- [Where do I put my business logic in a React/Redux application?](#)
- [How to Scale React Applications](#)
- [The Tao of Redux, Part 2 - Practice and Philosophy. Thick and thin reducers.](#)

Discussions

- [How putting too much logic in action creators could affect debugging](#)
- [#384: The more that's in a reducer, the more you can replay via time travel](#)
- [#1165: Where to put business logic / validation?](#)
- [#1171: Recommendations for best practices regarding action-creators, reducers, and selectors](#)
- [Stack Overflow: Accessing Redux state in an action creator?](#)

Why should I use action creators?

Redux does not require action creators. You are free to create actions in any way that is best for you, including simply passing an object literal to `dispatch`. Action creators emerged from the [Flux architecture](#) and have been adopted by the Redux community because they offer several benefits.

Action creators are more maintainable. Updates to an action can be made in one place and applied everywhere. All instances of an action are guaranteed to have the same shape and the same default values.

Action creators are testable. The correctness of an inline action must be verified manually. Like any function, tests for an action creator can be written once and run automatically.

Action creators are easier to document. The action creator's parameters enumerate the action's dependencies. And centralization of the action definition provides a convenient place for documentation comments. When actions are written inline, this information is harder to capture and communicate.

Action creators are a more powerful abstraction. Creating an action often involves transforming data or making AJAX requests. Action creators provide a uniform interface to this varied logic. This abstraction frees a component to dispatch an action without being complicated by the details of that action's creation.

Further information

Articles

- [Idiomatic Redux: Why use action creators?](#)

Discussions

- [Reddit: Redbox - Redux action creation made simple](#)

Redux FAQ: Performance

Table of Contents

- How well does Redux “scale” in terms of performance and architecture?
- Won’t calling “all my reducers” for each action be slow?
- Do I have to deep-clone my state in a reducer? Isn’t copying my state going to be slow?
- How can I reduce the number of store update events?
- Will having “one state tree” cause memory problems? Will dispatching many actions take up memory?

Performance

How well does Redux “scale” in terms of performance and architecture?

While there’s no single definitive answer to this, most of the time this should not be a concern in either case.

The work done by Redux generally falls into a few areas: processing actions in middleware and reducers (including object duplication for immutable updates), notifying subscribers after actions are dispatched, and updating UI components based on the state changes. While it’s certainly *possible* for each of these to become a performance concern in sufficiently complex situations, there’s nothing inherently slow or inefficient about how Redux is implemented. In fact, React Redux in particular is heavily optimized to cut down on unnecessary re-renders, and React-Redux v5 shows noticeable improvements over earlier versions.

Redux may not be as efficient out of the box when compared to other libraries. For maximum rendering performance in a React application, state should be stored in a normalized shape, many individual components should be connected to the store instead of just a few, and connected list components should pass item IDs to their connected child list items (allowing the list items to look up their own data by ID). This minimizes the overall amount of rendering to be done. Use of memoized selector functions is also an important performance consideration.

As for architecture, anecdotal evidence is that Redux works well for varying project and team sizes. Redux is currently used by hundreds of companies and thousands of developers, with several hundred thousand monthly installations from NPM. One developer reported:

for scale, we have ~500 action types, ~400 reducer cases, ~150 components, 5 middlewares, ~200 actions, ~2300 tests

Further information

Documentation

- [Recipes: Structuring Reducers - Normalizing State Shape](#)

Articles

- [How to Scale React Applications](#) (accompanying talk: [Scaling React Applications](#))
- [High-Performance Redux](#)
- [Improving React and Redux Perf with Reselect](#)
- [Encapsulating the Redux State Tree](#)
- [React/Redux Links: Performance - Redux](#)

Discussions

- #310: Who uses Redux?
- #1751: Performance issues with large collections
- React Redux #269: Connect could be used with a custom subscribe method
- React Redux #407: Rewrite connect to offer an advanced API
- React Redux #416: Rewrite connect for better performance and extensibility
- Redux vs MobX TodoMVC Benchmark: #1
- Reddit: What's the best place to keep the initial state?
- Reddit: Help designing Redux state for a single page app
- Reddit: Redux performance issues with a large state object?
- Reddit: React/Redux for Ultra Large Scale apps
- Twitter: Redux scaling
- Twitter: Redux vs MobX benchmark graph - Redux state shape matters
- Stack Overflow: How to optimize small updates to props of nested components?
- Chat log: React/Redux perf - updating a 10K-item Todo list
- Chat log: React/Redux perf - single connection vs many connections

Won't calling “all my reducers” for each action be slow?

It's important to note that a Redux store really only has a single reducer function. The store passes the current state and dispatched action to that one reducer function, and lets the reducer handle things appropriately.

Obviously, trying to handle every possible action in a single function does not scale well, simply in terms of function size and readability, so it makes sense to split the actual work into separate functions that can be called by the top-level reducer. In particular, the common suggested pattern is to have a separate sub-reducer function that is responsible for managing updates to a particular slice of state at a specific key. The `combineReducers()` that comes with Redux is one of the many possible ways to achieve this. It's also highly suggested to keep your store state as flat and as normalized as possible. Ultimately, though, you are in charge of organizing your reducer logic any way you want.

However, even if you happen to have many different reducer functions composed together, and even with deeply nested state, reducer speed is unlikely to be a problem. JavaScript engines are capable of running a very large number of function calls per second, and most of your reducers are probably just using a `switch` statement and returning the existing state by default in response to most actions.

If you actually are concerned about reducer performance, you can use a utility such as [redux-ignore](#) or [reduxr-scoped-reducer](#) to ensure that only certain reducers listen to specific actions. You can also use [redux-log-slow-reducers](#) to do some performance benchmarking.

Further information

Discussions

- #912: Proposal: action filter utility
- #1303: Redux Performance with Large Store and frequent updates
- Stack Overflow: State in Redux app has the name of the reducer
- Stack Overflow: How does Redux deal with deeply nested models?

Do I have to deep-clone my state in a reducer? Isn't copying my state going to be slow?

Immutably updating state generally means making shallow copies, not deep copies. Shallow copies are much faster than deep copies, because fewer objects and fields have to be copied, and it effectively comes down to moving some pointers around.

However, you *do* need to create a copied and updated object for each level of nesting that is affected. Although that shouldn't be particularly expensive, it's another good reason why you should keep your state normalized and shallow if possible.

Common Redux misconception: you need to deeply clone the state. Reality: if something inside doesn't change, keep its reference the same!

Further information

Documentation

- [Recipes: Structuring Reducers - Prerequisite Concepts](#)
- [Recipes: Structuring Reducers - Immutable Update Patterns](#)

Discussions

- [#454: Handling big states in reducer](#)
- [#758: Why can't state be mutated?](#)
- [#994: How to cut the boilerplate when updating nested entities?](#)
- [Twitter: common misconception - deep cloning](#)
- [Cloning Objects in JavaScript](#)

How can I reduce the number of store update events?

Redux notifies subscribers after each successfully dispatched action (i.e. an action reached the store and was handled by reducers). In some cases, it may be useful to cut down on the number of times subscribers are called, particularly if an action creator dispatches multiple distinct actions in a row.

If you use React, note that you can improve performance of multiple synchronous dispatches by wrapping them in `ReactDOM.unstable_batchedUpdates()`, but this API is experimental and may be removed in any React release so don't rely on it too heavily. Take a look at [redux-batched-actions](#) (a higher-order reducer that lets you dispatch several actions as if it was one and "unpack" them in the reducer), [redux-batched-subscribe](#) (a store enhancer that lets you debounce subscriber calls for multiple dispatches), or [redux-batch](#) (a store enhancer that handles dispatching an array of actions with a single subscriber notification).

Further information

Discussions

- [#125: Strategy for avoiding cascading renders](#)
- [#542: Idea: batching actions](#)
- [#911: Batching actions](#)
- [#1813: Use a loop to support dispatching arrays](#)
- [React Redux #263: Huge performance issue when dispatching hundreds of actions](#)

Libraries

- [Redux Addons Catalog: Store - Change Subscriptions](#)

Will having “one state tree” cause memory problems? Will dispatching many actions take up memory?

First, in terms of raw memory usage, Redux is no different than any other JavaScript library. The only difference is that all the various object references are nested together into one tree, instead of maybe saved in various independent model instances such as in Backbone. Second, a typical Redux app would probably have somewhat *less*

memory usage than an equivalent Backbone app because Redux encourages use of plain JavaScript objects and arrays rather than creating instances of Models and Collections. Finally, Redux only holds onto a single state tree reference at a time. Objects that are no longer referenced in that tree will be garbage collected, as usual.

Redux does not store a history of actions itself. However, the Redux DevTools do store actions so they can be replayed, but those are generally only enabled during development, and not used in production.

Further information

Documentation

- [Docs: Async Actions](#)

Discussions

- [Stack Overflow: Is there any way to "commit" the state in Redux to free memory?](#)
- [Stack Overflow: Can a Redux store lead to a memory leak?](#)
- [Stack Overflow: Redux and ALL the application state](#)
- [Stack Overflow: Memory Usage Concern with Controlled Components](#)
- [Reddit: What's the best place to keep initial state?](#)

Redux FAQ: React Redux

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- [Why isn't my component re-rendering, or my mapStateToProps running?](#)
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React Redux

Why isn't my component re-rendering, or my mapStateToProps running?

Accidentally mutating or modifying your state directly is by far the most common reason why components do not re-render after an action has been dispatched. Redux expects that your reducers will update their state “immutably”, which effectively means always making copies of your data, and applying your changes to the copies. If you return the same object from a reducer, Redux assumes that nothing has been changed, even if you made changes to its contents. Similarly, React Redux tries to improve performance by doing shallow equality reference checks on incoming props in `shouldComponentUpdate`, and if all references are the same, returns `false` to skip actually updating your original component.

It's important to remember that whenever you update a nested value, you must also return new copies of anything above it in your state tree. If you have `state.a.b.c.d`, and you want to make an update to `d`, you would also need to return new copies of `c`, `b`, `a`, and `state`. This [state tree mutation diagram](#) demonstrates how a change deep in a tree requires changes all the way up.

Note that “updating data immutably” does *not* mean that you must use [Immutable.js](#), although that is certainly an option. You can do immutable updates to plain JS objects and arrays using several different approaches:

- Copying objects using functions like `Object.assign()` or `_.extend()`, and array functions such as `slice()` and `concat()`
- The array spread operator in ES6, and the similar object spread operator that is proposed for a future version of JavaScript
- Utility libraries that wrap immutable update logic into simpler functions

Further information

Documentation

- [Troubleshooting](#)
- [React Redux: Troubleshooting](#)
- [Recipes: Using the Object Spread Operator](#)
- [Recipes: Structuring Reducers - Prerequisite Concepts](#)
- [Recipes: Structuring Reducers - Immutable Update Patterns](#)

Articles

- [Pros and Cons of Using Immutability with React](#)
- [React/Redux Links: Immutable Data](#)

Discussions

- #1262: Immutable data + bad performance
- React Redux #235: Predicate function for updating component
- React Redux #291: Should mapStateToProps be called every time an action is dispatched?
- Stack Overflow: Cleaner/shorter way to update nested state in Redux?
- Gist: state mutations

Why is my component re-rendering too often?

React Redux implements several optimizations to ensure your actual component only re-renders when actually necessary. One of those is a shallow equality check on the combined props object generated by the `mapStateToProps` and `mapDispatchToProps` arguments passed to `connect`. Unfortunately, shallow equality does not help in cases where new array or object instances are created each time `mapStateToProps` is called. A typical example might be mapping over an array of IDs and returning the matching object references, such as:

```
const mapStateToProps = state => {
  return {
    objects: state.objectIds.map(id => state.objects[id])
  }
}
```

Even though the array might contain the exact same object references each time, the array itself is a different reference, so the shallow equality check fails and React Redux would re-render the wrapped component.

The extra re-renders could be resolved by saving the array of objects into the state using a reducer, caching the mapped array using [Reselect](#), or implementing `shouldComponentUpdate` in the component by hand and doing a more in-depth props comparison using a function such as `_.isEqual`. Be careful to not make your custom `shouldComponentUpdate()` more expensive than the rendering itself! Always use a profiler to check your assumptions about performance.

For non-connected components, you may want to check what props are being passed in. A common issue is having a parent component re-bind a callback inside its render function, like `<Child onClick={this.handleClick.bind(this)} />`. That creates a new function reference every time the parent re-renders. It's generally good practice to only bind callbacks once in the parent component's constructor.

Further information

Documentation

- [FAQ: Performance - Scaling](#)

Articles

- [A Deep Dive into React Perf Debugging](#)
- [React.js pure render performance anti-pattern](#)
- [Improving React and Redux Performance with Reselect](#)
- [Encapsulating the Redux State Tree](#)
- [React/Redux Links: React/Redux Performance](#)

Discussions

- [Stack Overflow: Can a React Redux app scale as well as Backbone?](#)

Libraries

- [Redux Addons Catalog: DevTools - Component Update Monitoring](#)

How can I speed up my `mapStateToProps` ?

While React Redux does work to minimize the number of times that your `mapStateToProps` function is called, it's still a good idea to ensure that your `mapStateToProps` runs quickly and also minimizes the amount of work it does. The common recommended approach is to create memoized "selector" functions using [Reselect](#). These selectors can be combined and composed together, and selectors later in a pipeline will only run if their inputs have changed. This means you can create selectors that do things like filtering or sorting, and ensure that the real work only happens if needed.

Further information

Documentation

- [Recipes: Computed Derived Data](#)

Articles

- [Improving React and Redux Performance with Reselect](#)

Discussions

- [#815: Working with Data Structures](#)
- [Reselect #47: Memoizing Hierarchical Selectors](#)

Why don't I have `this.props.dispatch` available in my connected component?

The `connect()` function takes two primary arguments, both optional. The first, `mapStateToProps`, is a function you provide to pull data from the store when it changes, and pass those values as props to your component. The second, `mapDispatchToProps`, is a function you provide to make use of the store's `dispatch` function, usually by creating pre-bound versions of action creators that will automatically dispatch their actions as soon as they are called.

If you do not provide your own `mapDispatchToProps` function when calling `connect()`, React Redux will provide a default version, which simply returns the `dispatch` function as a prop. That means that if you *do* provide your own function, `dispatch` is *not* automatically provided. If you still want it available as a prop, you need to explicitly return it yourself in your `mapDispatchToProps` implementation.

Further information

Documentation

- [React Redux API: connect\(\)](#)

Discussions

- [React Redux #89: can i wrap multi actionCreators into one props with name?](#)
- [React Redux #145: consider always passing down dispatch regardless of what mapDispatchToProps does](#)
- [React Redux #255: this.props.dispatch is undefined if using mapDispatchToProps](#)
- [Stack Overflow: How to get simple dispatch from this.props using connect w/ Redux?](#)

Should I only connect my top component, or can I connect multiple components in my tree?

Early Redux documentation advised that you should only have a few connected components near the top of your component tree. However, time and experience has shown that that generally requires a few components to know too much about the data requirements of all their descendants, and forces them to pass down a confusing number of

props.

The current suggested best practice is to categorize your components as “presentational” or “container” components, and extract a connected container component wherever it makes sense:

Emphasizing “one container component at the top” in Redux examples was a mistake. Don’t take this as a maxim. Try to keep your presentation components separate. Create container components by connecting them when it’s convenient. Whenever you feel like you’re duplicating code in parent components to provide data for same kinds of children, time to extract a container. Generally as soon as you feel a parent knows too much about “personal” data or actions of its children, time to extract a container.

In fact, benchmarks have shown that more connected components generally leads to better performance than fewer connected components.

In general, try to find a balance between understandable data flow and areas of responsibility with your components.

Further information

Documentation

- [Basics: Usage with React](#)
- [FAQ: Performance - Scaling](#)

Articles

- [Presentational and Container Components](#)
- [High-Performance Redux](#)
- [React/Redux Links: Architecture - Redux Architecture](#)
- [React/Redux Links: Performance - Redux Performance](#)

Discussions

- [Twitter: emphasizing “one container” was a mistake](#)
- [#419: Recommended usage of connect](#)
- [#756: container vs component?](#)
- [#1176: Redux+React with only stateless components](#)
- [Stack Overflow: can a dumb component use a Redux container?](#)

Redux FAQ: Miscellaneous

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- [How can I implement authentication in Redux?](#)

Miscellaneous

Are there any larger, “real” Redux projects?

Yes, lots of them! To name just a few:

- [Twitter’s mobile site](#)
- [Wordpress’s new admin page](#)
- [Firefox’s new debugger](#)
- [Mozilla’s experimental browser testbed](#)
- [The HyperTerm terminal application](#)

And many, many more! The Redux Addons Catalog has [a list of Redux-based applications and examples](#) that points to a variety of actual applications, large and small.

Further information

Documentation

- [Introduction: Examples](#)

Discussions

- [Reddit: Large open source react/redux projects?](#)
- [HN: Is there any huge web application built using Redux?](#)

How can I implement authentication in Redux?

Authentication is essential to any real application. When going about authentication you must keep in mind that nothing changes with how you should organize your application and you should implement authentication in the same way you would any other feature. It is relatively straightforward:

1. Create action constants for `LOGIN_SUCCESS` , `LOGIN_FAILURE` , etc.
2. Create action creators that take in credentials, a flag that signifies whether authentication succeeded, a token, or an error message as the payload.
3. Create an async action creator with Redux Thunk middleware or any middleware you see fit to fire a network request to an API that returns a token if the credentials are valid. Then save the token in the local storage or show a response to the user if it failed. You can perform these side effects from the action creators you wrote in the previous step.
4. Create a reducer that returns the next state for each possible authentication case (`LOGIN_SUCCESS` , `LOGIN_FAILURE` , etc).

Further information

Articles

- [Authentication with JWT by Auth0](#)
- [Tips to Handle Authentication in Redux](#)

Examples

- [react-redux-jwt-auth-example](#)

Libraries

- [Redux Addons Catalog: Use Cases - Authentication](#)

Troubleshooting

This is a place to share common problems and solutions to them.

The examples use React, but you should still find them useful if you use something else.

Nothing happens when I dispatch an action

Sometimes, you are trying to dispatch an action, but your view does not update. Why does this happen? There may be several reasons for this.

Never mutate reducer arguments

It is tempting to modify the `state` or `action` passed to you by Redux. Don't do this!

Redux assumes that you never mutate the objects it gives to you in the reducer. **Every single time, you must return the new state object.** Even if you don't use a library like [Immutable](#), you need to completely avoid mutation.

Immutability is what lets [react-redux](#) efficiently subscribe to fine-grained updates of your state. It also enables great developer experience features such as time travel with [redux-devtools](#).

For example, a reducer like this is wrong because it mutates the state:

```
function todos(state = [], action) {
  switch (action.type) {
    case 'ADD_TODO':
      // Wrong! This mutates state
      state.push({
        text: action.text,
        completed: false
      })
      return state
    case 'COMPLETE_TODO':
      // Wrong! This mutates state[action.index].
      state[action.index].completed = true
      return state
    default:
      return state
  }
}
```

It needs to be rewritten like this:

```
function todos(state = [], action) {
  switch (action.type) {
    case 'ADD_TODO':
      // Return a new array
      return [
        ...state,
        {
          text: action.text,
          completed: false
        }
      ]
    case 'COMPLETE_TODO':
      // Return a new array
      return state.map((todo, index) => {
        if (index === action.index) {
          // Copy the object before mutating
          return Object.assign({}, todo, {
            completed: true
          })
        }
      })
  }
}
```

```

        return todo
    })
default:
    return state
}
}

```

It's more code, but it's exactly what makes Redux predictable and efficient. If you want to have less code, you can use a helper like `React.addons.update` to write immutable transformations with a terse syntax:

```

// Before:
return state.map((todo, index) => {
  if (index === action.index) {
    return Object.assign({}, todo, {
      completed: true
    })
  }
  return todo
})

// After
return update(state, {
  [action.index]: {
    completed: {
      $set: true
    }
  }
})

```

Finally, to update objects, you'll need something like `_.extend` from Underscore, or better, an `Object.assign` polyfill.

Make sure that you use `Object.assign` correctly. For example, instead of returning something like `Object.assign(state, newData)` from your reducers, return `Object.assign({}, state, newData)`. This way you don't override the previous `state`.

You can also enable the [object spread operator proposal](#) for a more succinct syntax:

```

// Before:
return state.map((todo, index) => {
  if (index === action.index) {
    return Object.assign({}, todo, {
      completed: true
    })
  }
  return todo
})

// After:
return state.map((todo, index) => {
  if (index === action.index) {
    return { ...todo, completed: true }
  }
  return todo
})

```

Note that experimental language features are subject to change.

Also keep an eye out for nested state objects that need to be deeply copied. Both `_.extend` and `Object.assign` make a shallow copy of the state. See [Updating Nested Objects](#) for suggestions on how to deal with nested state objects.

Don't forget to call `dispatch(action)`

If you define an action creator, calling it will *not* automatically dispatch the action. For example, this code will do nothing:

TodoActions.js

```
export function addTodo(text) {
  return { type: 'ADD_TODO', text }
}
```

AddTodo.js

```
import React, { Component } from 'react'
import { addTodo } from './TodoActions'

class AddTodo extends Component {
  handleClick() {
    // Won't work!
    addTodo('Fix the issue')
  }

  render() {
    return (
      <button onClick={() => this.handleClick()}>
        Add
      </button>
    )
  }
}
```

It doesn't work because your action creator is just a function that *returns* an action. It is up to you to actually dispatch it. We can't bind your action creators to a particular Store instance during the definition because apps that render on the server need a separate Redux store for every request.

The fix is to call `dispatch()` method on the `store` instance:

```
handleClick() {
  // Works! (but you need to grab store somehow)
  store.dispatch(addTodo('Fix the issue'))
}
```

If you're somewhere deep in the component hierarchy, it is cumbersome to pass the store down manually. This is why `react-redux` lets you use a `connect` higher-order component that will, apart from subscribing you to a Redux store, inject `dispatch` into your component's props.

The fixed code looks like this:

AddTodo.js

```
import React, { Component } from 'react'
import { connect } from 'react-redux'
import { addTodo } from './TodoActions'

class AddTodo extends Component {
  handleClick() {
    // Works!
    this.props.dispatch(addTodo('Fix the issue'))
  }

  render() {
    return (
      <button onClick={() => this.handleClick()}>
        Add
      </button>
    )
  }
}
```

```
        </button>
    )
}

// In addition to the state, `connect` puts `dispatch` in our props.
export default connect()(AddTodo)
```

You can then pass `dispatch` down to other components manually, if you want to.

Make sure `mapStateToProps` is correct

It's possible you're correctly dispatching an action and applying your reducer but the corresponding state is not being correctly translated into props.

Something else doesn't work

Ask around on the [#redux Reactiflux](#) Discord channel, or [create an issue](#).

If you figure it out, [edit this document](#) as a courtesy to the next person having the same problem.

Glossary

This is a glossary of the core terms in Redux, along with their type signatures. The types are documented using [Flow notation](#).

State

```
type State = any
```

State (also called the *state tree*) is a broad term, but in the Redux API it usually refers to the single state value that is managed by the store and returned by [`getState\(\)`](#). It represents the entire state of a Redux application, which is often a deeply nested object.

By convention, the top-level state is an object or some other key-value collection like a Map, but technically it can be any type. Still, you should do your best to keep the state serializable. Don't put anything inside it that you can't easily turn into JSON.

Action

```
type Action = Object
```

An *action* is a plain object that represents an intention to change the state. Actions are the only way to get data into the store. Any data, whether from UI events, network callbacks, or other sources such as WebSockets needs to eventually be dispatched as actions.

Actions must have a `type` field that indicates the type of action being performed. Types can be defined as constants and imported from another module. It's better to use strings for `type` than [Symbols](#) because strings are serializable.

Other than `type`, the structure of an action object is really up to you. If you're interested, check out [Flux Standard Action](#) for recommendations on how actions should be constructed.

See also [async action](#) below.

Reducer

```
type Reducer<S, A> = (state: S, action: A) => S
```

A *reducer* (also called a *reducing function*) is a function that accepts an accumulation and a value and returns a new accumulation. They are used to reduce a collection of values down to a single value.

Reducers are not unique to Redux—they are a fundamental concept in functional programming. Even most non-functional languages, like JavaScript, have a built-in API for reducing. In JavaScript, it's [`Array.prototype.reduce\(\)`](#).

In Redux, the accumulated value is the state object, and the values being accumulated are actions. Reducers calculate a new state given the previous state and an action. They must be *pure functions*—functions that return the exact same output for given inputs. They should also be free of side-effects. This is what enables exciting features like hot reloading and time travel.

Reducers are the most important concept in Redux.

Do not put API calls into reducers.

Dispatching Function

```
type BaseDispatch = (a: Action) => Action
type Dispatch = (a: Action | AsyncAction) => any
```

A *dispatching function* (or simply *dispatch function*) is a function that accepts an action or an [async action](#); it then may or may not dispatch one or more actions to the store.

We must distinguish between dispatching functions in general and the base `dispatch` function provided by the store instance without any middleware.

The base dispatch function *always* synchronously sends an action to the store's reducer, along with the previous state returned by the store, to calculate a new state. It expects actions to be plain objects ready to be consumed by the reducer.

[Middleware](#) wraps the base dispatch function. It allows the dispatch function to handle [async actions](#) in addition to actions. Middleware may transform, delay, ignore, or otherwise interpret actions or async actions before passing them to the next middleware. See below for more information.

Action Creator

```
type ActionCreator = (...args: any) => Action | AsyncAction
```

An *action creator* is, quite simply, a function that creates an action. Do not confuse the two terms—again, an action is a payload of information, and an action creator is a factory that creates an action.

Calling an action creator only produces an action, but does not dispatch it. You need to call the store's `dispatch` function to actually cause the mutation. Sometimes we say *bound action creators* to mean functions that call an action creator and immediately dispatch its result to a specific store instance.

If an action creator needs to read the current state, perform an API call, or cause a side effect, like a routing transition, it should return an [async action](#) instead of an action.

Async Action

```
type AsyncAction = any
```

An *async action* is a value that is sent to a dispatching function, but is not yet ready for consumption by the reducer. It will be transformed by [middleware](#) into an action (or a series of actions) before being sent to the base `dispatch()` function. Async actions may have different types, depending on the middleware you use. They are often asynchronous primitives, like a Promise or a thunk, which are not passed to the reducer immediately, but trigger action dispatches once an operation has completed.

Middleware

```
type MiddlewareAPI = { dispatch: Dispatch, getState: () => State }
type Middleware = (api: MiddlewareAPI) => (next: Dispatch) => Dispatch
```

A middleware is a higher-order function that composes a [dispatch function](#) to return a new dispatch function. It often turns [async actions](#) into actions.

Middleware is composable using function composition. It is useful for logging actions, performing side effects like routing, or turning an asynchronous API call into a series of synchronous actions.

See [applyMiddleware\(...middlewares\)](#) for a detailed look at middleware.

Store

```
type Store = {
  dispatch: Dispatch
  getState: () => State
  subscribe: (listener: () => void) => () => void
  replaceReducer: (reducer: Reducer) => void
}
```

A store is an object that holds the application's state tree.

There should only be a single store in a Redux app, as the composition happens on the reducer level.

- `dispatch(action)` is the base dispatch function described above.
- `getState()` returns the current state of the store.
- `subscribe(listener)` registers a function to be called on state changes.
- `replaceReducer(nextReducer)` can be used to implement hot reloading and code splitting. Most likely you won't use it.

See the complete [store API reference](#) for more details.

Store creator

```
type StoreCreator = (reducer: Reducer, preloadedState: ?State) => Store
```

A store creator is a function that creates a Redux store. Like with dispatching function, we must distinguish the base store creator, `createStore(reducer, preloadedState)` exported from the Redux package, from store creators that are returned from the store enhancers.

Store enhancer

```
type StoreEnhancer = (next: StoreCreator) => StoreCreator
```

A store enhancer is a higher-order function that composes a store creator to return a new, enhanced store creator. This is similar to middleware in that it allows you to alter the store interface in a composable way.

Store enhancers are much the same concept as higher-order components in React, which are also occasionally called “component enhancers”.

Because a store is not an instance, but rather a plain-object collection of functions, copies can be easily created and modified without mutating the original store. There is an example in [compose](#) documentation demonstrating that.

Most likely you'll never write a store enhancer, but you may use the one provided by the [developer tools](#). It is what makes time travel possible without the app being aware it is happening. Amusingly, the [Redux middleware implementation](#) is itself a store enhancer.

API Reference

The Redux API surface is tiny. Redux defines a set of contracts for you to implement (such as [reducers](#)) and provides a few helper functions to tie these contracts together.

This section documents the complete Redux API. Keep in mind that Redux is only concerned with managing the state. In a real app, you'll also want to use UI bindings like [react-redux](#).

Top-Level Exports

- [createStore\(reducer, \[preloadedState\], \[enhancer\]\)](#)
- [combineReducers\(reducers\)](#)
- [applyMiddleware\(...middlewares\)](#)
- [bindActionCreators\(actionCreators, dispatch\)](#)
- [compose\(...functions\)](#)

Store API

- **Store**
 - [getState\(\)](#)
 - [dispatch\(action\)](#)
 - [subscribe\(listener\)](#)
 - [replaceReducer\(nextReducer\)](#)

Importing

Every function described above is a top-level export. You can import any of them like this:

ES6

```
import { createStore } from 'redux'
```

ES5 (CommonJS)

```
var createStore = require('redux').createStore
```

ES5 (UMD build)

```
var createStore = Redux.createStore
```

createStore(reducer, [preloadedState], [enhancer])

Creates a Redux [store](#) that holds the complete state tree of your app.

There should only be a single store in your app.

Arguments

1. `reducer` (*Function*): A [reducing function](#) that returns the next [state tree](#), given the current state tree and an [action](#) to handle.
2. `[preloadedState]` (*any*): The initial state. You may optionally specify it to hydrate the state from the server in universal apps, or to restore a previously serialized user session. If you produced `reducer` with `combineReducers`, this must be a plain object with the same shape as the keys passed to it. Otherwise, you are free to pass anything that your `reducer` can understand.
3. `[enhancer]` (*Function*): The store enhancer. You may optionally specify it to enhance the store with third-party capabilities such as middleware, time travel, persistence, etc. The only store enhancer that ships with Redux is `applyMiddleware()`.

Returns

(`store`): An object that holds the complete state of your app. The only way to change its state is by [dispatching actions](#). You may also [subscribe](#) to the changes to its state to update the UI.

Example

```
import { createStore } from 'redux'

function todos(state = [], action) {
  switch (action.type) {
    case 'ADD_TODO':
      return state.concat([action.text])
    default:
      return state
  }
}

let store = createStore(todos, ['Use Redux'])

store.dispatch({
  type: 'ADD_TODO',
  text: 'Read the docs'
})

console.log(store.getState())
// [ 'Use Redux', 'Read the docs' ]
```

Tips

- Don't create more than one store in an application! Instead, use `combineReducers` to create a single root reducer out of many.
- It is up to you to choose the state format. You can use plain objects or something like [Immutable](#). If you're not sure, start with plain objects.

- If your state is a plain object, make sure you never mutate it! For example, instead of returning something like `Object.assign(state, newData)` from your reducers, return `Object.assign({}, state, newData)`. This way you don't override the previous `state`. You can also write `return { ...state, ...newData }` if you enable the [object spread operator proposal](#).
- For universal apps that run on the server, create a store instance with every request so that they are isolated. Dispatch a few data fetching actions to a store instance and wait for them to complete before rendering the app on the server.
- When a store is created, Redux dispatches a dummy action to your reducer to populate the store with the initial state. You are not meant to handle the dummy action directly. Just remember that your reducer should return some kind of initial state if the state given to it as the first argument is `undefined`, and you're all set.
- To apply multiple store enhancers, you may use `compose()`.

Store

A store holds the whole `state tree` of your application.

The only way to change the state inside it is to dispatch an `action` on it.

A store is not a class. It's just an object with a few methods on it.

To create it, pass your root `reducing function` to `createStore`.

A Note for Flux Users

If you're coming from Flux, there is a single important difference you need to understand. Redux doesn't have a Dispatcher or support many stores. **Instead, there is just a single store with a single root reducing function.** As your app grows, instead of adding stores, you split the root reducer into smaller reducers independently operating on the different parts of the state tree. You can use a helper like `combineReducers` to combine them. This is similar to how there is just one root component in a React app, but it is composed out of many small components.

Store Methods

- `getState()`
- `dispatch(action)`
- `subscribe(listener)`
- `replaceReducer(nextReducer)`

Store Methods

`getState()`

Returns the current state tree of your application.

It is equal to the last value returned by the store's reducer.

Returns

(*any*): The current state tree of your application.

`dispatch(action)`

Dispatches an action. This is the only way to trigger a state change.

The store's reducing function will be called with the current `getState()` result and the given `action` synchronously. Its return value will be considered the next state. It will be returned from `getState()` from now on, and the change listeners will immediately be notified.

A Note for Flux Users

If you attempt to call `dispatch` from inside the `reducer`, it will throw with an error saying "Reducers may not dispatch actions." This is similar to "Cannot dispatch in a middle of dispatch" error in Flux, but doesn't cause the problems associated with it. In Flux, a dispatch is forbidden while Stores are handling the action and emitting updates. This is unfortunate because it makes it impossible to dispatch actions from component lifecycle hooks or other benign places.

In Redux, subscriptions are called after the root reducer has returned the new state, so you *may* dispatch in the subscription listeners. You are only disallowed to dispatch inside the reducers because they must have no side effects. If you want to cause a side effect in response to an action, the right place to do this is in the potentially async [action creator](#).

Arguments

1. `action (Object†)`: A plain object describing the change that makes sense for your application. Actions are the only way to get data into the store, so any data, whether from the UI events, network callbacks, or other sources such as WebSockets needs to eventually be dispatched as actions. Actions must have a `type` field that indicates the type of action being performed. Types can be defined as constants and imported from another module. It's better to use strings for `type` than [Symbols](#) because strings are serializable. Other than `type`, the structure of an action object is really up to you. If you're interested, check out [Flux Standard Action](#) for recommendations on how actions could be constructed.

Returns

`(Object†)`: The dispatched action (see notes).

Notes

[†] The “vanilla” store implementation you get by calling `createStore` only supports plain object actions and hands them immediately to the reducer.

However, if you wrap `createStore` with `applyMiddleware`, the middleware can interpret actions differently, and provide support for dispatching [async actions](#). Async actions are usually asynchronous primitives like Promises, Observables, or thunks.

Middleware is created by the community and does not ship with Redux by default. You need to explicitly install packages like [redux-thunk](#) or [redux-promise](#) to use it. You may also create your own middleware.

To learn how to describe asynchronous API calls, read the current state inside action creators, perform side effects, or chain them to execute in a sequence, see the examples for `applyMiddleware`.

Example

```
import { createStore } from 'redux'
let store = createStore(todos, ['Use Redux'])

function addTodo(text) {
  return {
    type: 'ADD_TODO',
    text
  }
}

store.dispatch(addTodo('Read the docs'))
store.dispatch(addTodo('Read about the middleware'))
```

subscribe(listener)

Adds a change listener. It will be called any time an action is dispatched, and some part of the state tree may potentially have changed. You may then call `getState()` to read the current state tree inside the callback.

You may call `dispatch()` from a change listener, with the following caveats:

1. The listener should only call `dispatch()` either in response to user actions or under specific conditions (e.g. dispatching an action when the store has a specific field). Calling `dispatch()` without any conditions is technically possible, however it leads to an infinite loop as every `dispatch()` call usually triggers the listener again.
2. The subscriptions are snapshotted just before every `dispatch()` call. If you subscribe or unsubscribe while the listeners are being invoked, this will not have any effect on the `dispatch()` that is currently in progress. However, the next `dispatch()` call, whether nested or not, will use a more recent snapshot of the subscription list.
3. The listener should not expect to see all state changes, as the state might have been updated multiple times during a nested `dispatch()` before the listener is called. It is, however, guaranteed that all subscribers registered before the `dispatch()` started will be called with the latest state by the time it exits.

It is a low-level API. Most likely, instead of using it directly, you'll use React (or other) bindings. If you commonly use the callback as a hook to react to state changes, you might want to [write a custom `observeStore` utility](#). The `store` is also an `Observable`, so you can `subscribe` to changes with libraries like [RxJS](#).

To unsubscribe the change listener, invoke the function returned by `subscribe`.

Arguments

1. `listener (Function)`: The callback to be invoked any time an action has been dispatched, and the state tree might have changed. You may call `getState()` inside this callback to read the current state tree. It is reasonable to expect that the store's reducer is a pure function, so you may compare references to some deep path in the state tree to learn whether its value has changed.

Returns

`(Function)`: A function that unsubscribes the change listener.

Example

```
function select(state) {
  return state.some.deep.property
}

let currentValue
function handleChange() {
  let previousValue = currentValue
  currentValue = select(store.getState())

  if (previousValue !== currentValue) {
    console.log(
      'Some deep nested property changed from',
      previousValue,
      'to',
      currentValue
    )
  }
}

let unsubscribe = store.subscribe(handleChange)
unsubscribe()
```

replaceReducer(nextReducer)

Replaces the reducer currently used by the store to calculate the state.

It is an advanced API. You might need this if your app implements code splitting, and you want to load some of the reducers dynamically. You might also need this if you implement a hot reloading mechanism for Redux.

Arguments

1. `nextReducer` (*Function*) The next reducer for the store to use.

combineReducers(reducers)

As your app grows more complex, you'll want to split your [reducing function](#) into separate functions, each managing independent parts of the [state](#).

The `combineReducers` helper function turns an object whose values are different reducing functions into a single reducing function you can pass to [createStore](#).

The resulting reducer calls every child reducer, and gathers their results into a single state object. **The shape of the state object matches the keys of the passed reducers**.

Consequently, the state object will look like this:

```
{
  reducer1: ...
  reducer2: ...
}
```

You can control state key names by using different keys for the reducers in the passed object. For example, you may call `combineReducers({ todos: myTodosReducer, counter: myCounterReducer })` for the state shape to be `{ todos, counter }`.

A popular convention is to name reducers after the state slices they manage, so you can use ES6 property shorthand notation: `combineReducers({ counter, todos })`. This is equivalent to writing `combineReducers({ counter: counter, todos: todos })`.

A Note for Flux Users

This function helps you organize your reducers to manage their own slices of state, similar to how you would have different Flux Stores to manage different state. With Redux, there is just one store, but `combineReducers` helps you keep the same logical division between reducers.

Arguments

- reducers (Object):** An object whose values correspond to different reducing functions that need to be combined into one. See the notes below for some rules every passed reducer must follow.

Earlier documentation suggested the use of the ES6 `import * as reducers` syntax to obtain the reducers object. This was the source of a lot of confusion, which is why we now recommend exporting a single reducer obtained using `combineReducers()` from `reducers/index.js` instead. An example is included below.

Returns

(*Function*): A reducer that invokes every reducer inside the `reducers` object, and constructs a state object with the same shape.

Notes

This function is mildly opinionated and is skewed towards helping beginners avoid common pitfalls. This is why it attempts to enforce some rules that you don't have to follow if you write the root reducer manually.

Any reducer passed to `combineReducers` must satisfy these rules:

- For any action that is not recognized, it must return the `state` given to it as the first argument.

- It must never return `undefined`. It is too easy to do this by mistake via an early `return` statement, so `combineReducers` throws if you do that instead of letting the error manifest itself somewhere else.
- If the `state` given to it is `undefined`, it must return the initial state for this specific reducer. According to the previous rule, the initial state must not be `undefined` either. It is handy to specify it with ES6 optional arguments syntax, but you can also explicitly check the first argument for being `undefined`.

While `combineReducers` attempts to check that your reducers conform to some of these rules, you should remember them, and do your best to follow them. `combineReducers` will check your reducers by passing `undefined` to them; this is done even if you specify initial state to `Redux.createStore(combineReducers(...), initialState)`. Therefore, you **must** ensure your reducers work properly when receiving `undefined` as state, even if you never intend for them to actually receive `undefined` in your own code.

Example

reducers/todos.js

```
export default function todos(state = [], action) {
  switch (action.type) {
    case 'ADD_TODO':
      return state.concat([action.text])
    default:
      return state
  }
}
```

reducers/counter.js

```
export default function counter(state = 0, action) {
  switch (action.type) {
    case 'INCREMENT':
      return state + 1
    case 'DECREMENT':
      return state - 1
    default:
      return state
  }
}
```

reducers/index.js

```
import { combineReducers } from 'redux'
import todos from './todos'
import counter from './counter'

export default combineReducers({
  todos,
  counter
})
```

App.js

```
import { createStore } from 'redux'
import reducer from './reducers/index'

let store = createStore(reducer)
console.log(store.getState())
// {
//   counter: 0,
//   todos: []
// }
```

```
// }

store.dispatch({
  type: 'ADD_TODO',
  text: 'Use Redux'
})
console.log(store.getState())
// {
//   counter: 0,
//   todos: [ 'Use Redux' ]
// }
```

Tips

- This helper is just a convenience! You can write your own `combineReducers` that [works differently](#), or even assemble the state object from the child reducers manually and write a root reducing function explicitly, like you would write any other function.
- You may call `combineReducers` at any level of the reducer hierarchy. It doesn't have to happen at the top. In fact you may use it again to split the child reducers that get too complicated into independent grandchildren, and so on.

applyMiddleware(...middleware)

Middleware is the suggested way to extend Redux with custom functionality. Middleware lets you wrap the store's `dispatch` method for fun and profit. The key feature of middleware is that it is composable. Multiple middleware can be combined together, where each middleware requires no knowledge of what comes before or after it in the chain.

The most common use case for middleware is to support asynchronous actions without much boilerplate code or a dependency on a library like `Rx`. It does so by letting you dispatch `async actions` in addition to normal actions.

For example, `redux-thunk` lets the action creators invert control by dispatching functions. They would receive `dispatch` as an argument and may call it asynchronously. Such functions are called *thunks*. Another example of middleware is `redux-promise`. It lets you dispatch a `Promise` async action, and dispatches a normal action when the Promise resolves.

Middleware is not baked into `createStore` and is not a fundamental part of the Redux architecture, but we consider it useful enough to be supported right in the core. This way, there is a single standard way to extend `dispatch` in the ecosystem, and different middleware may compete in expressiveness and utility.

Arguments

- `...middleware (arguments)`: Functions that conform to the Redux *middleware API*. Each middleware receives `Store`'s `dispatch` and `getState` functions as named arguments, and returns a function. That function will be given the `next` middleware's `dispatch` method, and is expected to return a function of `action` calling `next(action)` with a potentially different argument, or at a different time, or maybe not calling it at all. The last middleware in the chain will receive the real store's `dispatch` method as the `next` parameter, thus ending the chain. So, the middleware signature is `({ getState, dispatch }) => next => action`.

Returns

(*Function*) A store enhancer that applies the given middleware. The store enhancer signature is `createStore => createStore'` but the easiest way to apply it is to pass it to `createStore()` as the last `enhancer` argument.

Example: Custom Logger Middleware

```
import { createStore, applyMiddleware } from 'redux'
import todos from './reducers'

function logger({ getState }) {
  return next => action => {
    console.log('will dispatch', action)

    // Call the next dispatch method in the middleware chain.
    let returnValue = next(action)

    console.log('state after dispatch', getState())

    // This will likely be the action itself, unless
    // a middleware further in chain changed it.
    return returnValue
  }
}

let store = createStore(
  todos,
  ['Use Redux'],
  applyMiddleware(logger)
)
```

```

store.dispatch({
  type: 'ADD_TODO',
  text: 'Understand the middleware'
})
// (These lines will be logged by the middleware:)
// will dispatch: { type: 'ADD_TODO', text: 'Understand the middleware' }
// state after dispatch: [ 'Use Redux', 'Understand the middleware' ]

```

Example: Using Thunk Middleware for Async Actions

```

import { createStore, combineReducers, applyMiddleware } from 'redux'
import thunk from 'redux-thunk'
import * as reducers from './reducers'

let reducer = combineReducers(reducers)
// applyMiddleware supercharges createStore with middleware:
let store = createStore(reducer, applyMiddleware(thunk))

function fetchSecretSauce() {
  return fetch('https://www.google.com/search?q=secret+sauce')
}

// These are the normal action creators you have seen so far.
// The actions they return can be dispatched without any middleware.
// However, they only express "facts" and not the "async flow".
function makeASandwich(forPerson, secretSauce) {
  return {
    type: 'MAKE_SANDWICH',
    forPerson,
    secretSauce
  }
}

function apologize(fromPerson, toPerson, error) {
  return {
    type: 'APOLOGIZE',
    fromPerson,
    toPerson,
    error
  }
}

function withdrawMoney(amount) {
  return {
    type: 'WITHDRAW',
    amount
  }
}

// Even without middleware, you can dispatch an action:
store.dispatch(withdrawMoney(100))

// But what do you do when you need to start an asynchronous action,
// such as an API call, or a router transition?

// Meet thunks.
// A thunk is a function that returns a function.
// This is a thunk.
function makeASandwichWithSecretSauce(forPerson) {

  // Invert control!
  // Return a function that accepts `dispatch` so we can dispatch later.
  // Thunk middleware knows how to turn thunk async actions into actions.
  return function (dispatch) {
    return fetchSecretSauce().then(
      sauce => dispatch(makeASandwich(forPerson, sauce)),
      error => dispatch(apologize('The Sandwich Shop', forPerson, error))
    )
  }
}

```

```

// Thunk middleware lets me dispatch thunk async actions
// as if they were actions!
store.dispatch(makeASandwichWithSecretSauce('Me'))

// It even takes care to return the thunk's return value
// from the dispatch, so I can chain Promises as long as I return them.
store.dispatch(makeASandwichWithSecretSauce('My wife')).then(() => {
  console.log('Done!')
})

// In fact I can write action creators that dispatch
// actions and async actions from other action creators,
// and I can build my control flow with Promises.
function makeSandwichesForEverybody() {
  return function (dispatch, getState) {
    if (!getState().sandwiches.isShopOpen) {

      // You don't have to return Promises, but it's a handy convention
      // so the caller can always call .then() on async dispatch result.
      return Promise.resolve()
    }

    // We can dispatch both plain object actions and other thunks,
    // which lets us compose the asynchronous actions in a single flow.
    return dispatch(makeASandwichWithSecretSauce('My Grandma'))
      .then(() =>
        Promise.all([
          dispatch(makeASandwichWithSecretSauce('Me')),
          dispatch(makeASandwichWithSecretSauce('My wife'))
        ])
      )
      .then(() => dispatch(makeASandwichWithSecretSauce('Our kids')))
      .then(() =>
        dispatch(
          getState().myMoney > 42
            ? withdrawMoney(42)
            : apologize('Me', 'The Sandwich Shop')
        )
      )
    }
  }
}

// This is very useful for server side rendering, because I can wait
// until data is available, then synchronously render the app.

import { renderToString } from 'react-dom/server'

store
  .dispatch(makeSandwichesForEverybody())
  .then(() => response.send(renderToString(<MyApp store={store} />)))

// I can also dispatch a thunk async action from a component
// any time its props change to load the missing data.

import { connect } from 'react-redux'
import { Component } from 'react'

class SandwichShop extends Component {
  componentDidMount() {
    this.props.dispatch(makeASandwichWithSecretSauce(this.props.forPerson))
  }

  componentWillReceiveProps(nextProps) {
    if (nextProps.forPerson !== this.props.forPerson) {
      this.props.dispatch(makeASandwichWithSecretSauce(nextProps.forPerson))
    }
  }

  render() {
    return <p>{this.props.sandwiches.join('mustard')}</p>
  }
}

export default connect(state => ({

```

```
    sandwiches: state.sandwiches
  }))(SandwichShop)
```

Tips

- Middleware only wraps the store's `dispatch` function. Technically, anything a middleware can do, you can do manually by wrapping every `dispatch` call, but it's easier to manage this in a single place and define action transformations on the scale of the whole project.
- If you use other store enhancers in addition to `applyMiddleware`, make sure to put `applyMiddleware` before them in the composition chain because the middleware is potentially asynchronous. For example, it should go before `redux-devtools` because otherwise the DevTools won't see the raw actions emitted by the Promise middleware and such.
- If you want to conditionally apply a middleware, make sure to only import it when it's needed:

```
let middleware = [a, b]
if (process.env.NODE_ENV !== 'production') {
  let c = require('some-debug-middleware')
  let d = require('another-debug-middleware')
  middleware = [...middleware, c, d]
}

const store = createStore(
  reducer,
  preloadedState,
  applyMiddleware(...middleware)
)
```

This makes it easier for bundling tools to cut out unneeded modules and reduces the size of your builds.

- Ever wondered what `applyMiddleware` itself is? It ought to be an extension mechanism more powerful than the middleware itself. Indeed, `applyMiddleware` is an example of the most powerful Redux extension mechanism called `store enhancers`. It is highly unlikely you'll ever want to write a store enhancer yourself. Another example of a store enhancer is `redux-devtools`. Middleware is less powerful than a store enhancer, but it is easier to write.
- Middleware sounds much more complicated than it really is. The only way to really understand middleware is to see how the existing middleware works, and try to write your own. The function nesting can be intimidating, but most of the middleware you'll find are, in fact, 10-liners, and the nesting and composability is what makes the middleware system powerful.
- To apply multiple store enhancers, you may use `compose()`.

bindActionCreators(actionCreators, dispatch)

Turns an object whose values are [action creators](#), into an object with the same keys, but with every action creator wrapped into a `dispatch` call so they may be invoked directly.

Normally you should just call `dispatch` directly on your `store` instance. If you use Redux with React, [react-redux](#) will provide you with the `dispatch` function so you can call it directly, too.

The only use case for `bindActionCreators` is when you want to pass some action creators down to a component that isn't aware of Redux, and you don't want to pass `dispatch` or the Redux store to it.

For convenience, you can also pass a single function as the first argument, and get a function in return.

Parameters

1. `actionCreators` (*Function or Object*): An [action creator](#), or an object whose values are action creators.
2. `dispatch` (*Function*): A `dispatch` function available on the `Store` instance.

Returns

(*Function or Object*): An object mimicking the original object, but with each function immediately dispatching the action returned by the corresponding action creator. If you passed a function as `actionCreators`, the return value will also be a single function.

Example

`TodoActionCreators.js`

```
export function addTodo(text) {
  return {
    type: 'ADD_TODO',
    text
  }
}

export function removeTodo(id) {
  return {
    type: 'REMOVE_TODO',
    id
  }
}
```

`SomeComponent.js`

```
import { Component } from 'react'
import { bindActionCreators } from 'redux'
import { connect } from 'react-redux'

import * as TodoActionCreators from './TodoActionCreators'
console.log(TodoActionCreators)

// {
//   addTodo: Function,
//   removeTodo: Function
// }

class TodoListContainer extends Component {
  constructor(props) {
    super(props);
```

```

const {dispatch} = props;

// Here's a good use case for bindActionCreators:
// You want a child component to be completely unaware of Redux.
// We create bound versions of these functions now so we can
// pass them down to our child later.

this.bindActionCreators = bindActionCreators(TodoActionCreators, dispatch)
console.log(this.bindActionCreators)
// {
//   addTodo: Function,
//   removeTodo: Function
// }
}

componentDidMount() {
  // Injected by react-redux:
  let { dispatch } = this.props

  // Note: this won't work:
  // TodoActionCreators.addTodo('Use Redux')

  // You're just calling a function that creates an action.
  // You must dispatch the action, too!

  // This will work:
  let action = TodoActionCreators.addTodo('Use Redux')
  dispatch(action)
}

render() {
  // Injected by react-redux:
  let { todos } = this.props

  return <TodoList todos={todos} {...this.bindActionCreators} />
}

// An alternative to bindActionCreators is to pass
// just the dispatch function down, but then your child component
// needs to import action creators and know about them.

// return <TodoList todos={todos} dispatch={dispatch} />
}

export default connect(
  state => ({ todos: state.todos })
)(TodoListContainer)

```

Tips

- You might ask: why don't we bind the action creators to the store instance right away, like in classical Flux? The problem is that this won't work well with universal apps that need to render on the server. Most likely you want to have a separate store instance per request so you can prepare them with different data, but binding action creators during their definition means you're stuck with a single store instance for all requests.
- If you use ES5, instead of `import * as` syntax you can just pass `require('./TodoActionCreators')` to `bindActionCreators` as the first argument. The only thing it cares about is that the values of the `actionCreators` arguments are functions. The module system doesn't matter.

compose(...functions)

Composes functions from right to left.

This is a functional programming utility, and is included in Redux as a convenience.

You might want to use it to apply several [store enhancers](#) in a row.

Arguments

1. (*arguments*): The functions to compose. Each function is expected to accept a single parameter. Its return value will be provided as an argument to the function standing to the left, and so on. The exception is the right-most argument which can accept multiple parameters, as it will provide the signature for the resulting composed function.

Returns

(*Function*): The final function obtained by composing the given functions from right to left.

Example

This example demonstrates how to use `compose` to enhance a [store](#) with `applyMiddleware` and a few developer tools from the [redux-devtools](#) package.

```
import { createStore, combineReducers, applyMiddleware, compose } from 'redux'
import thunk from 'redux-thunk'
import DevTools from './containers/DevTools'
import reducer from '../reducers/index'

const store = createStore(
  reducer,
  compose(
    applyMiddleware(thunk),
    DevTools.instrument()
  )
)
```

Tips

- All `compose` does is let you write deeply nested function transformations without the rightward drift of the code.
Don't give it too much credit!

Change Log

This project adheres to [Semantic Versioning](#).

Every release, along with the migration instructions, is documented on the Github [Releases](#) page.

Patrons

The work on Redux was [funded by the community](#).

Meet some of the outstanding companies and individuals that made it possible:

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We appreciate feedback from the community. You can post feature requests and bug reports on [Product Pains](#).