FULLSTACK REACT NATIVE

The Complete Guide to React Native

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Fullstack React Native

The Complete Guide to React Native

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Contents

Book Revision

Revision 9

Bug Reports

If you'd like to report any bugs, typos, or suggestions just email us at: rn@fullstack.io[1].

Be notified of updates via Twitter

If you'd like to be notified of updates to the book on Twitter, follow @fullstackreact[2]

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[1] mailto:rn@fullstack.io?Subject=Fullstack%20React%20Native%20book%20feedback
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Introduction

One of the major problems that teams face when writing native mobile applications is *becoming familiar with all the different technologies*. iOS and Android - the two dominant mobile platforms - support different languages. For iOS, Apple supports the languages Swift[4] and Objective-C[5]. For Android, Google supports the languages Java[6] and Kotlin[7].

And the differences don't end there. These platforms have different toolchains. And they have different interfaces for the device's core functionality. Developers have to learn each platform's procedure for things like accessing the camera or checking network connectivity.

One trend is to write mobile apps that are powered by **WebViews**. These types of apps have minimal native code. Instead, the interface is a web browser running an app written in HTML, CSS, and JS. This web app can use the native wrapper to access features on the device, like the camera roll.

Tools like Cordova[8] enable developers to write these hybrid apps. The advantage is that developers can write apps that run on multiple platforms. Instead of learning iOS and Android specifics, they can use HTML, CSS, and JS to write a "universal" app.

The disadvantage, though, is that it's hard to make these apps look and feel like *real* native applications. And users can tell.

While universal WebView-powered apps were built with the idea of *build once, run anywhere*, React Native was built with the goal of *learn once, write anywhere*.

React is a JavaScript framework for building rich, interactive web applications. With React Native, we can build native mobile applications for multiple platforms using

[4] https://developer.apple.com/swift/

[5] https://developer.apple.com/library/content/documentation/Cocoa/Conceptual/ProgrammingWithObjectiveC/Introduction/Introduction.html

[6] https://docs.oracle.com/javase/8/docs/technotes/guides/language/index.html

[7] https://developer.android.com/kotlin/index.html

[8] https://cordova.apache.org/

JavaScript and React. Importantly, the interfaces we build are *translated into native views*. React Native apps are not composed of WebViews.

We'll be able to share a lot of the code we write between iOS and Android. And React Native makes it easy to write code specific to each platform when the need arises. We get to use one language (JavaScript), one framework (React), one styling engine, and one toolchain to write apps for both platforms. *Learn once, write anywhere.*

At its core, React Native is composed of React components. We'll dig deep into components throughout this book, but here's an example of what a React component looks like:

```
import React from 'react';
import { StyleSheet, Text } from 'react-native';

export default class StyledText extends React.Component {
  render() {
    return (
      <Text style={styles.text}>{this.props.content}</Text>
    );
  }
}

const styles = StyleSheet.create({
  text: {
    color: 'red',
    fontWeight: 'bold',
  },
});
```

React Native **works**. It is currently being used in production at Facebook, Instagram, Microsoft, Amazon, and thousands of other companies.

About This Book

This book aims to be an extensive React Native resource. By the time you're done reading this book, you (and your team) will have everything you need to build

reliable React Native applications.

React Native is rich and feature-filled, but that also means it can be tricky to understand all of its parts. In this book, we'll walk through everything, such as installing its tools, writing components, navigating between screens, and integrating native modules.

But before we dig in, there are a few guidelines we want to give you in order to get the most out of this book. Specifically:

- how to approach the code examples
- how to get help if something goes wrong

Running Code Examples

This book comes with a library of runnable code examples. If you purchased a digital copy of this book, the code is available to download from the same place where you downloaded the book. If you purchased a physical copy, you can find download instructions right after the table of contents and before this Introduction chapter.

We use yarn[9] to run every example in this book. This means you can type the following commands to run any example:

- `yarn start` will start the React Native packager and print a QR code. If you're on an Android mobile device, scanning this code with the Expo[10] app will load the application. For iOS devices, see the instructions for loading apps onto your phone at the beginning of the first chapter.
- `yarn run ios` will start the React Native packager and open your app in the iOS Simulator if you are using a Mac.
- `yarn run android` will start the React Native packager and open your app on a connected Android device or emulator.

In the next chapter we'll explain each of these commands in detail.

[9] https://yarnpkg.com/en/
[10] https://expo.io/

Code Blocks and Context

Nearly every code block in this book is pulled from a runnable code example, which you can find in the sample code. For example, here is a code block pulled from the first chapter:

weather/1/App.js

```
import React from 'react';
import { StyleSheet, Text, View } from 'react-native';

export default class App extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <Text>Open up App.js to start working on your app!</Text>
      </View>
    );
  }
}

const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: '#fff',
    alignItems: 'center',
    justifyContent: 'center',
  },
});
```

Notice that the header of this code block states the path to the file which contains this code: `code/weather/1/App.js`.

This book is written with the expectation that you'll also be looking at the example code alongside the chapter. If you ever feel like you're missing the context for a code example, open up the full code file using your favorite text editor.

For example, we often need to import libraries to get our code to run. In the early chapters of the book we show these import statements, because it's not clear where the libraries are coming from otherwise. However, the later chapters of the book are more advanced and they focus on key concepts instead of repeating boilerplate code that was covered earlier in the book. If at any point you're not clear on the context, open up the code example on disk.

Getting Help

While we've made every effort to be clear, precise, and accurate you may find that when you're writing your code you run into a problem.

Generally, there are three types of problems:

- A "bug" in the book (e.g. something is explained incorrectly)
- A "bug" in our code
- A "bug" in your code

If you find an inaccuracy in our description of something, or you feel a concept isn't clear, email us! We want to make sure that the book is both accurate and clear.

Similarly, if you've found a bug in our code we definitely want to hear about it.

If you're having trouble getting your own app working (and it isn't *our* example code), this case is a bit harder for us to handle. If you're still stuck, we'd still love to hear from you, and here some tips for getting a clear, timely response.

Emailing Us

If you're emailing us asking for technical help, here's what we'd like to know:

- What revision of the book are you referring to?
- What operating system are you on? (e.g. Mac OS X 10.8, Windows 95)
- Which chapter and which example project are you on?
- What were you trying to accomplish?

- What have you tried already?
- What output did you expect?
- What actually happened? (Including relevant log output.)

The absolute best way to get technical support is to send us a short, self-contained example of the problem. Our preferred way to receive this would be for you to send us an Expo Snack link[11]. Snack is an online code editor that let's one quickly develop and demo React Native components on the browser or an actual device without having to set up a brand new project. We'll explain Expo in more detail in the next chapter.

When you've written down these things, email us at **rn@fullstack.io**. We look forward to hearing from you.

[11] https://snack.expo.io/

Getting Started with React Native

Weather App

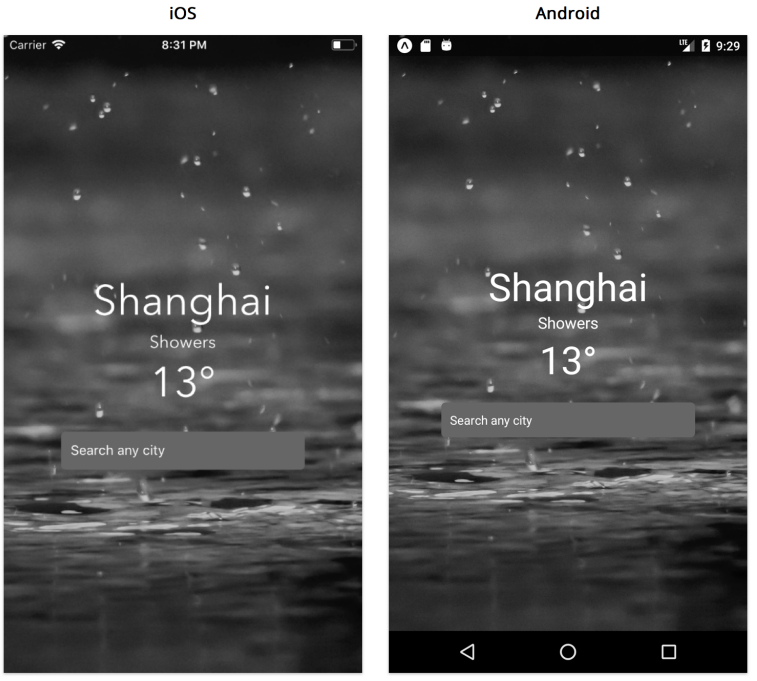
In this chapter we're going to build a weather application that allows the user to search for any city and view its current forecast.

With this simple app we'll cover some essentials of React Native including:

- Using core and custom components
- Passing data between components
- Handling component state
- Handling user input
- Applying styles to components
- Fetching data from a remote API

By the time we're finished with this chapter, you'll know how to get started by building a basic application with local state management. You'll have the foundation you need to build a wide variety of your own React Native apps.

Here's a screenshot of what our app will look like when it's done:



The completed app

In this chapter, we'll build an entire React Native application from scratch. We'll talk about how to set up our development environment and how to initialize a new React Native application. We'll also learn how Expo allows us to rapidly prototype and preview our application on our mobile device. After covering some of the basics of React Native, we'll explore how we compose apps using *components*. Components are a powerful paradigm for organizing views and managing dynamic data.

We're about to touch on a wide variety of topics, like styling and data management. This chapter will exhibit how all these topics fit together at a high-level. In subsequent chapters, we'll dive deep into the concepts that we touch on here.

Code examples

This book is example-driven. Each chapter is set up as a hands-on tutorial.

We'll be building apps from the ground up. Included with this book is a download that contains completed versions of each app as well as each of the versions we develop

along the way (the "sample code.") If you're following along, we recommend you use the sample code for copying and pasting longer examples or debugging unexpected errors. If you're not following along, you can refer to the sample code for more context around a given code example.

The structure of the sample code for all the chapters in this book follows this pattern:

```
├── components/
├── App.js
├── 1/
│   ├── components/
│   └── App.js
├── 2/
│   ├── components/
│   └── App.js
├── 3/
│   ├── components/
│   └── App.js
// ...
```

At the top-level of the directory is `App.js` and `components/`. This is the code for the completed version of the application. Inside the numbered folders (`1/`, `2/`, `3/`) are the different versions of the app as we build it up throughout the chapter.

Here's what a code example in this book looks like:

weather/1/App.js

```
  render() {
    return (
      <View style={styles.container}>
        <Text>Open up App.js to start working on your app!</Text>
      </View>
    );
  }
```

Note that the title of the code block contains the path within the sample code where you can find this example (`weather/1/App.js`).

JavaScript

This book assumes some JavaScript knowledge.

React Native uses Babel[12] as a JavaScript compiler to allow us to develop in the latest version of JavaScript, regardless of what version the underlying platform supports. To understand what we mean by JavaScript versions, you can refer to the Appendix.

We highlight some of JavaScript's newer features in the Appendix. We reference the appendix when relevant.

Starting the project

yarn

We can install all the required tools to begin our project by using `yarn`. `yarn`[13] is a JavaScript package manager – it *automates* the process of managing all the required dependencies from npm, an online repository of published JavaScript libraries and projects, in an application. This is done by defining all our dependencies in a single `package.json` file.

You can refer to the documentation[14] for instructions to install `yarn` for your operating system. The documentation also explains how to install node[15] as well. In order to use the Expo CLI however, `Node.js` v6 or later is required.

Here's a list of some commonly used `yarn` commands:

- `yarn init` creates a `package.json` file and adds it directly to our project.
- `yarn` installs all the dependencies listed in `package.json` into a local `node_modules` folder.
- `yarn add new-package` will install a specific package to our project as well as include it as a dependency in `package.json`. Dependencies are packages needed when we run our code.

[12] https://babeljs.io/
[13] https://yarnpkg.com
[14] https://yarnpkg.com/lang/en/docs/install
[15] https://nodejs.org/en/

- `yarn add new-package --dev` will install a specific package to our project as well as include it as a *development* dependency in `package.json`. Development dependencies are packages needed only during the development workflow. They are not needed for running our application in production.
- `yarn global add new-package` will install the package globally, rather than locally to a specific project. This is useful when we need to use a command line tool anywhere on our machine.

If you're already familiar with `npm` and have it installed, you may use it instead of `yarn` and run its equivalent commands[16]. These tools both manage dependencies specified in a `package.json` file. However, we find that `yarn` results in signficantly more consistent builds when working with React Native, so we recommend using `yarn`.

Watchman

Watchman[17] is a file watching service that watches files and triggers actions when they are modified. If you use macOS as your operating system, the Expo and React Native documentation recommend installing Watchman for better performance. The instructions to install the service can be found here[18].

Expo

Expo[19] is a platform that provides a number of different tools to build fully functional React Native applications without having to write native code. If you've used Create React App[20] before, you'll notice similarities in that no build configuration is required to get up and running.

Building an application also does not require using Xcode for iOS, or Android Studio for Android. This means that developers can build native iOS applications without

[16] https://yarnpkg.com/lang/en/docs/migrating-from-npm/#toc-cli-commands-comparison
[17] https://facebook.github.io/watchman/
[18] https://facebook.github.io/watchman/docs/install.html#installing-on-os-x-via-homebrew
[19] https://expo.io/
[20] https://github.com/facebookincubator/create-react-app

even owning a Mac computer. Using Expo is the easiest way to get started with React Native and is recommended in the React Native documentation[21].

Expo provides two local development tools that allow us to build, preview, share and publish React Native projects:

- **Expo client app**: A client iOS/Android mobile application for previewing projects.
- **Expo CLI**: A local development tool for building React Native projects with no build configuration. This is done through Create React Native App, which is merged directly with the CLI.

Including Native Code

The Expo CLI is not the only way to start a React Native application. If we need to start a project with the ability to include native code, we'll need to use the React Native CLI[a] instead. With this however, our application will require Xcode and Android Studio for iOS and Android respectively.

Expo also provides a number of different APIs for device specific properties such as contacts, camera and video. However, if we need to include a native iOS or Android dependency that is not provided by Expo, we'll need to *eject* from the platform entirely. Ejecting an Expo application means we have full control of managing our native dependencies, but we would need to use the React Native CLI from that point on.

We'll explore how to use React Native CLI and add native modules to a project later on in this book.

[a] https://facebook.github.io/react-native/docs/getting-started.html#installing-dependencies

Previewing with the Expo client

To develop and preview apps with Expo, we need to install its client iOS or Android app[22] to develop and run React Native apps on our device.

[21] https://facebook.github.io/react-native/docs/getting-started.html
[22] https://github.com/expo/expo

Android

On your Android mobile device, install the Expo client on Google Play[23]. You can then select `Scan QR code` and scan this QR code once you've installed the app:

QR Code

If this QR code doesn't work, we recommend making sure you have the latest version of that Expo app installed, and that you're reading the latest edition of this book.

Instead of scanning the QR code, you can also type the project URL, `exp://exp.host/@fullstackio/weather`, inside of Expo to load the application.

iOS

You can install the Expo client via the App Store[24]. With an iOS device however, there is no capability to scan a QR code. This means we'll first need to build the final app in order to preview it. We can do this by navigating to the `weather/` directory in the sample code folder and running the following commands:

```
cd weather
yarn
yarn start
```

This will start the React Native packager. Pressing `e` will allow you to send a link to your device by SMS or e-mail (you'll need to provide your mobile phone number

[23] https://play.google.com/store/apps/details?id=host.exp.exponent
[24] https://itunes.apple.com/us/app/expo-client/id982107779?mt=8

or email address). Once done, clicking the link will open the application in the Expo client.

For the app to load on your physical device, you'll need to make sure that your phone is connected to the same local network as your computer.

Using a supported version

The Expo client app only supports the most recent 5 or 6 releases of Expo and React Native. This book uses Expo SDK 33 (React Native version 0.59). If you're reading this book more than 6 months after the release date, you may receive an error indicating the Expo version of your project is too old if you try to run your app in the Expo client. You can upgrade to the latest version of Expo and React Native by referring to the upgrade guide for your current version in the documentation[25].

Most of the time, updates don't cause significant API changes. However, if you purchased a digital copy of the book, we recommend you download an updated version of the book just in case.

Preparing the app with the CLI

At this point, you should see the final application load successfully on your device. Play around with the app for a few minutes to get a feel for it. Try searching for different cities as well a location that doesn't even exist.

If you plan on building the application as you read through the chapter, you'll need to create a brand new project. Once `yarn` is installed, let's run the following command to install the Expo CLI globally:

```
yarn global add expo-cli@2.5.0
```

The `@2.5.0` specifies the *version* of `expo-cli` to install. It's important to lock in version `2.5.0` so that the version on your machine matches that here in the book.

We'll call our application `weather` and can use the following command to get started:

[25] https://docs.expo.io/versions/latest/workflow/upgrading-expo

```
expo init weather --template blank@sdk-33 --yarn
```

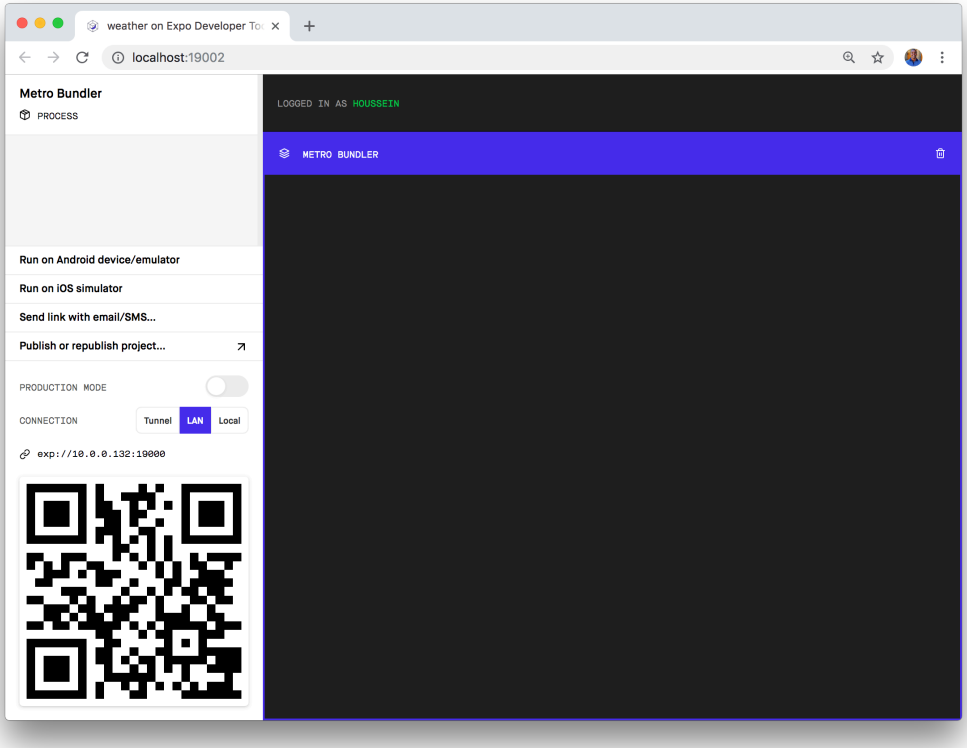
The CLI will take a few minutes to download and extract all the project files. We used the `--template` option to specify that we want the *blank* template built with Expo SDK 33. We used the `--yarn` option to use `yarn` instead of `npm` for installing dependencies. Navigate to the `weather` directory once that command is finished to boot the app:

```
cd weather
yarn start
```

Once the project has finished starting, you should see some information outputted to the console.

With the packager running, scanning the QR code with an Android device or sending a link directly to an iOS device using the `e` hotkey will allow you to preview the application. It is important to remember that a device needs to be connected to the same local network as the computer in order for this to work.

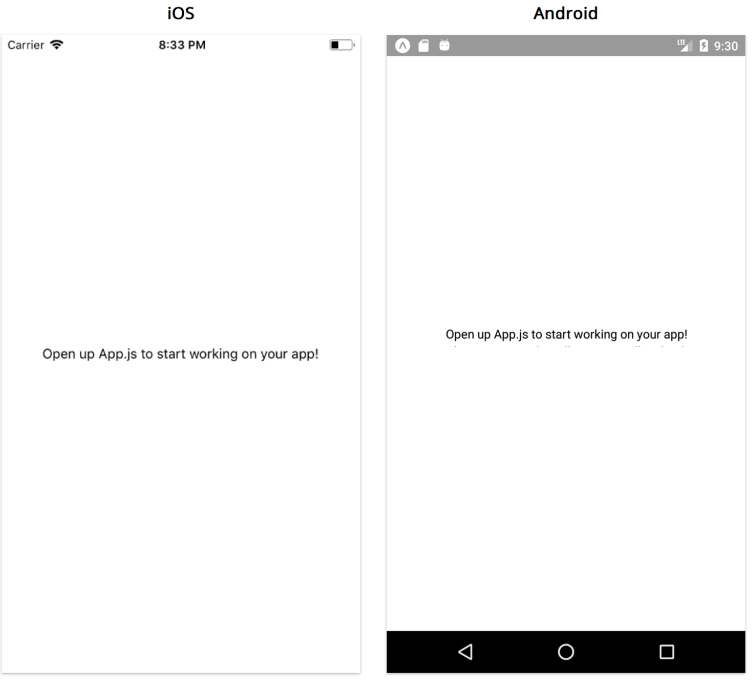
Secondly, a browser tab that renders Expo's Developer Tools should have also opened for you automatically.



Expo Developer Tools

With Expo DevTools, you can see outputted logs easier as well as perform a number of actions, such as sending an email link, directly through its interface instead of typing into the console if you prefer.

Open the application with your Android device by using the QR code or by sending a link to your iOS device. Once it finishes loading, we should see the starting point:



Application

Running on a simulator

As we mentioned, using the Expo client app allows us to run our application without using native tooling (Xcode for iOS, or Android Studio for Android).

However if we happen to have the required build tools we can still run our application in a virtual device or simulator:

- With a Mac, `yarn run ios` will start the development server and run the application in an iOS simulator. We can also start the packager separately with `yarn start` and press `i` to open the simulator.
- With the required Android tools[26], `yarn run android` will start the application in an Android emulator. Similarly, pressing `a` when the React Native packager is running will also boot up the emulator.

Running an application using an emulator/simulator can be useful to test on different devices and screen sizes. It can also be quicker to update and test code changes on a virtual device. However, it's important to run your application on an actual device at some point in order to get a better idea of how exactly it looks and feels.

By default, the Expo CLI comes with *live reload* enabled. This means if you edit and save any file, the application on your mobile device will **automatically reload**. Moreover, any build errors and logs will be displayed directly in the terminal.

Let's see what the directory structure of our app looks like. Open up a new terminal window.

Navigate to this app:

```
cd weather
```

And then run `ls -a` to see all the contents of the directory:

```
ls -a
```

[26] https://facebook.github.io/react-native/docs/getting-started.html

If you're using PowerShell or another non-Unix shell, you can just run `ls`.

Although your output will look slightly different based on your operating system, you should see all the files in your directory listed:

```
├── .expo/
├── assets/
├── node_modules/
├── .gitignore
├── .watchmanconfig
├── App.js
├── app.json
├── babel.config.js
├── package.json
```

Let's go through each of these files:

- `.expo/` contains files that define configurations for the Expo packager and for device connection settings.
- `.assets/` contains a few image assets by default. These are the app icon and splash screen images.
- `node_modules/` contains all third party packages in our application. Any new dependencies and development dependencies go here.
- `.gitignore` is where we specify which files should be ignored by Git. We can see that both the `node_modules/` and `.expo/` directories are already included.
- `.watchmanconfig` defines configurations for Watchman.
- `App.js` is where our application code lives.
- `app.json` is a configuration file that allows us to add information about our Expo app. The list of properties that can be included in this file is listed in the documentation[27]. Examples of properties that can be changed here include the app icon and splash screen.

[27] https://docs.expo.io/versions/latest/workflow/configuration

- `.babel.config.js` allows us to define presets and plugins for configuring Babel[28]. As we mentioned previously, Babel is a transpiler that compiles newer experimental JavaScript into older versions so that it stays compatible with different platforms.
- `package.json` is where we provide information of the application to our package manager as well as specify all our project dependencies.

package.json

Let's take a closer look at the generated `package.json` file:

```
{
  "name": "empty-project-template",
  "main": "node_modules/expo/AppEntry.js",
  "private": true,
  "scripts": {
    "start": "expo start",
    "android": "expo start --android",
    "ios": "expo start --ios",
    "eject": "expo eject"
  },
  "dependencies": {
    "expo": "^33.0.0",
    "react": "16.8.3",
    "react-native": "https://github.com/expo/react-native/archive/sdk-3\
3.0.0.tar.gz"
  },
  "devDependencies": {
    "babel-preset-expo": "^5.0.0"
  }
}
```

The `scripts` property contains all the commands needed to run the application. `yarn start`, `yarn run android`, and `yarn run ios` allow us to start the application

[28] https://babeljs.io/

development server and/or run on a virtual device or simulator. `yarn run eject` starts the process of ejecting the application from the Expo toolchain. As we mentioned earlier, this can be necessary if we need to include a React Native library that contains native code or if we need to write native code ourselves.

The `dependencies` and `devDependencies` properties define the application and development dependencies respectively. Expo, the React core library and the version of React Native needed for this specific version of Expo are all included as dependencies. `babel-preset-expo`, a Babel preset that contains a number of predefined Babel plugins, is the only development dependency included by default.

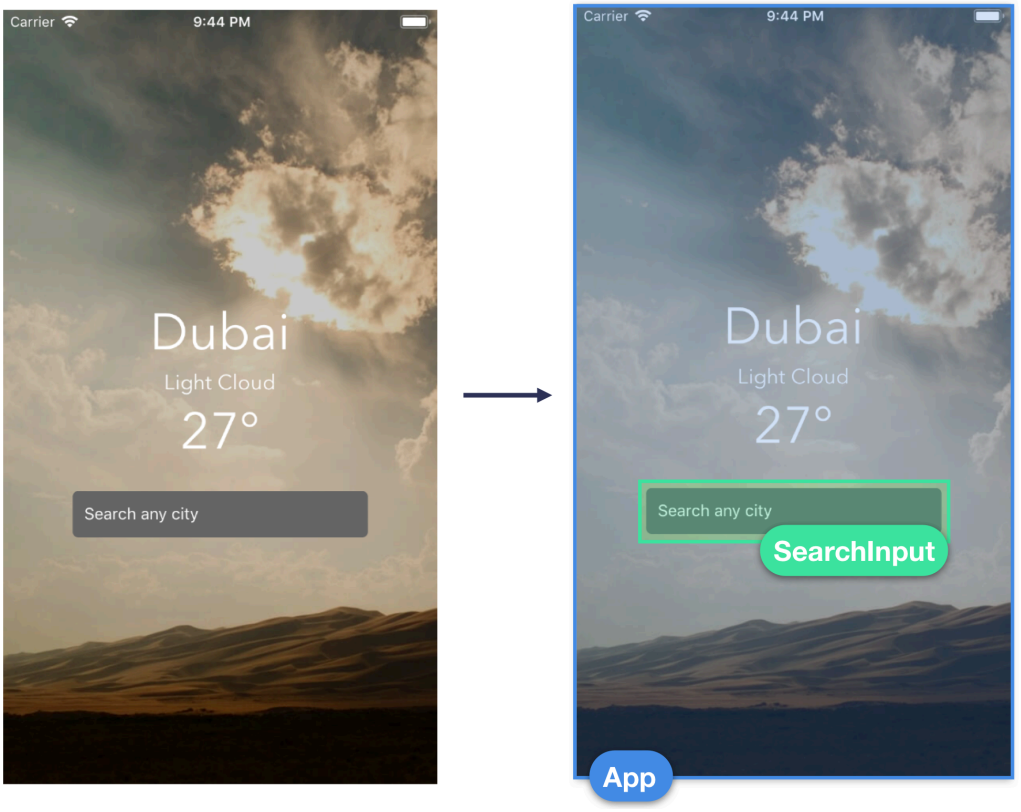
The `utils/` directory

If you look at the book's sample code, you'll note that every application has a `utils/` directory. This directory contains helper functions that the application will use. You don't need to concern yourself with the details of these functions as they're not relevant to the chapter's core concepts.

When we reach the point in the application's development where we need to use a utility provided by `utils/`, we'll remind you to copy over that folder from the sample code. You can also do this immediately after initializing each project.

Components

With newer versions of JavaScript, we can define objects with properties using *classes*. React Native lets us use this syntax to create *components*. Let's take a look at a visual breakdown of the components in our application:



Component Structure

We have an `App` component that represents the entire *screen* and contains the weather information displayed to the use. Inside of this component, we have a `SearchInput` component that allows us to search for different cities.

App

`App` is the only component created with a default application using a blank template. Let's take a look at its file:

weather/1/App.js

```
import React from 'react';
import { StyleSheet, Text, View } from 'react-native';

export default class App extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <Text>Open up App.js to start working on your app!</Text>
      </View>
    );
  }
}

const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: '#fff',
    alignItems: 'center',
    justifyContent: 'center',
  },
});
```

Notice how we have a class defined in our file named `App` that extends `React.Component`. Using `extends` allows us to declare a class as a subclass of another class. In here, we've defined `App` as a subclass of `React.Component`. This is how we specify a specific class to be a *component* in our application.

If you'd like to learn more about how classes work in JavaScript, refer to our Appendix.

We can also attach methods as properties to classes, and the same applies to component classes in React Native. We can see we already have one for this component, the `render` method:

weather/1/App.js

```
5   render() {
6     return (
7       <View style={styles.container}>
8         <Text>Open up App.js to start working on your app!</Text>
9       </View>
10    );
11  }
```

What we see on our device when launching our device matches what we see described in this method. **The `render()` method is the only required method for a React Native component**. React Native uses the return value from this method to determine what to render for the component.

When we use React Native, we represent different parts of our application as **components**. This means we can build our app using different reusable pieces of logic with each piece displaying a specific part of our UI. Let's break down what we already have in terms of components:

- Our entire application is rendered with `App` as our top-level component. Although created automatically as part of setting up a new Expo CLI project, this component is a custom component responsible for rendering what we need in our application.
- The `View` component is used as a layout container.
- Within `View`, we use the `Text` component to display lines of text in our application. Unlike `App`, both `View` and `Text` are **built-in** React Native components that are imported and used in our custom component.

We can see that our `App` component uses and returns an HTML-like structure. This is **JSX**, which is an extension of JavaScript that allows us to use an XML-like syntax to define our UI structure.

JSX

When we build an application with React Native, components ultimately render native views which are displayed on our device. As such, the `render()` method of a

component needs to describe how the view should be represented. In other words, React Native allows us to describe a component's iOS and Android representation in JavaScript.

JSX was created to make the JavaScript representation of components easier to understand. It allows us to structure components and show their hierarchy visually in markup. Consider this JSX snippet:

```
<View>
  <Text style={{ color: 'red' }}>
    Hello, friend! I am a basic React Native component.
  </Text>
</View>
```

In here, we've nested a `Text` component within a `View` component. Notice how we use braces (`{}`) around an object (`{ color: 'red' }`) to set the style property value for `Text`. In JSX, braces are a delimiter, signaling to JSX that what resides in-between the braces is a JavaScript expression. The other delimiter is using quotes for strings, like this:

```
<TextInput placeholder="This is a string" />
```

Even though the JSX above might look similar to HTML, it is actually just compiled into JavaScript function calls (ex: `React.createElement(View)`). For this reason, we need to import `React` at the top of any file that contains JSX. You can refer to the Appendix for more detail.

During runtime React Native takes care of rendering the actual native UI for each component.

Props

We use the imported `Text` component to wrap each line of text output for our `App` component:

```
<Text>Open up App.js to start working on your app!</Text>
```

And we use the imported `View` component to wrap all the `Text` components:

```
<View style={styles.container}>
...
</View>
```

Props allow us to pass parameters to components to customize their features. Here, `View` is used to layout the entire content of the screen. We only have a single prop attached, `style`, that allows us to pass in style parameters to adjust how our `View` component is rendered on our devices. Each built-in component provided by React Native has its own set of valid props that we can use for customization.

> If you're familiar with HTML, it's very similar. For example, in HTML, say you wanted to insert an image named `image.png`. You'd specify an `img` tag with a `src` attribute like this:
>
> ```
> <img src="path/to/image.png">
> ```
>
> To give you an idea of the similarity, in React Native we can include images using the `Image` component. We specify the location using the `source` prop:
>
> ```
> <Image source={require('./image.png')}>
> ```
>
> We'll cover images in greater detail later.

Like our `View` component, many components in React Native accept a `style` prop. Styling is a large topic that we explore throughout this book. However, we can take a look at our `styles` object at the bottom of `App.js` and get an idea of how it works:

weather/1/App.js

```
14 const styles = StyleSheet.create({
15   container: {
16     flex: 1,
17     backgroundColor: '#fff',
18     alignItems: 'center',
19     justifyContent: 'center',
20   },
21 });
```

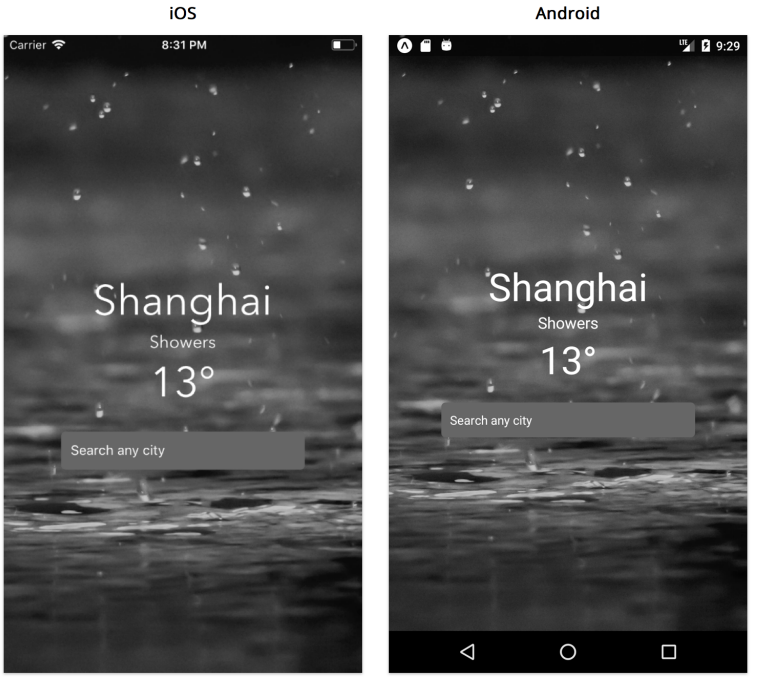
Web developers may recognize that this looks like CSS (Cascading Style Sheets) which is used to style web pages. It's important to note that styling in React Native *does not* use CSS. However, React Native borrows a lot of styling nomenclature from web development. Here, we specify that the text should be centered and that the background color should be white (`#fff`).

If you've used CSS before, you'll find styling in React Native very familiar. If not, don't worry! It's easy to get the hang of it.

Specifically, `styles.container` has the attributes `flex`, `alignItems` and `justifyContent`. These are used to position the `View` in the center of the screen. React Native uses **flexbox** to layout and align items consistently on different device sizes. We'll go into more detail about how exactly flexbox works in later chapters.

To build our weather app, we'll start with layout and styling. Once we have some of the essence of our weather app in place we can begin to explore strategies for managing data.

As we saw in the completed version of the app, we want our app to display the **city**, **temperature**, and **weather conditions** as separate text fields. Although we'll eventually interface with a weather API in order to retrieve actual data, we'll begin with hard-coding these values.



The completed app

Adding styles

To get a better handle on styling, let's try adding an object with a color attribute to one of the text fields:

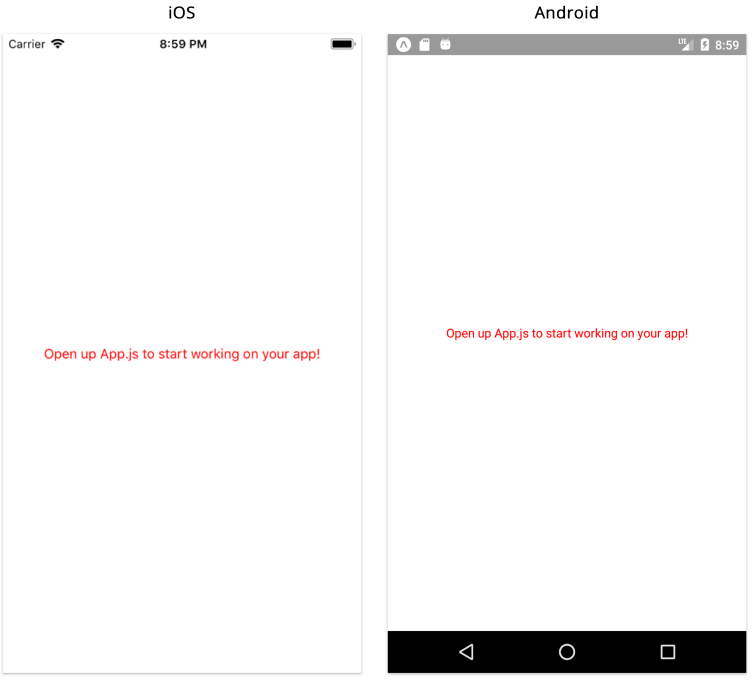
```
<View style={styles.container}>
  <Text style={{ color: 'red' }}>
    Open up App.js to start working on your app!
  </Text>
</View>
```

Note that the outer-most set of brackets above are *delimiters* enclosing our JavaScript statement. Inside of the delimiters is a JavaScript object. In React Native, if the object is small enough it's common to just write it all on one line.

However, the double brackets (`{{}}`) might be confusing. Here's another way of writing the same component:

```
const style = { color: 'red' };

return (
  <View style={styles.container}>
    <Text style={style}>
      Open up App.js to start working on your app!
    </Text>
```

Save `App.js`. We can see our style applied once the application reloads:



As we mentioned previously, **live reload** is enabled by default in Expo. This means that with any change to the code, the application will reload immediately. If you happen to not see any changes reflected as soon as you save the file, you may have to check to see if this is enabled. The documentation[29] explains how to open up the developer menu and enable/disable the feature.

Although we can style our entire component this way, a lot of *inline* styles (or style attributes defined directly *within* the delimeter of the `style` prop) used in a component can make things harder to read and digest.

We can solve this by leveraging React Native's `Stylesheet` API to separate our styles from our component. With `Stylesheet`, we can create styles with attributes similar to CSS stylesheets. We can see that `Stylesheet` is already imported at the top of the file. It's used to declare our first style, `styles.container`, which we use for `View`. We can add a new style called `red` to our `styles`:

[29] https://docs.expo.io/versions/latest/guides/up-and-running.html#cant-see-your-changes

```
const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: '#fff',
    alignItems: 'center',
    justifyContent: 'center',
  },
  red: {
    color: 'red',
  },
});
```

We'll then have `Text` use this style:

```
<View style={styles.container}>
  <Text style={styles.red}>
    Open up App.js to start working on your app!
  </Text>
</View>
```

If we save our file and take a look at our app, we can see that the end result is the same.

Now let's add some appropriate styles and text fields in order to display some weather data for a location. To add multiple styles to a single component, we can pass in **an array of styles**:

weather/2/App.js

```
17          <Text style={[styles.largeText, styles.textStyle]}>
18            San Francisco
19          </Text>
20          <Text style={[styles.smallText, styles.textStyle]}>
21            Light Cloud
22          </Text>
23          <Text style={[styles.largeText, styles.textStyle]}>24°</Text>
```

It is important to mention that when passing an array, the styles at the end of the array take precedence over earlier styles, in case of any repeated attributes. We can see that we're referencing three new styles; `textStyle`, `smallText`, and `largeText`. Let's define these within our `styles` object:

weather/2/App.js

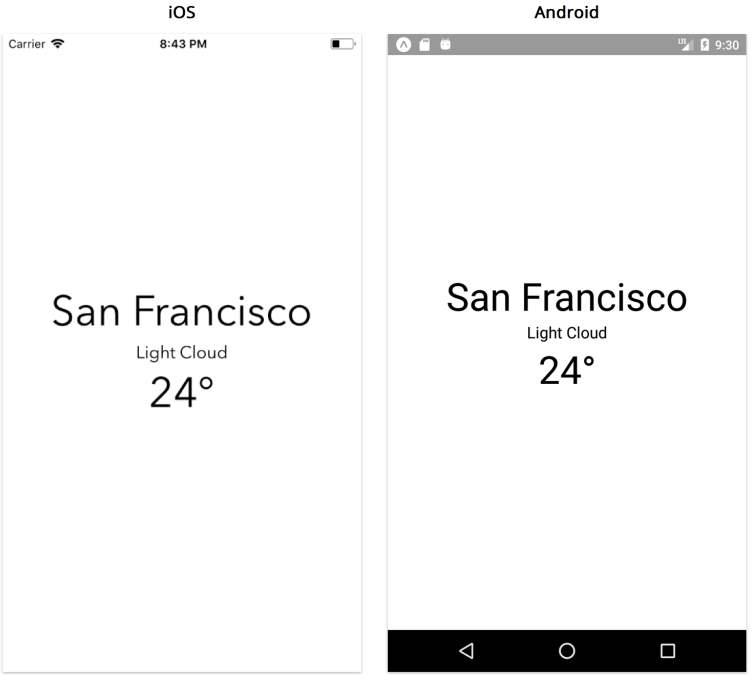
```
36  const styles = StyleSheet.create({
37    container: {
38      flex: 1,
39      backgroundColor: '#fff',
40      alignItems: 'center',
41      justifyContent: 'center',
42    },
43    textStyle: {
44      textAlign: 'center',
45      fontFamily:
46        Platform.OS === 'ios' ? 'AvenirNext-Regular' : 'Roboto',
47    },
48    largeText: {
49      fontSize: 44,
50    },
51    smallText: {
52      fontSize: 18,
53    },
```

- `textStyle` specifies an alignment (`center`) as well as the `fontFamily`. Notice how we use `Platform` to define platform specific fonts for both iOS and Android. We do this because both operating systems provide a different set of native fonts.
- `smallText` and `largeText` both specify different font sizes.

`Platform` is a built-in React Native API. We'll need to make sure to import it:

```
import { StyleSheet, Text, View, Platform } from 'react-native';
```

Let's take a look at our application now:



Styled Text

Platform specific properties

The `Platform` API allows us to conditionally apply different styles or properties in our component based on the device's operating system. The `OS` attribute of the object returns either `ios` or `android` depending on the user's device.

Although this is a relatively simple way to apply different properties in our application based on the user's device, there may be scenarios where we may want our component to be substantially different between operating systems.

We can also use the `Platform.select` method that takes the operating system as keys within an object and returns the correct result based on the device:

```
textStyle: {
  textAlign: 'center',
  ...Platform.select({
    ios: {
      fontFamily: 'AvenirNext-Regular',
    },
    android: {
      fontFamily: 'Roboto',
    },
  }),
},
```

Separate files

Instead of applying conditional checks using `Platform.OS` a number times throughout the entire component file, we can also leverage the use of **platform specific files** instead. We can create two separate files to represent the same component each with a different extension: `.ios.js` and `.android.js`. If both files export the same component class name, the React Native packager knows to choose the right file based on the path extension. We'll dive deeper into platform specific differences later in this book.

Text input

We now have text fields that display the location, weather condition, and temperature. The next thing we need to do is provide some sort of input to allow the user to search for a specific city. Again, we'll continue using hardcoded data for now. We'll only begin using an API for real data once we have all of our components in place.

React Native provides a built-in `TextInput` component that we can import into our component that allows us to accept user input. Let's include it within our `View` container underneath the `Text` components (make sure to import it as well!):

weather/2/App.js

```
        <Text style={[styles.largeText, styles.textStyle]}>
          San Francisco
        </Text>
        <Text style={[styles.smallText, styles.textStyle]}>
          Light Cloud
        </Text>
        <Text style={[styles.largeText, styles.textStyle]}>24°</Text>

        <TextInput
          autoCorrect={false}
          placeholder="Search any city"
          placeholderTextColor="white"
          style={styles.textInput}
          clearButtonMode="always"
        />
```

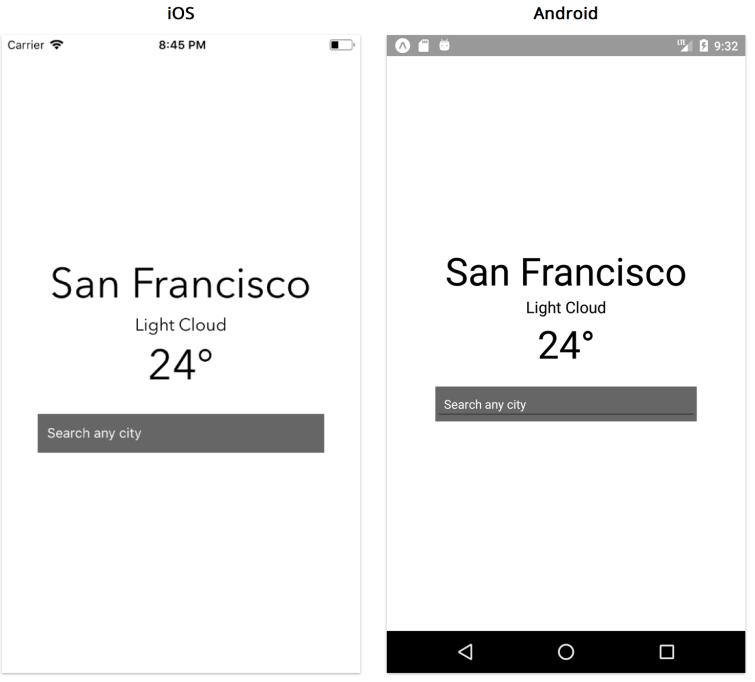
`TextInput` here is being referenced using a *self-closing* tag (`<TextInput />`). JSX allows us to use this shorthand version instead of an opening and closing tag (`<TextInput></TextInput>`) when a component has no children elements nested within.

There are a number of props associated with `TextInput` that we can use. We'll cover the basics here but go into more detail about them in the "Core Components" chapter. Here we're specifying a placeholder, its color, as well as a style for the component itself. Let's create its style object, `textInput`, underneath our other styles:

weather/2/App.js

```
  smallText: {
    fontSize: 18,
  },
  textInput: {
    backgroundColor: '#666',
    color: 'white',
    height: 40,
    width: 300,
    marginTop: 20,
    marginHorizontal: 20,
    paddingHorizontal: 10,
    alignSelf: 'center',
  },
```

As we mentioned previously, all the attributes that we provide styles with in React Native are extremely similar to how we would apply them using CSS. Now let's take a look at our application:



Text Input

We can see that the text input has a default underline on Android. We'll go over how to remove this in a bit.

We've also specified the `clearButtonMode` prop to be `always`. This shows a button on the right side of the input field when characters are inserted that allows us to clear the text. This is only available on iOS.

Text Input Clear Button

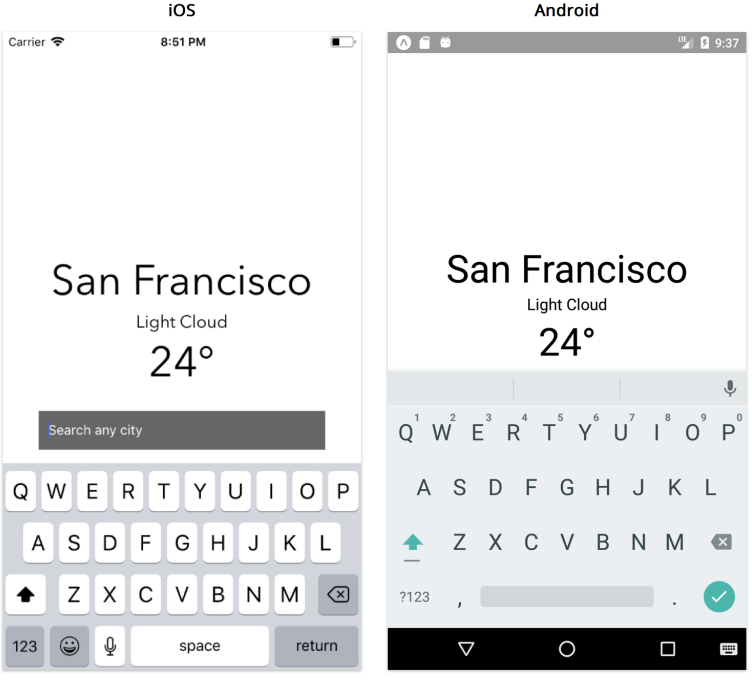
We can now type into the input field!

If you're using the iOS simulator, you can connect your hardware keyboard and use that with any input field. This can be done with `Shift + ⌘ + K` or going to `Hardware -> Keyboard -> Connect Hardware Keyboard`

With this enabled, the software keyboard may not show by default. You can toggle this by pressing `⌘ + K` or going to `Hardware -> Keyboard -> Toggle Software Keyboard`

Now every time you click an input field, the software keyboard will display exactly how it would if you were using a real device and you can type using your hardware keyboard.

However one thing you may have noticed is that when you focus on the input field with a tap, the keyboard pops up and covers it on Android and comes quite close on iOS:



Keyboard

Since the virtual keyboard can cover roughly half the device screen, this is a common problem that occurs when using text inputs in an application. Fortunately, React

Native includes `KeyboardAvoidingView`, a component that solves this problem by allowing us to adjust where other components render in relation to the virtual keyboard. Let's import and use this component instead of `View`:

weather/2/App.js

```
render() {
  return (
    <KeyboardAvoidingView
      style={styles.container}
      behavior="padding"
    >
      <Text style={[styles.largeText, styles.textStyle]}>
        San Francisco
      </Text>
      <Text style={[styles.smallText, styles.textStyle]}>
        Light Cloud
      </Text>
      <Text style={[styles.largeText, styles.textStyle]}>24°</Text>

      <TextInput
        autoCorrect={false}
        placeholder="Search any city"
        placeholderTextColor="white"
        style={styles.textInput}
        clearButtonMode="always"
      />
    </KeyboardAvoidingView>
  );
}
```

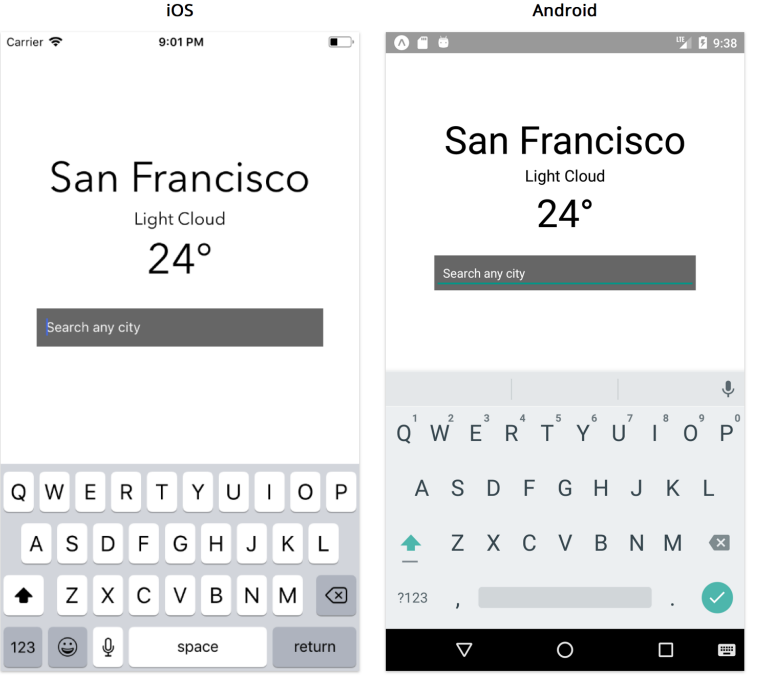
Notice that `KeyboardAvoidingView` accepts a `behavior` prop with which we can customize how the keyboard adjusts. It can change its height, position or bottom padding in relation to the position of the virtual keyboard. Here, we've specified `padding`.

And finally, it's important to double check our imports to make sure we have everything that we're using:

weather/2/App.js

```
import React from 'react';
import {
  StyleSheet,
  Text,
  KeyboardAvoidingView,
  Platform,
  TextInput,
} from 'react-native';
```

Now tapping the text input will shift our component text and input fields out of the way of the software keyboard.



Keyboard Avoiding View

Custom components

So far, we've explored how to add styling into our application, and we've included some built-in components into our main `App` component. We use `View` as our component container and import `Text` and `TextInput` components in order to display hardcoded weather data as well as an input field for the user to change locations.

It's important to re-iterate that React Native is **component-driven**. We're already representing our application in terms of components that describe different parts of our UI without too much effort, and this is because React Native provides a number of different built-in components that you can use immediately to shape and structure your application.

However, as our application begins to grow, it's important to begin thinking of how it can further be broken down into smaller and simpler chunks. We can do this by creating **custom components** that contain a small subset of our UI that we feel fits better into a separate, distinct component file. This is useful in order to allow us to further split parts of our application into something more manageable, reusable and testable.

Although our application in its current state isn't extremely large or unmanageable, there's still some room for improvement. The first way we can refactor our component is to move our `TextInput` into a separate component to hide its implementation details from the main `App` component. Let's create a `components` directory in the root of the application with the following file:

```
├── components/
      - SearchInput.js
```

All the custom components we create that we use in our main `App` component will live inside this directory. For more advanced apps, we might create directories within `components` to categorize them more specifically. Since this app is pretty simple, let's use a flat `components` directory.

The `SearchInput` will be our first custom component so let's move all of our code for `TextInput` from `App.js` to `SearchInput.js`:

weather/3/components/SearchInput.js

```
import React from 'react';
import { StyleSheet, TextInput, View } from 'react-native';

export default class SearchInput extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <TextInput
          autoCorrect={false}
          placeholder={this.props.placeholder}
          placeholderTextColor="white"
          underlineColorAndroid="transparent"
          style={styles.textInput}
          clearButtonMode="always"
        />
      </View>
    );
  }
}

const styles = StyleSheet.create({
  container: {
    height: 40,
    width: 300,
    marginTop: 20,
    backgroundColor: '#666',
    marginHorizontal: 40,
    paddingHorizontal: 10,
    borderRadius: 5,
  },
  textInput: {
    flex: 1,
    color: 'white',
  },
});
```

Let's break down what this file contains:

- We export a component named `SearchInput`.
- This component accepts a `placeholder` prop.
- This component returns a React Native `TextInput` with a few of its properties specified wrapped within a `View`.
- We've applied the appropriate styles to our view container including a `borderRadius`.
- We also added `underlineColorAndroid="transparent"` to remove the dark underline that shows by default on Android.

`this` is a special keyword in JavaScript. The details about this are a bit nuanced, but for the purposes of the majority of this book, **`this` will be bound to the React Native component class**. So, when we write `this.props` inside the component, we're accessing the props property on the component. When we diverge from this rule in later sections, we'll point it out.

For more details on this, check out this page on MDN[30].

Custom props

As you may recall, in `App.js` we set the `placeholder` prop for `TextInput` to "Search any city." That renders the text input with a placeholder:

For `SearchInput`, we could hardcode a string again for `placeholder`. But what if we wanted to add a search input elsewhere in our application? It would be nice if `placeholder` was customizable.

[30] https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Operators/this

Earlier in this chapter, we explored how we can use `props` with a number of built-in components in order to customize their features. We can also *create* `props` for custom components that we build as well.

That's what we do here in `SearchInput`. The component accepts the prop `placeholder`. In turn, `SearchInput` uses this value to set the `placeholder` prop on `TextInput`.

The way data flows from parent to child in React Native is through props. When a parent renders a child, it can send along props the child depends on. A component can access all its props through the object `this.props`. If we decide to pass down the string `"Type Here"` as the `placeholder` prop, the `this.props` object will look like this:

```
{ "placeholder": "Type Here" }
```

In here, we'll set up `App` to render `SearchInput` which means that `App` is the *parent* of `SearchInput`. Our parent component will be responsible for passing down the actual value of `placeholder`.

We're getting somewhere interesting now. We've set up a custom `SearchInput` component and by building it to accept a `placeholder` prop, we're already setting it up to be configurable. Based on what it receives, it can render any placeholder message that we'd like.

Importing components

In order to use `SearchInput` in `App`, we need to import the component first. We can remove the `TextInput` logic from `App.js` and have `App` use `SearchInput` instead:

weather/3/App.js

```
import React from 'react';
import {
  StyleSheet,
  Text,
  KeyboardAvoidingView,
  Platform,
} from 'react-native';

import SearchInput from './components/SearchInput';

export default class App extends React.Component {
  render() {
    return (
      <KeyboardAvoidingView
        style={styles.container}
        behavior="padding"
      >
        <Text style={[styles.largeText, styles.textStyle]}>
          San Francisco
        </Text>
        <Text style={[styles.smallText, styles.textStyle]}>
          Light Cloud
        </Text>
        <Text style={[styles.largeText, styles.textStyle]}>24°</Text>

        <SearchInput placeholder="Search any city" />
      </KeyboardAvoidingView>
    );
  }
}
```

By moving the entire `TextInput` details into a separate component called `SearchInput`, we've made sure to not have any of its specific implementation details showing in

the parent component anymore. We can also remove the text input's styling defined within the `styles` object.

There's no specific answer to how often we should isolate different UI logic into separate custom components. React Native was built in order to allow us to lay out our entire application in terms of self-contained components, and that means we should separate parts of our application into distinct units with custom functionality attached to them. This allows us to build a more manageable application that's easier to control and understand. We've isolated knowledge of our search input to the component `SearchInput` and we'll continue to isolate specific pieces of our app throughout this chapter.

It's common to separate your imports into two groups: imports from dependencies, and imports from other files in your project. That's why we put a blank line above `SearchInput`. This comes down to personal style preference.

Background image

As we saw in the photo of the completed version of the app at the beginning of this chapter, we can make our application more visually appealing by displaying a background image that represents the current weather condition.

In this book's sample code, we've included a number of images for various weather conditions. If you inspect the `weather/assets` directory, you'll find images like `clear.png`, `hail.png`, and `showers.png`.

If you're following along, copy these two folders over from the sample code into your project:

1. `weather/assets`
2. `weather/utils`

We mentioned earlier that we've included a `utils/` folder for each project in the book's sample code. This folder contains helper functions that we'll use below.

If you're on macOS or Linux, you can use `cp -r` to copy directories:

```
cp -r weather/{assets,utils} ~/react-native-projects/weather/
```

With the `assets` and `utils` folders copied over, let's update our `App` component:

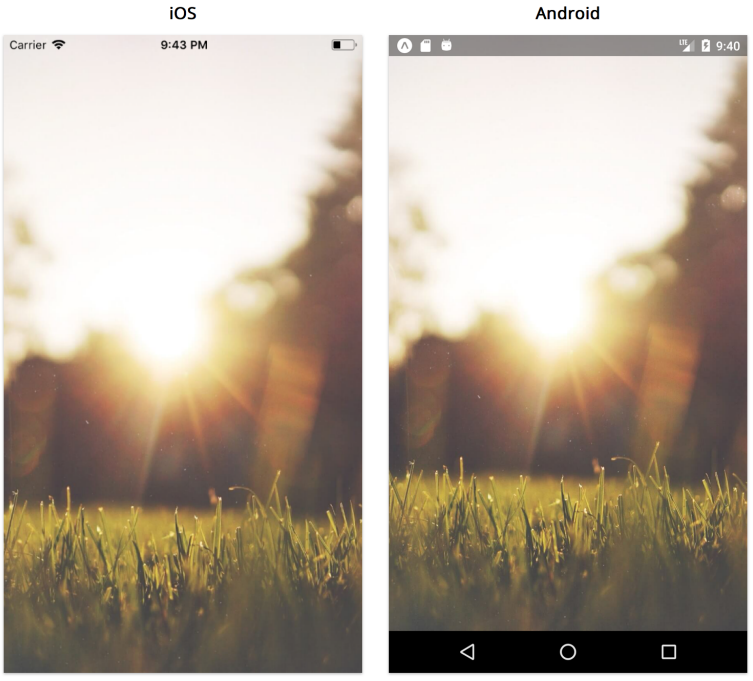
weather/4/App.js

```
import React from 'react';
import {
  StyleSheet,
  View,
  ImageBackground,
  Text,
  KeyboardAvoidingView,
  Platform,
} from 'react-native';

import getImageForWeather from './utils/getImageForWeather';

import SearchInput from './components/SearchInput';

export default class App extends React.Component {
  render() {
    return (
      <KeyboardAvoidingView
        style={styles.container}
        behavior="padding"
      >
        <ImageBackground
          source={getImageForWeather('Clear')}
          style={styles.imageContainer}
          imageStyle={styles.image}
        >
          <View style={styles.detailsContainer}>
```

```
            <Text style={[styles.largeText, styles.textStyle]}>
              San Francisco
            </Text>
            <Text style={[styles.smallText, styles.textStyle]}>
              Light Cloud
            </Text>
            <Text style={[styles.largeText, styles.textStyle]}>
              24°
            </Text>

            <SearchInput placeholder="Search any city" />
          </View>
        </ImageBackground>
      </KeyboardAvoidingView>
    );
  }
}
```

In this component, we're importing a `getImageForWeather` method from our `utils` directory which returns a specific image from the `assets` directory depending on a weather type.

For example, `getImageForWeather('Clear')` returns the following image:



Feel free to peek into the implementation details of any function we use from the `utils` directory to get a better idea of how it works.

We also import React Native's built-in `ImageBackground` component. Let's take a closer look at how we're making use of it in our render method:

weather/4/App.js

```
render() {
  return (
    <KeyboardAvoidingView
      style={styles.container}
      behavior="padding"
    >
      <ImageBackground
        source={getImageForWeather('Clear')}
        style={styles.imageContainer}
```

```
          imageStyle={styles.image}
        >
```

Conceptually, the `ImageBackground` component is a `View` with an `Image` nested within.

The `source` prop accepts an image location, which we've set to:

`getImageForWeather('Clear')`.

We know this will always return the image displayed above. `ImageBackground` also uses the prop `style` for styling the `View` container and the prop `imageStyle` for styling the image itself. Let's add two new styles and modify the `container` style:

weather/4/App.js

```
const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: '#34495E',
  },
  imageContainer: {
    flex: 1,
  },
  image: {
    flex: 1,
    width: null,
    height: null,
    resizeMode: 'cover',
  },
```

Defining component styles with a `flex` attribute mean that they will expand to take up any room remaining in their parent container in relation to any sibling components. They share this space in proportion to their defined `flex` values. Since `ImageBackground` is the only nested element within `KeyboardAvoidingView`, setting `imageContainer` to `flex: 1` means that this element will fill up the entire space of its parent component. We've removed `justifyContent` and `alignItems` from `container` so that the `ImageBackground` can take up the entire device screen.

We also used `flex: 1` to style the actual image itself, `image`, to make sure it takes up the entire space of its parent container. With images in particular, the component will fetch and use the actual width and height of the source image by default. For this reason, we've also set its `height` and `width` attribues to `null` so that the dimensions of the image fit the container instead. The `resizeMode` attribute allows us to define how the image is resized when the `Image` element does not match its actual dimensions. Setting this attribute to *cover* means that the image will scale uniformly until it is equal to the size of the component.

The "Core Components" chapter will dive deeper into how flexbox, layout, and the `Image` component work in React Native

We also wrapped all of our `Text` elements and `SearchInput` within a view container styled with `detailsContainer`:

weather/4/App.js

```
<View style={styles.detailsContainer}>
  <Text style={[styles.largeText, styles.textStyle]}>
    San Francisco
  </Text>
  <Text style={[styles.smallText, styles.textStyle]}>
    Light Cloud
  </Text>
  <Text style={[styles.largeText, styles.textStyle]}>
    24°
  </Text>

  <SearchInput placeholder="Search any city" />
</View>
```

Now let's set up its style:

weather/4/App.js

```
  detailsContainer: {
    flex: 1,
    justifyContent: 'center',
    backgroundColor: 'rgba(0,0,0,0.2)',
    paddingHorizontal: 20,
  },
```

Here, we're ensuring the container within `ImageBackground` also fills up the entire space of its parent component as well as have its items aligned at the center of the screen. We also add a semi-transparent overlay to our image by setting the `backgroundColor` of this component.

The last thing we'll need to do here is change our `Text` elements to white instead of black to show more clearly with a background image:

weather/4/App.js

```
  textStyle: {
    textAlign: 'center',
    fontFamily:
      Platform.OS === 'ios' ? 'AvenirNext-Regular' : 'Roboto',
    color: 'white',
  },
```

Try it out

Save the file and take a look at our app. We should now see the background image displayed!

Modifying location

The steps we've taken so far are quite common when starting React Native applications. We hardcode all our data, organize our app into components, and get an idea of the visual layout as well as how it breaks down into components.

However, our app really isn't very useful at this moment. If we take a look at our `SearchInput` component for instance, we can type anything into the input field but nothing actually happens as a result. We need to find a way to track changes made to the component and store that information somewhere. In other words, we need some piece of **mutable data** that updates whenever the user changes or submits the input field.

Instead of having `SearchInput` not actually manage any data that represents the text inputted by the user, let's pass in a `prop` for it called `location` to reflect what the user has inputted into the text input field:

```
render() {
  const location = 'San Francisco';

  return (
    <KeyboardAvoidingView
      style={styles.container}
      behavior="padding"
    >
      <ImageBackground
        source={getImageForWeather('Clear')}
        style={styles.imageContainer}
        imageStyle={styles.image}
      >
        <View style={styles.detailsContainer}>
          <Text style={[styles.largeText, styles.textStyle]}>
            {location}
          </Text>
          <Text style={[styles.smallText, styles.textStyle]}>
            Light Cloud
          </Text>
          <Text style={[styles.largeText, styles.textStyle]}>
            24°
          </Text>

          <SearchInput placeholder="Search any city" />
        </View>
```

```
      </ImageBackground>
    </KeyboardAvoidingView>
```

The reason we want to pass in the property that contains our `location` data is we need a way for our child component to modify that field and communicate back up to our container `App` component. Notice how we've moved the static string for `location` into a separate constant which we pass down to `SearchInput`. We've instantiated it as `San Francisco` so that it can show as the first location when the user loads the application. The next thing we just need to do is make sure that this `location` constant is updated when the user actually changes the field in `SearchInput`:

```
export default class SearchInput extends React.Component {
  handleChangeText(newLocation) {
    // We need to do something with newLocation
  }

  render() {
    return (
      <TextInput
        autoCorrect={false}
        placeholder={this.props.placeholder}
        placeholderTextColor="white"
        underlineColorAndroid="transparent"
        style={styles.textInput}
        clearButtonMode="always"
        onChangeText={this.handleChangeText}
      />
    );
  }
}
```

So what did we just do? We've just added `onChangeText` as a new prop to our `TextInput` component. Notice that we don't pass in a specific object or property, but a *function* instead:

```
  onChangeText={this.handleChangeText}
```

This method is invoked everytime the text within the input field is changed. A number of built-in components provided by React Native include *event-driven* props which we can attach specific methods to. We'll explore more throughout this book.

With `onChangeText`, our `TextInput` returns the changed text as an argument which we're attempting to pass into a separate method called `handleChangeText`. Currently our method is blank and we'll explore how we can complete it in a bit.

In React Native, we need to pass in functions when we want to handle certain events related to the component being referenced. For the `TextInput` component, `onChangeText` is set to fire every single time the text within the input field has changed. We need to "listen" to this specific event in our child component (`TextInput`) so that it can notify our parent component (`SearchInput`) to respond to this event. To do this, we pass in a function that calls another function, or in other words, a callback.

This is a common pattern when building components which need to notify a parent component of some event. Unfortunately with the way we've just set it up, it wouldn't work in this example. This is because the function `handleChangeText` has a different local scope than the component instance. We can work around this by binding our function to the correct context of its **`this`** object.

```
<TextInput
  placeholder={placeholder}
  placeholderTextColor="white"
  underlineColorAndroid="transparent"
  style={styles.textInput}
  clearButtonMode="always"
  onChangeText={this.handleChangeText.bind(this)}
/>
```

Now this might seem okay for the current context, but it can quickly become unwieldy if we build our components with `bind` statements in each event handler. One reason why is if we wanted to use `handleChangeText` in multiple different sub-components for example, we would have to make sure to `bind` it to the correct context

every single time. To help solve this, we can take care of handling our event using **property initializers**:

```
export default class SearchInput extends React.Component {
  handleChangeText = (newLocation) => {
    // We need to do something with newLocation
  }

  render() {
    return (
      <TextInput
        autoCorrect={false}
        placeholder={this.props.placeholder}
        placeholderTextColor="white"
        underlineColorAndroid="transparent"
        style={styles.textInput}
        clearButtonMode="always"
        onChangeText={this.handleChangeText}
      />
    );
  }
}
```

This allows us to declare the member methods as arrow functions:

```
  handleChangeText = (newLocation) => {
    // We need to do something with newLocation
  }
```

And we pass the method name to the prop and nothing more:

```
  onChangeText={this.handleChangeText}
```

Property Initializers

Supported by Babel[31], property initializers are still in the proposal phase and have not yet been slated for adoption in future JavaScript versions. Although this pattern is used quite often in many React and React Native applications, it is important to keep in mind that it is still *experimental* syntax.

For more information on the different ways to handle events in React Native, refer to the Appendix.

Now that we've set up our callback correctly, let's modify `handleChangeText` to change our `text` prop in order to change the data to match what the user is typing:

```
handleChangeText = (newLocation) => {
  this.props.location = newLocation;
};
```

Let's run our application and try typing into the `TextInput` field. You'll immediately notice that the first location that shows is `San Francisco`, so we know that the `text` prop is being passed down successfully!

However, if we type anything into our `TextInput`, you'll notice *nothing happens*. Changing the text within the input field does not actually update the parent `location` property and from the way we've designed our component logic, it looks like it should. This is because `this.props`, which is referenced in `SearchInput`, **is actually owned by `App` and not the child component, `SearchInput`**. A component's `props` are **immutable** and create a one-way data pipeline from parent to children.

We have a bit of a problem. We need to find a way to:

- store local data in our child component, `SearchInput`, that represents the value in the input field
- track changes to the search input field as it's updated by the user
- notify our parent component, `App`, whenever our location changes

This is where we can use a component's **`state`**.

[31] https://babeljs.io/docs/plugins/transform-class-properties/

Storing local data

Let's modify our `SearchInput` component once more. Currently the text input within the component does nothing, so let's add some local component state to control actual data. We can do this by adding a `constructor` method to the component. We can then initialize the component's state within this method:

weather/5/components/SearchInput.js

```
export default class SearchInput extends React.Component {
  constructor(props) {
    super(props);
    this.state = {
      text: '',
    };
  }
```

We can use the `constructor` method to to initialize our **component-specific data**, or `state`. We do this here because this method fires before our component is mounted and rendered. Here, we defined our `state` object to only contain a `text` property:

Remember, components in React Native are extended from `React.Component` to create derived classes. `super()` is required in derived classes in order to reference `this` within the constructor.

Much like how we can access the component's props with `this.props`, we can access the component's state via `this.state`. For example if we wanted to output our state property in a single `Text` component, we could do this:

```
export default class HiThere extends React.Component {
  constructor(props) {
    super(props);
    this.state = {
      text: 'Hi there!',
    };
  }

  render() {
    return <Text>{this.state.text}</Text>;
  }
}
```

This component would now render `'Hi there!'` since that's how we defined our `state.text` property in our constructor. For our current component however, our `text` property in state will be used to define the text typed by the user into the input field. Let's now modify our component's `render` method to allow for this:

weather/5/components/SearchInput.js

```
  render() {
    const { placeholder } = this.props;
    const { text } = this.state;

    return (
      <View style={styles.container}>
        <TextInput
          autoCorrect={false}
          value={text}
          placeholder={placeholder}
          placeholderTextColor="white"
          underlineColorAndroid="transparent"
          style={styles.textInput}
          clearButtonMode="always"
          onChangeText={this.handleChangeText}
          onSubmitEditing={this.handleSubmitEditing}
        />
```

```
      </View>
    );
  }
```

The first thing we did was destructure the component `props` and `state` objects:

weather/5/components/SearchInput.js

```
  render() {
    const { placeholder } = this.props;
    const { text } = this.state;
```

Destructuring

Instead of using `this.props.placeholder` and `this.state.text` directy, we destructured both objects at the beginning of our `render` method into individual variables (`text` and `placeholder`). Please refer to the Appendix for more details on destructuring assignments.

We then make sure that the `TextInput placholder` prop is still accepting our `props.placeholder` attribute. We also pass `state.text` to a `value` prop:

weather/5/components/SearchInput.js

```
        <TextInput
          autoCorrect={false}
          value={text}
          placeholder={placeholder}
          placeholderTextColor="white"
          underlineColorAndroid="transparent"
          style={styles.textInput}
          clearButtonMode="always"
          onChangeText={this.handleChangeText}
          onSubmitEditing={this.handleSubmitEditing}
        />
```

The `value` prop is responsible for the content showed in the input field. With this, we now know whatever is displayed in input field will **always represent our local state**.

We've also attached two additional props to our component, `onChangeText` and `onSubmitEditing` with methods we haven't set up yet.

Tracking changes to input

Let's take a look at how `onChangeText` can allow us to update our `state` every time the input field is changed. As we just did previously, we're attaching a method to the `onChangeText` prop of `TextInput`:

weather/5/components/SearchInput.js

```
          onChangeText={this.handleChangeText}
```

Previously, we set up a `handleChangeText` method that modifies our location prop value when the user changes the text within the input. We quickly realized that this didn't work. This is because `props` are immutable and are always "**owned**" **by a component's parent** while `state` can be mutated and is "**owned**" **by the component itself**. This is an extremely important pattern to remember while building components with React Native.

This brings us to `setState()`, a method we can use to **change our state** correctly. Let's make use of this in our `handleChangeText` method which we can declare right underneath our constructor:

weather/5/components/SearchInput.js

```
export default class SearchInput extends React.Component {
  constructor(props) {
    super(props);
    this.state = {
      text: '',
    };
  }
```

```
handleChangeText = text => {
  this.setState({ text });
};
```

Shorthand property names

With later versions of JavaScript, we can define objects using shorthand form where possible. Our `handleChangeText` method can also be written in a more explicit syntax:

```
handleChangeText = (text) => {
  this.setState({ text: text });
};
```

Please refer to the Appendix for a little more detail on this concept.

Now we might be tempted to update our state by using `this.state.text = text`, but this will **not work**. For all state modifications after the initial state we've defined in our `constructor`, React provides components with the method `setState()` to do this. In addition to mutating the component's `state` object, this method triggers the React component to re-render, which is essential after the `state` changes.

It's good practice to initialize components with "empty" state as we've done in this component. However, after our `SearchInput` component is initialized, we want to update the state with data the user types into the text input. This is why we use the `text` argument provided into our callback method as part of the `onChangeText` prop and pass that into `this.setState()`.

Never modify state outside of `this.setState()`. This function has important hooks around state modification that we would be bypassing.

We discuss state management in detail throughout the book.

Notifying the parent component

So we've found a way to correctly store local state in our component that represents the text within the search input *and* make sure that it updates as the user changes the

value. We still need to do one more thing which is to notify our parent `App` component when the user submits a new searched value. This is why we've attached a method to the `onSubmitEditing` prop of `TextInput`:

weather/5/components/SearchInput.js

```
          onSubmitEditing={this.handleSubmitEditing}
```

The idea here is we don't necessarily want to communicate with our parent component everytime the user changes the input field. That's why `onChangeText` is purely responsible for storing the latest typed input value into the local state of the component. Fortunately, the `TextInput` component has an `onSubmitEditing` prop which fires when the user **submits** the field and not just changes it. This happens specifically when the user presses the action button of the virtual keyboard in order to *submit* their input. This is where we would want to notify our container component of the typed user data. Let's take a look at how we can set up the `handleSubmitEditing` function that we're passing in:

weather/5/components/SearchInput.js

```
  handleSubmitEditing = () => {
    const { onSubmit } = this.props;
    const { text } = this.state;

    if (!text) return;

    onSubmit(text);
    this.setState({ text: '' });
  };
```

In here, we check if `this.state.text` is not blank (which means the user has typed something into the field), and if that's the case:

1. **Run an `onSubmit` function obtained from the component's props.** We pass `text` as an argument here.
2. Clear the `text` property in state using `this.setState()`

We've seen how `this.props` can be used to pass information down from a parent component to child and we've also seen how built-in components such as `TextInput` can notify their parent component through callbacks in some of their props. Similarly, we can create `props` in our custom components to do the *exact same thing*. In here, we need `SearchInput` to communicate with the `App` component whenever the user submits the input field. We do this because we want our parent component to handle the event of the user typing and submitting a new city. This is why we have an `onSubmit` prop here that gets fired.

The next thing we need to do is pass a method to the `onSubmit` prop of `SearchInput` in `App` and handle the event:

weather/5/App.js

```
<SearchInput
  placeholder="Search any city"
  onSubmit={this.handleUpdateLocation}
/>
```

Let's define local state for this component as well as the `handleUpdateLocation` method:

weather/5/App.js

```
export default class App extends React.Component {
  constructor(props) {
    super(props);
    this.state = {
      location: 'San Francisco',
    };
  }

  handleUpdateLocation = city => {
    this.setState({
      location: city,
    });
  };
```

We defined local state for this component with just a `location` property and have it set to `San Francisco`. We do this to ensure that an initial location is shown when we reload our application. We also included a `handleUpdateLocation` method that takes in a parameter to change our location state. This method will fire everytime the user submits the search input field because we pass this method as the `onSubmit` prop for `SearchInput`.

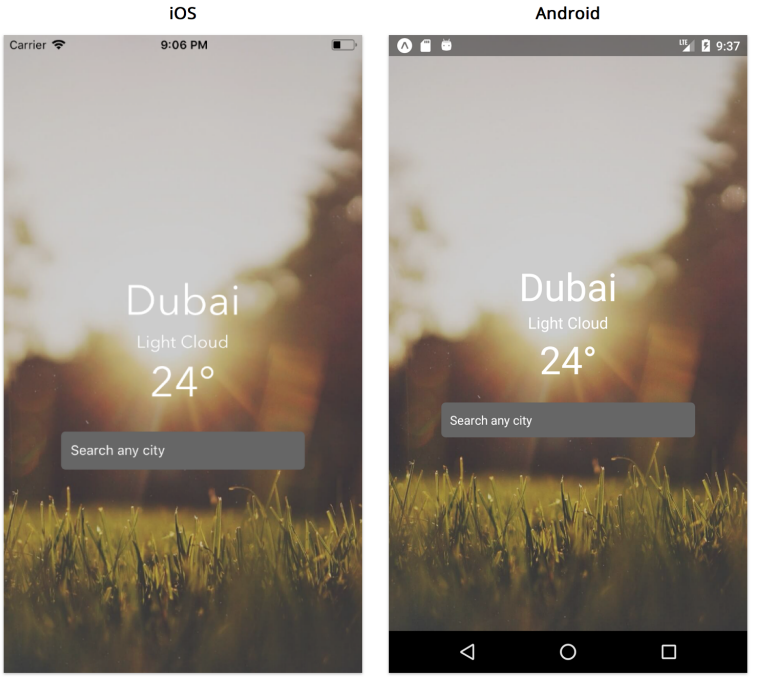
Since we actually have "living" location data represented by what the user submits in the input field, we can now display it in our first `Text` element instead of a hardcoded string:

weather/5/App.js

```
  render() {
    const { location } = this.state;

    return (
      <KeyboardAvoidingView
        style={styles.container}
        behavior="padding"
      >
        <ImageBackground
          source={getImageForWeather('Clear')}
          style={styles.imageContainer}
          imageStyle={styles.image}
        >
          <View style={styles.detailsContainer}>
            <Text style={[styles.largeText, styles.textStyle]}>
```

Try it out

If we type any city in the search input and press return, we'll see the name of the city being displayed immediately.



Component State

This shows that we've wired everything correctly!

We've sequenced each of our problems step by step and showed how `props` and `state` differ when trying to pass and store component data. However, `handleUpdateLocation` doesn't really get *real* weather information and just updates the city name that's being displayed. We'll wire it up to get actual weather data soon.

Architecting state

We may have already considered controlling all the location state within `SearchInput` and not having to deal with passing information upwards to a container component. There's no specific answer to *where each piece of state should live* and it depends on the type of application we're building. This is a core concept of building React Native applications and tools like Redux[32] and MobX[33] aim to simplify this even further by allowing you to manage the entire state of the application in a single

[32] https://github.com/reactjs/redux
[33] https://github.com/mobxjs/mobx

location. However, even when we decide to use state management libraries such as these examples, we still need to spend time deciding on how we want to structure our state logic.

In our current app, we need to have `App` know the `location` data in order to display correct weather conditions. `SearchInput` doesn't really need to store this information without actually passing it up to the component that handles the logic. The motivation behind keeping `SearchInput` simple is that we can leverage React's component-driven paradigm. We can re-use it in various places across our application whenever we need a search input.

We can think of `SearchInput` as a component that provides presentational markup and **does not** manage any real application data. Such components accept props from parent components which specify the data a presentational component should render. This parent container component also specifies behavior. If the lower level presentational component has any interactivity — like our search input — it calls a prop-function given to it by the parent. We'll go into more detail about this important pattern throughout this book.

Lifecycle methods

We've wired up how our components communicate with each other to have a new location displayed immediately when the user submits the text input field. However, you'll notice that the city shows a blank string when the app first loads. We *could* instantiate it with the name of an actual city instead but we know we want to be getting actual weather information eventually. Although we haven't set that up just yet, the asynchronous action to fetch actual weather data for a city will be happening in the `handleUpdateLocation`. Therefore it makes sense to call this method when our component first loads. One thing we might be tempted to try is firing this method in our `constructor`:

```
constructor(props) {
  super(props);
  this.state = {
    location: '',
  };

  this.handleUpdateLocation('San Francisco');
}
```

However, firing off asynchronous requests in the `constructor` is typically an *anti-pattern*. This is because the `constructor` is called before the component is first mounted. As such, this method should usually only be used to initialize state and bind methods.

Instead, we can make use of one of React Native's **lifecycle methods**. Like the name suggests, these methods allow you to access specific points in the lifecycle of a component. The term lifecycle here applies to how React Native **instantiates**, **changes** and **destroys** components. We can use lifecycle hooks to do something when these functions are called during different phases of component rendering.

The most common lifecycle method used is the one that allows us to set component data *after* the component is mounted – **`componentDidMount()`**. This method is commonly used to trigger network requests to fetch data that the component would need. To understand when this method fires, let's add it to our component right after our `constructor` with a `console.log`:

```
export default class App extends React.Component {
  constructor(props) {
    super(props);
    this.state = {
      location: 'San Francisco',
    };
  }

  componentDidMount() {
    console.log('Component has mounted!');
  }
```

When we reload our application, we can see `Component has mounted!` outputted directly to our terminal as soon as the component has mounted.

Debugging in React Native

If you've worked with JavaScript on the web, you may be familiar with using `console.log`, `console.warn` or `console.error` to output messages to the browser's console for debugging purposes. Similarly, Expo allows us to use these methods to output logs to our terminal. For more detail about viewing logs, you can refer to the documentation[34].

Aside from logging, React Native also allows us to debug the JavaScript code in our app using the Chrome Developer Tools. With Expo, we can do this by pressing `Debug Remote JS` in the developer menu. You can refer to the documentation[35] to learn more.

Now let's update it to fire `handleUpdateLocation`:

weather/6/App.js

```
  componentDidMount() {
    this.handleUpdateLocation('San Francisco');
  }
```

With this, we can remove `San Francisco` as our default location in `state` and set it to an empty string.

```
export default class App extends React.Component {
  constructor(props) {
    super(props);
    this.state = {
      location: '',
    };
  }
```

[34] https://docs.expo.io/versions/latest/guides/logging.html
[35] https://docs.expo.io/versions/latest/guides/debugging.html

Since we're using `componentDidMount`, we should still see `San Francisco` populated in place of the text field as soon as we reload the app.

Although `componentDidMount()` allows us to create event listeners and fetch network requests right after the component has rendered for the first time, there are number of other lifecycle methods that React Native provides. We'll go through each of them throughout this book.

Networking

We've built all the components that make up the UI of our app and refined it to show a nice background image for the user. As we mentioned previously, the approach we've taken so far is a common pattern used when building brand new React Native applications. We first organized our views using components and then introduced some state and state management.

However, nobody will find our app *useful* unless it's actually connected to real data. When building a new mobile app, chances are we'll need to communicate with a server. Communicating with a server is a crucial component of most mobile applications.

For the purpose of this application, we'll use the MetaWeather[36] API to fetch real weather information. MetaWeather is a weather data aggregator that calculates the most likely outcome from predictions of different forecasters. They provide an API[37] that provides this information over a set of different endpoints:

1. Location search (`/api/location/search/`) which allows us to search for a particular city
2. Location weather information (`/api/location/{woeid}`) which provides a 5 day forecast for a certain location
3. Location day which provides (`/api/location/{woeid}/{date}/`) forecast history and information for a particular day and location

[36] https://www.metaweather.com/
[37] https://www.metaweather.com/api/

WOEID, or Where On Earth ID, is a location identifier that allows us find details about a specific location. For more detail on how exactly the MetaWeather API works, feel free to take a closer look at the documentation[38].

Now that we have a basic understanding of how `state` and `props` control the flow of data between different components, let's move on to using this API to render real weather data. It's possible to put API calls directly in our component methods, but it's usually a good idea to abstract that logic away in its own file. In the `utils` directory, we've set up two separate API calls in `api.js`:

- `fetchLocationId` returns an array of locations based on a search query
- `fetchWeather` returns weather details about a specific location using a location identifier known as Where On Earth ID[39]

The combination of both calls will allow us to search for a city and retrieve its weather information. Feel free to open the file and take a look at how these methods work if you're interested.

Async Functions

Callbacks and Promises are two ways to define asynchronous code in JavaScript. Built on top of promises, **`async`** functions are a newer syntax that allows us to define asynchronous methods in a synchronous manner. Both methods we've set up in `api.js` use this syntax.

Although supported by Babel, it is still in draft proposal stage and will most likely be ratified into a future JavaScript release. Here's the MDN[40] resource if you happen to be interested in learning more about this syntax further.

When building components that fetch information over the network, it's inevitable that the user will have to wait a certain period of time before the data is retreived. With most applications, it makes sense to show a loading indicator of some sort so the user knows they have to wait a bit before they can see the content. Fortunately, React

[38] https://www.metaweather.com/api/
[39] https://developer.yahoo.com/geo/geoplanet/guide/concepts.html
[40] https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Statements/async_function

Native provides a built-in `ActivityIndicator` component that displays a circular loading spinner. Let's update our root `App` component beginning with some new imports:

weather/6/App.js

```
import React from 'react';
import {
  StyleSheet,
  View,
  ImageBackground,
  Text,
  KeyboardAvoidingView,
  Platform,
  ActivityIndicator,
  StatusBar,
} from 'react-native';

import { fetchLocationId, fetchWeather } from './utils/api';
import getImageForWeather from './utils/getImageForWeather';

import SearchInput from './components/SearchInput';
```

We've added the following imports:

- `ActivityIndicator` is a built-in component that displays a circular loading spinner. We'll use it when data is being fetched from the network
- `fetchLocationId`, `fetchWeather` are the methods for interacting with the weather API
- `StatusBar` is a built-in component that allows us to modify the app status bar at the top of the device

Now let's make some changes to our component. We need to apply our network request logic and store that information so that it can be easily displayed. We also need to make sure that a loading indicator is shown while the request is firing. Let's begin with updating our state:

weather/6/App.js

```
  constructor(props) {
    super(props);

    this.state = {
      loading: false,
      error: false,
      location: '',
      temperature: 0,
      weather: '',
    };
  }
```

We just expanded our state object to include `loading`, `error`, `temperature`, and `weather` in addition to `location`. The three latter properties are data we'll retreive from the API. The `loading` property represents when a call is still being made (in order to show a loading icon) and `error` is used to store the error message if our call fails or returns unusable information.

With `setState`, updates to our state can happen *asynchronously*. For this reason, the method accepts a callback as an optional second parameter that allows us to define an action to fire after the state is updated. Consider the following as an example:

```
export default class Example extends React.Component {
  state = {
    weather: '',
  };

  componentDidMount() {
    this.setState({ weather: 'Clear' }, () =>
      console.log(this.state),
    );
  }
}

// { weather: 'Clear' } is logged right after component mounts
```

We can apply this logic to the method responsible for interfacing with our external API: `handleUpdateLocation`:

weather/6/App.js

```
  handleUpdateLocation = async city => {
    if (!city) return;

    this.setState({ loading: true }, async () => {
      try {
        const locationId = await fetchLocationId(city);
        const { location, weather, temperature } = await fetchWeather(
          locationId,
        );

        this.setState({
          loading: false,
          error: false,
          location,
          weather,
          temperature,
        });
      } catch (e) {
        this.setState({
          loading: false,
          error: true,
        });
      }
    });
  };
```

We've updated it to be an asynchronous function that uses `setState` to change our loading attribute to `true`. We also pass in an asynchronous function as its second argument. In here, we first call `fetchLocationId` with the user queried city (if present) and pass the location ID to `fetchWeather` to return an object that contains the required information (`location`, `weather`, and `temperature`). Once complete, our

state is updated with the correct parameters. Moreover, if any of the calls happen to error, the catch statement will update the `error` property in our state to true.

Now that we have our API logic in place, we'll need to do a few things in the UI of our component:

- We need to display a loading spinner *only* when our API calls have fired but not completed
- We should show an error message if the user types in an incorrect address *or* our API call fails
- We need to render the correct weather information for a certain location

Let's take a look at how we can update our `render()` method to do this:

weather/6/App.js

```
render() {
  const {
    loading,
    error,
    location,
    weather,
    temperature,
  } = this.state;

  return (
    <KeyboardAvoidingView
      style={styles.container}
      behavior="padding"
    >
      <StatusBar barStyle="light-content" />
      <ImageBackground
        source={getImageForWeather(weather)}
        style={styles.imageContainer}
        imageStyle={styles.image}
      >
        <View style={styles.detailsContainer}>
```

```
<ActivityIndicator
  animating={loading}
  color="white"
  size="large"
/>

{!loading && (
  <View>
    {error && (
      <Text style={[styles.smallText, styles.textStyle]}>
        Could not load weather, please try a different
        city.
      </Text>
    )}

    {!error && (
      <View>
        <Text
          style={[styles.largeText, styles.textStyle]}
        >
          {location}
        </Text>
        <Text
          style={[styles.smallText, styles.textStyle]}
        >
          {weather}
        </Text>
        <Text
          style={[styles.largeText, styles.textStyle]}
        >
          {`${Math.round(temperature)}°`}
        </Text>
      </View>
    )}

    <SearchInput
```

```
                placeholder="Search any city"
                onSubmit={this.handleUpdateLocation}
              />
            </View>
          )}
        </View>
      </ImageBackground>
    </KeyboardAvoidingView>
  );
}
```

It might look like a lot is going on in the file, but let's break it down piece by piece. We first included our `StatusBar` component:

weather/6/App.js

```
      <StatusBar barStyle="light-content" />
```

The `StatusBar` component allows us to customize the status bar of our application using a `barStyle` prop that lets us change the color of the text within the bar. A value of `light-content` renders a lighter color (white) and `dark-content` will change it to a darker color (dark-grey).

With Expo, we can also configure the status bar for Android by modifying `app.json`.

Expo defaults `barStyle` for Android to `light-content` and makes the background translucent. Although this looks fine for our current application, you can remove the translucency by providing a background color. Take a look at the documentation[41] for more details.

We then added `ActivityIndicator` along with assigning its color and size prop:

[41] https://docs.expo.io/versions/latest/guides/configuring-statusbar.html

weather/6/App.js

```
<ActivityIndicator
  animating={loading}
  color="white"
  size="large"
/>
```

Notice how we've also included an `animating` prop which we've set to be our `state.loading` attribute. This prop is responsible for showing or hiding the component entirely.

After that, we've included a curly brace container in our JSX:

weather/6/App.js

```
{!loading && (
  <View>
    {error && (
      <Text style={[styles.smallText, styles.textStyle]}>
        Could not load weather, please try a different
        city.
      </Text>
    )}

    {!error && (
      <View>
        <Text
          style={[styles.largeText, styles.textStyle]}
        >
          {location}
        </Text>
        <Text
          style={[styles.smallText, styles.textStyle]}
        >
          {weather}
        </Text>
        <Text
```

```
                style={[styles.largeText, styles.textStyle]}
              >
                {`${Math.round(temperature)}°`}
              </Text>
            </View>
          )}

          <SearchInput
            placeholder="Search any city"
            onSubmit={this.handleUpdateLocation}
          />
        </View>
      )}
    </View>
```

We've previously seen how JSX allows us to embed JavaScript expressions within curly braces. Fortunately, this lets us include operators as well, allowing us to **conditionally render** certain parts of our UI. In here, `!loading && <...>` means that this statement will evaluate and display the element if and only if `loading` is false. We can see we've pretty much wrapped most of the elements that make up our component within here, and this makes sense since we don't want to show any text fields or the search input while the API call is being fetched.

Conditional Rendering

Using logical && operators within the render method is not the only way to conditionally render parts of the component. At times, this approach can make it harder to read a component file if a significant number of lines are being conditionally rendered.

If this happens, it might be a good idea to use *helper methods*. For example, our render method can be rewritten following this pattern:

```
renderContent() {
  const { error } = this.state;
  return (
    <View>
      {error && <Text>Error</Text>}
      {!error && this.renderInfo()}
    </View>
  );
}
renderInfo() {
  const { info } = this.state;
  return <Text>{info}</Text>;
}
render() {
  const { loading } = this.state;
  return (
    <View>
      <ActivityIndicator
        animating={loading} color="white" size="large"
      />
      {!loading && this.renderContent()}
    </View>
  );
}
```

The React documentation[42] goes into more detail as well as explaining more ways to conditionally render parts of components.

[42] https://reactjs.org/docs/conditional-rendering.html

Now within the content that shows when the API call isn't being fired, we still need to be able to display an appropriate error message if there's an issue. We can use the `state.error` attribute to conditionally display text in this scenario:

weather/6/App.js

```
{error && (
  <Text style={[styles.smallText, styles.textStyle]}>
    Could not load weather, please try a different
    city.
  </Text>
)}

{!error && (
  <View>
    <Text
      style={[styles.largeText, styles.textStyle]}
    >
      {location}
    </Text>
    <Text
      style={[styles.smallText, styles.textStyle]}
    >
      {weather}
    </Text>
    <Text
      style={[styles.largeText, styles.textStyle]}
    >
      {`${Math.round(temperature)}°`}
    </Text>
  </View>
)}

<SearchInput
  placeholder="Search any city"
  onSubmit={this.handleUpdateLocation}
/>
```

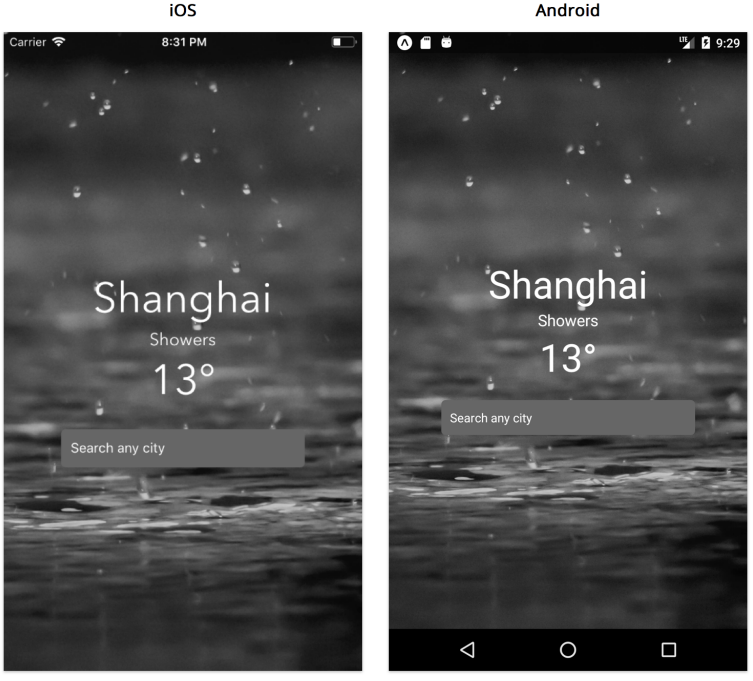
Notice how we now display our state information (`location`, `weather`, and `temperature`) in our `Text` elements instead of hard-coded values. For temperature, we're making use of the JavaScript `Math` object and its `round()` method to round the temperature to the nearest integer.

The last thing we also do is pass the dynamic `weather` attribute to `ImageBackground` instead of a hardcoded `Clear` string:

weather/6/App.js

```
        <ImageBackground
          source={getImageForWeather(weather)}
          style={styles.imageContainer}
          imageStyle={styles.image}
        >
```

Now if we run our application, typing a city into the input field will return its actual weather data!



We've pretty much finished connecting all the major points of our application by wiring in network requests to retreive actual data. After slowly beginning with hardcoded data and building our components that make up the building blocks of our UI, our application now works just as we intended from the beginning of this chapter. The next few sections will explore some additional enhancements to our code but won't add any new functionality to our app.

PropTypes

With React Native, we can include validation functions using the `prop-types` library. This allows us to specify and enforce the type of our component props and ensure that they match what we expect them to be. This can not only help us catch development errors sooner but also provide a layer of documentation to the consumer of our components

We can add `prop-types` as a dependency:

```
yarn add prop-types
```

Now let's take a look at how we can use `PropTypes` in `SearchInput`:

weather/6/components/SearchInput.js

```
SearchInput.propTypes = {
  onSubmit: PropTypes.func.isRequired,
  placeholder: PropTypes.string,
};

SearchInput.defaultProps = {
  placeholder: '',
};
```

We've defined a `propTypes` object which instructs React to validate the props given to our component. We're specifying that `onSubmit` **must** be a function and `placeholder` **must** be a string. We've also specified `onSubmit` to be required which means it has to be provided to our component and is not optional.

We've left `placeholder` to be optional. For this, we're making use of the `defaultProps` object. This allows us to create our component and not specify `placeholder` if we don't need to, `defaultProps` will take care of providing it's value in that case. It's important to note that the value passed into `defaultProps` also undergoes type-checking as well by the library.

Now what exactly happens when a prop's type is not validated successfully? When a prop is passed in with an invalid type or fails the `propType` validation, a warning is passed into the JavaScript console. These warnings will only be shown in development mode, so if we accidentally deploy our app into production with an improper use of a component, our users won't see the warning.

Class properties

React Native includes class properties transformation[43] from Babel that allows us to simplify how we define our component `state`, `props`, and `propTypes`. For example, we can update the `constructor` in `App.js` to:

weather/App.js

```
state = {
  loading: false,
  error: false,
  location: '',
  temperature: 0,
  weather: '',
};
```

This gets transpiled into the **exact same result** as using a `constructor`. Similarly, we can simplify how we define our `state` in `SearchInput`:

[43] https://babeljs.io/docs/plugins/transform-class-properties/

weather/components/SearchInput.js

```
  state = {
    text: '',
  };
```

Moreover, we can also set `propTypes` and `defaultProps` using static properties in our class. In other words, we can remove the object references in `SearchInput` and define a static method *within* the class:

weather/components/SearchInput.js

```
  static propTypes = {
    onSubmit: PropTypes.func.isRequired,
    placeholder: PropTypes.string,
  };

  static defaultProps = {
    placeholder: '',
  };
```

Using this pattern and leveraging class properties transform is purely syntactical sugar over defining methods and objects separately and allows us to write in a cleaner, simpler syntax.

Summary

Congratulations, we've just built our very first React Native application and covered almost all of the essentials needed to build a complete and fully functional mobile app. We began by exploring each of the files generated as a result of starting a new project and how the Expo CLI allows us to run our application smoothly on our device without worrying about Xcode and Android Studio set up. We then built out each of the components that make up our application using the built-in components provided by React Native. While doing so, we dove into the fundamentals of React Native understanding JSX, how to apply custom styling as well as understanding

how to use `props` and `state` to manage and control data. We moved on to more complex topics including lifecycle methods and how to use external network calls to provide real content to our application. Finally, we finished off with a brief look into how `propTypes` can add an additional layer of safety by adding type validation to our application. The rest of this book will dive deeper into core concepts of React Native and the concepts learned in this chapter will serve as the foundation for everything else in the text.

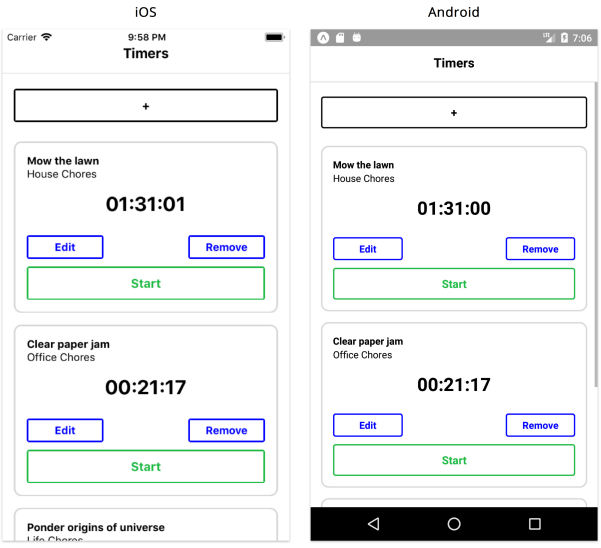
So far, we've only scratched the surface of what React Native allows us to do. By knowing the setup/development details like Expo and the core concepts of props, state, and components, you already have the essentials of React Native development under your belt. As of now, you can already build a wide variety of applications using the framework – so go forth and build something amazing!

React Fundamentals

In the last chapter, we built our first React Native application. We explored how React applications are organized by *components*. Using the key React concepts of *state* and *props*, we saw how data is managed and how it flows between components. We also discussed other useful concepts, like handling user input and fetching data from a remote API.

In this section, we'll build another application step-by-step. We'll dive even deeper into React's fundamentals. We'll investigate a pattern that you can use to build React Native apps from scratch and then put those steps to work to build a time-tracking application.

In this app, a user can add, delete, and modify various timers. Each timer corresponds to a different task that the user would like to keep time for:



Time Tracking App

This app will have significantly more interactive capabilities than the one built in the last chapter. As we'll see, this will present us with some interesting challenges.

Getting started

This chapter assumes you've setup your system by following the steps at the beginning of the first chapter.

As with all the chapters in this book, make sure you have the book's sample code at the ready.

Previewing the app

Let's begin by viewing the completed app. To try the completed app on your device:

- On Android, you can scan this QR code using the Expo app:

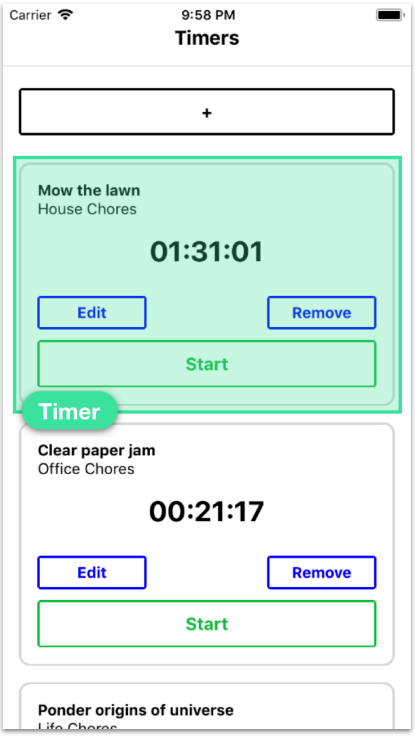
QR Code

- On iOS, you can navigate to the `time-tracking/` directory within the sample code folder and either preview it on the iOS simulator or send the link of the project URL to your device as we explained in the previous chapter.

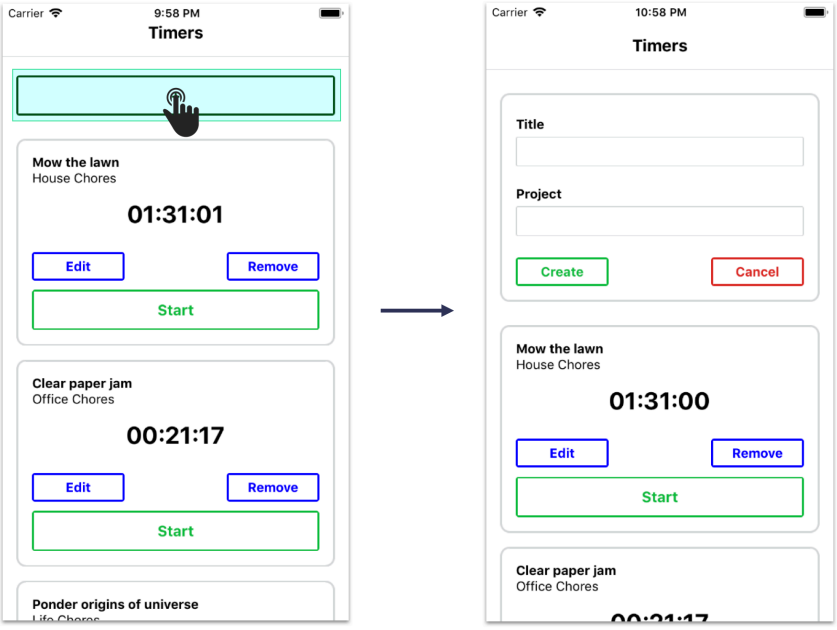
Play around with it to get a feel for all the functionality.

Breaking the app into components

Let's start by breaking our app down into its components. As we noticed in our last project, visual components usually map tightly to their respective React Native components. For example, we can imagine that we'd want a `Timer` component for each timer:



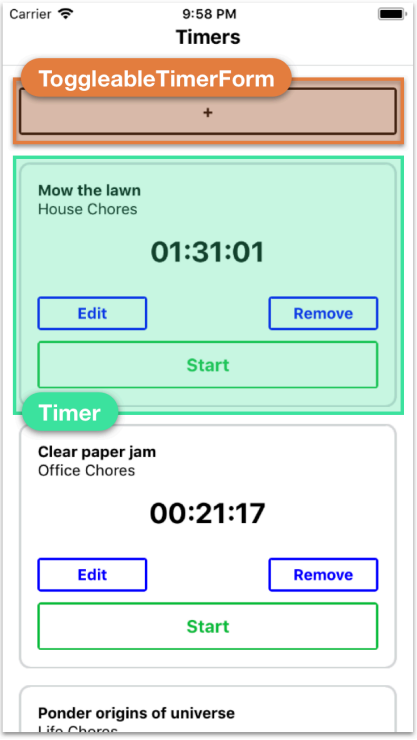
Our application displays a list of timers *and* has a "+" icon at the top. We're able to add new timers to the list using this button. This "+" component is interesting because it has two distinct representations. When the "+" button is pressed, the component changes into a form:



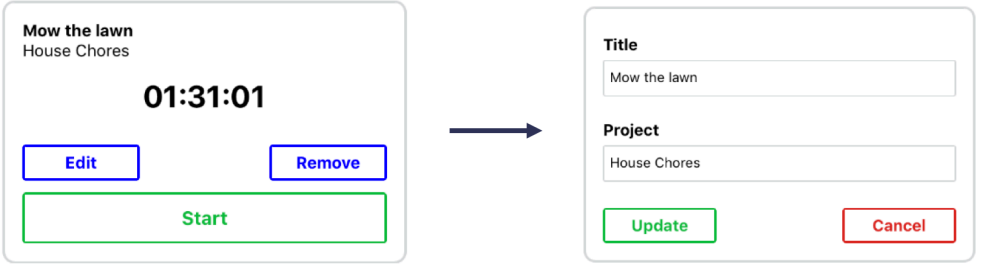
When the form is closed, the component changes back into a "+" button.

There are two approaches we could take. The first one is to have the parent component decide whether or not to render a "+" component or a form component based on some piece of stateful data. It could swap between the two children. However, this adds more responsibility to the parent component. Since no other child components need this piece of information, it might make more sense to have a new child component own the single responsibility of determining whether or not to display a "+" button or a create timer form. We'll call it `ToggleableTimerForm`. As a child, it can either render the component `TimerForm` or the "+" button.

So, we've identified two components in addition to our root application component:



But the `Timer` component has a fair bit of functionality. As we saw in the completed version of the app, each timer turns into a form when the user clicks "Edit":



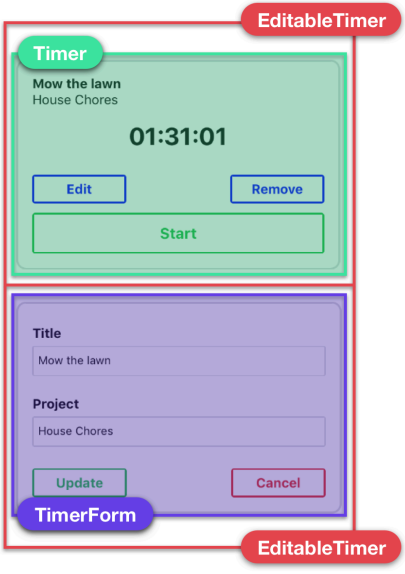
A single timer: Displaying time (left) vs. edit form (right)

In addition, timers delete themselves when "Remove" is pressed and have buttons for starting and stopping. Do we need to break this up? And if so, how?

Displaying a timer and editing a timer are indeed two distinct UI components. They

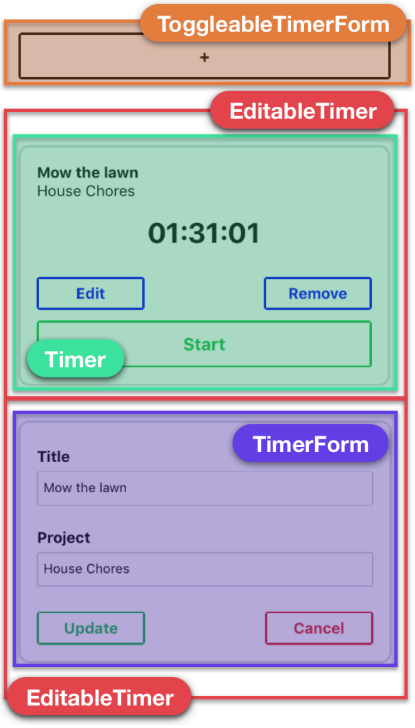
should be two distinct React components. Like `ToggleableTimerForm`, we need some container component that renders either the timer's face or its edit form depending on if the timer is being edited.

We'll call this `EditableTimer`. The child of `EditableTimer` will then be either a `Timer` component or the edit form component. The form for creating and editing timers is very similar, so let's assume that we can use the component `TimerForm` in both contexts:



As for the other functionality of the timer, like the start and stop buttons, it's a bit tough to determine at this point whether or not they should be their own components. We can trust that the answers will be more apparent after we've started writing some code and have a better idea of the general structure of the components in our application.

So, we have our final component hierarchy, with some ambiguity around the final state of the timer component:



- `App`: Root container
  - `EditableTimer`: Displays either a timer or a timer's edit form
    * `Timer`: Displays a given timer
    * `TimerForm`: Displays a given timer's edit form
  - `ToggleableTimerForm`: Displays a form to create a new timer
    * `TimerForm`: Displays a new timer's create form

For all the buttons in the app, we'll create and use a component called `TimerButton`.

7 step process

Now that we have a good understanding of the composition of our components, we're ready to build a static version of our app that only contains hardcoded data. As we noticed in the previous chapter, many applications we build will require our

top-level component to communicate with a server. In these scenarios, **the server will be the initial source of state**, and React Native will render itself according to the data the server provides. If our current app followed this pattern it would also send updates to the server, like when a timer is started. However, for simplicity, in this chapter we'll render local state rather than communicating with a server.

It always simplifies things to start off with static components, as we did in the last chapter. The static version of the app will not be interactive. Pressing buttons, for example, won't do anything. But this will enable us to lay the framework for the app, getting a clear idea of how the component tree is organized.

Next, we can determine what the **state** should be for the app and in which component it should live. At that point, we'll have the data flow **from parent to child** in place. Then we can add inverse data flow, propagating events **from child to parent**.

In fact, this follows from a handy process for developing a React Native app from scratch:

1. Break the app into components
2. Build a static version of the app
3. Determine what should be stateful
4. Determine in which component each piece of state should live
5. Hardcode initial states
6. Add inverse data flow
7. Add server communication (if present)

We followed this pattern in the last project:

1. Break the app into components

We looked at the desired UI and determined we wanted a custom `SearchInput` component.

2. Build a static version of the app

Our components started off without using `state`. Instead, we had our root `App` component pass down location as a static `prop` to `SearchInput`.

3. Determine what should be stateful

In order for our application to become interactive, we had to be able to modify the search value of the search input. The value submitted was our stateful `location` property.

4. Determine in which component each piece of state should live

Our root `App` component was responsible for managing the `location`, `temperature`, and `weather` state parameters using React component class methods.

5. Hardcode initial state

We defined a hardcoded `location` value and passed it down to `SearchInput` as a custom prop.

6. Add inverse data flow

We defined the `handleUpdateLocation` function in our `App` container and passed it down in props so that `SearchInput` could inform the parent of when our search input's submit button is pressed.

7. Add server communication

We added server communication between our parent component and the `MetaWeather` API to retrieve actual weather data.

These steps only serve as a *guideline*. You don't necessarily have to follow it every time you build an application, but you'll likely internalize and become more accustomed to following this structure as you build more applications. If steps in this process aren't completely clear right now, don't worry. The purpose of this chapter is to familiarize yourself with this procedure.

We've already covered step (1) and have a good understanding of all of our components, except for some uncertainty down at the `Timer` component. Step (2) is to build a static version of the app. As in the last project, this amounts to defining React components, their hierarchy, and their HTML representation. We avoid state for now.

Step 2: Build a static version of the app

Prepare the app

Before beginning, run the following commands in your terminal to create a new React Native app:

```
expo init time-tracking --template blank@sdk-33 --yarn
cd time-tracking
yarn start
```

App

Let's start off by writing our `App` component in the file `App.js`. We'll begin with our imports:

time-tracking/1/App.js

```
import React from 'react';

import { StyleSheet, View, ScrollView, Text } from 'react-native';

import EditableTimer from './components/EditableTimer';
import ToggleableTimerForm from './components/ToggleableTimerForm';
```

After importing the core React Native components we'll be using in `App`, we import `EditableTimer` and `ToggleableTimerForm`. We'll be implementing those shortly.

We'll have our `App` component render both `ToggleableTimerForm` and a couple of `EditableTimer` components. Because we're building the static version of our app, we'll manually set all the props:

time-tracking/1/App.js

```
export default class App extends React.Component {
  render() {
    return (
      <View style={styles.appContainer}>
        <View style={styles.titleContainer}>
          <Text style={styles.title}>Timers</Text>
        </View>
        <ScrollView style={styles.timerList}>
          <ToggleableTimerForm isOpen={false} />
          <EditableTimer
            id="1"
            title="Mow the lawn"
            project="House Chores"
            elapsed="8986300"
            isRunning
          />
          <EditableTimer
            id="2"
            title="Bake squash"
            project="Kitchen Chores"
            elapsed="3890985"
            editFormOpen
          />
        </ScrollView>
      </View>
    );
  }
}
```

At the top, we display a title ("Timers") inside of a `Text` component. We'll look at the `styles` object in a moment.

After our title, we render the rest of the components in a `ScrollView` component. The built-in `ScrollView` component in React Native is responsible for wrapping components within a scrolling container.

We're passing down one prop to `ToggleableTimerForm`: `isOpen`. This is used by the child component to determine whether to render a "+" or `TimerForm`. When `ToggleableTimerForm` is "open" the form is being displayed.

We also include two separate `EditableTimer` components within `App`. We'll dig into each of these props when we build the component. Notably, `isRunning` specifies whether the timer is running and `editFormOpen` specifies whether `EditableTimer` should display the timer's face or its edit form.

Note that we don't explicitly set any values for the props `isRunning` on the first `EditableTimer` or `editFormOpen` on the second:

time-tracking/1/App.js

```
          <EditableTimer
            id="1"
            title="Mow the lawn"
            project="House Chores"
            elapsed="8986300"
            isRunning
          />
          <EditableTimer
            id="2"
            title="Bake squash"
            project="Kitchen Chores"
            elapsed="3890985"
            editFormOpen
          />
```

This is a style for boolean props you'll often encounter in React Native apps. When no explicit value is passed, the prop defaults to `true`. So `<ToggleableTimerForm isOpen />` will give the same result as `<ToggleableTimerForm isOpen={true}/>`. Conversely, when a prop is *absent* it is `undefined`. This means that for the first timer `editFormOpen` is "falsy."

`ScrollView` renders all of its components at once, even those not currently shown in the screen.

Last, here are the styles we're using:

time-tracking/1/App.js

```
const styles = StyleSheet.create({
  appContainer: {
    flex: 1,
  },
  titleContainer: {
    paddingTop: 35,
    paddingBottom: 15,
    borderBottomWidth: 1,
    borderBottomColor: '#D6D7DA',
  },
  title: {
    fontSize: 18,
    fontWeight: 'bold',
    textAlign: 'center',
  },
  timerList: {
    paddingBottom: 15,
  },
});
```

We're not going to focus on styles in this chapter so feel free to just copy over the `styles` object for each component.

`EditableTimer`

With all of our child components, we'll save their respective files within a `components` subdirectory. Let's create `components/EditableTimer.js`.

First, we'll begin by implementing `TimerForm` and `Timer`. We'll be creating those shortly:

time-tracking/1/components/EditableTimer.js

```
import React from 'react';

import TimerForm from './TimerForm';
import Timer from './Timer';
```

`EditableTimer` will either return a timer's face (`Timer`) or a timer's edit form (`TimerForm`) based on the prop `editFormOpen`. We don't anticipate this component will ever manage state.

So far, we've written React components as ES6 classes that extend `React.Component`. However, there's another way to declare React components: as functions.

Let's see what that looks like:

time-tracking/1/components/EditableTimer.js

```
export default function EditableTimer({
  id,
  title,
  project,
  elapsed,
  isRunning,
  editFormOpen,
}) {
  if (editFormOpen) {
    return <TimerForm id={id} title={title} project={project} />;
  }
  return (
    <Timer
      id={id}
      title={title}
      project={project}
      elapsed={elapsed}
      isRunning={isRunning}
    />
  );
}
```

`EditableTimer` is a regular JavaScript function. In React, we call components written this way *stateless functional components* or *functional components* for short. While we can write `EditableTimer` using either component style, it's a perfect candidate to be written as a function.

Think of functional components as components that only need to implement the `render()` method. They don't manage state and don't need any of React's special lifecycle hooks.

Throughout this book, we'll refer to the two different types as *class components* and *functional components*.

Note that the **props are passed in as the first argument to the function**. We don't use `this` when working with functional components. Here, we use destructuring to extract all the props from the props object.

The component's render method switches on the prop `editFormOpen`. If true, we render a `TimerForm`. Otherwise, we render `Timer`.

As we saw in `App`, this component receives six props. This component passes down the props `id`, `title` and `project` to `TimerForm`. For `Timer`, we pass down all the timer attributes.

Benefits of functional components

Why would we want to use functional components? There are two main reasons:

First, using functional components where possible encourages developers to manage state in fewer locations. This makes our programs easier to reason about.

Second, using functional components are a great way to create reusable components. Because functional components need to have all their configuration passed from the outside, they are easy to reuse across apps or projects.

A good rule of thumb is to use functional components as much as possible. If we don't need any lifecycle methods and can get away with only a `render()` function, using a functional component is a great choice.

Note that React still allows us to set `propTypes` and `defaultProps` on functional components.

`TimerForm`

`TimerForm` will contain two `TextInput` fields for editing a timer's `title` and `project`. We'll also add a pair of buttons at the bottom.

Like `EditableTimer`, we can write this component as a functional component:

time-tracking/1/components/TimerForm.js

```
import React from 'react';
import { StyleSheet, View, Text, TextInput } from 'react-native';

import TimerButton from './TimerButton';

export default function TimerForm({ id, title, project }) {
  const submitText = id ? 'Update' : 'Create';

  return (
    <View style={styles.formContainer}>
      <View style={styles.attributeContainer}>
        <Text style={styles.textInputTitle}>Title</Text>
        <View style={styles.textInputContainer}>
          <TextInput
            style={styles.textInput}
            underlineColorAndroid="transparent"
            defaultValue={title}
          />
        </View>
      </View>
      <View style={styles.attributeContainer}>
        <Text style={styles.textInputTitle}>Project</Text>
        <View style={styles.textInputContainer}>
          <TextInput
```

```
            style={styles.textInput}
            underlineColorAndroid="transparent"
            defaultValue={project}
          />
        </View>
      </View>
      <View style={styles.buttonGroup}>
        <TimerButton small color="#21BA45" title={submitText} />
        <TimerButton small color="#DB2828" title="Cancel" />
      </View>
    </View>
  );
}

const styles = StyleSheet.create({
  formContainer: {
    backgroundColor: 'white',
    borderColor: '#D6D7DA',
    borderWidth: 2,
    borderRadius: 10,
    padding: 15,
    margin: 15,
    marginBottom: 0,
  },
  attributeContainer: {
    marginVertical: 8,
  },
  textInputContainer: {
    borderColor: '#D6D7DA',
    borderRadius: 2,
    borderWidth: 1,
    marginBottom: 5,
  },
  textInput: {
    height: 30,
    padding: 5,
```

```
    fontSize: 12,
  },
  textInputTitle: {
    fontSize: 14,
    fontWeight: 'bold',
    marginBottom: 5,
  },
  buttonGroup: {
    flexDirection: 'row',
    justifyContent: 'space-between',
  },
});
```

We wrap each of our form elements in a `View` container. Each input field has a label ("Title" and "Project") above a `TextInput`.

At the end of the component, we have a button group with two `TimerButton` instances. We'll create this component in a bit.

Let's take a closer look at how we've set up `TextInput` for the timer's `title`:

time-tracking/1/components/TimerForm.js

```
          <TextInput
            style={styles.textInput}
            underlineColorAndroid="transparent"
            defaultValue={title}
          />
```

And for the timer's `project`:

time-tracking/1/components/TimerForm.js

```
        <TextInput
          style={styles.textInput}
          underlineColorAndroid="transparent"
          defaultValue={project}
        />
```

Aside from adding styles using the `style` prop, we're also using the `TextInput` component's `defaultValue` property. When the form is used for editing as it is here, we want the fields to be populated with the current `title` and `project` values for this timer. Using `defaultValue` initializes these fields with the current values, as desired.

Later, we'll use `TimerForm` again within `ToggleableTimerForm` for *creating* timers. `ToggleableTimerForm` will not pass `TimerForm` the `title` or `project` props. We'll use `defaultProps` to default these values to empty strings.

At the beginning of the component function, before the `return` statement, we define the variable `submitText`. This variable uses the presence of `props.id` to determine what text the submit button at the bottom of the form should display. If `id` is present, we know we're editing an existing timer, so it displays "Update." Otherwise, it displays "Create."

With all of this logic in place, `TimerForm` is prepared to render a form for creating a new timer or editing an existing one.

We used an expression with the **ternary operator** to set the value of `submitText`. The syntax is:

```
condition ? expression1 : expression2
```

If the `condition` is true, the ternary expression evaluates to `expression1`. Otherwise, it evaluates to `expression2`. In our example, the variable `submitText` is set to the result of the ternary expression.

TimerButton

Now let's set up a component that we can use for all the buttons in our application, `TimerButton`. Again, we can write this as a functional component:

time-tracking/1/components/TimerButton.js

```
import { StyleSheet, Text, TouchableOpacity } from 'react-native';
import React from 'react';

export default function TimerButton({
  color,
  title,
  small,
  onPress,
}) {
  return (
    <TouchableOpacity
      style={[styles.button, { borderColor: color }]}
      onPress={onPress}
    >
      <Text
        style={[
          styles.buttonText,
          small ? styles.small : styles.large,
          { color },
        ]}
      >
        {title}
      </Text>
    </TouchableOpacity>
  );
}

const styles = StyleSheet.create({
  button: {
    marginTop: 10,
```

```
    minWidth: 100,
    borderWidth: 2,
    borderRadius: 3,
  },
  small: {
    fontSize: 14,
    padding: 5,
  },
  large: {
    fontSize: 16,
    padding: 10,
  },
  buttonText: {
    textAlign: 'center',
    fontWeight: 'bold',
  },
  title: {
    fontSize: 14,
    fontWeight: 'bold',
  },
  elapsedTime: {
    fontSize: 18,
    fontWeight: 'bold',
    textAlign: 'center',
    paddingVertical: 10,
  },
});
```

React Native provides a built-in `Button` component, but it only allows for limited customization. For this reason, we're leveraging `TouchableOpacity`, which renders a wrapper to allow for components to respond with opacity changes when pressed.

For easier customization, we've included `color`, `title`, and `small` as props that will allow us to change how our button looks. The `title` prop is responsible for the button text while the `color` prop changes the text and border colors. The `small` prop is a boolean prop passed in to render a smaller button with slightly different styling.

Since we plan on using this component in multiple places in our app, we've defined an `onPress` prop in order to fire a specific function that's passed into our component when the button is pressed. We're not using it currently in `TimerForm` but we will as soon as we add actual data in our application.

`TouchableOpacity` accepts an `activeOpacity` prop that allows us to determine what the opacity of the view should be when pressed. This defaults to a value of 0.2.

ToggleableTimerForm

Let's turn our attention next to `ToggleableTimerForm`. Recall that this is a wrapper component around `TimerForm`. It will display either a "+" or a `TimerForm`. Right now, it accepts a single prop, `isOpen`, from its parent that instructs its behavior:

time-tracking/1/components/ToggleableTimerForm.js

```
import React from 'react';
import { StyleSheet, View } from 'react-native';

import TimerButton from './TimerButton';
import TimerForm from './TimerForm';

export default function ToggleableTimerForm({ isOpen }) {
  return (
    <View style={[styles.container, !isOpen && styles.buttonPadding]}>
      {isOpen ? (
        <TimerForm />
      ) : (
        <TimerButton title="+" color="black" />
      )}
    </View>
  );
}

const styles = StyleSheet.create({
```

```
  container: {
    paddingVertical: 10,
  },
  buttonPadding: {
    paddingHorizontal: 15,
  },
});
```

As noted earlier, `TimerForm` does not receive any props from `ToggleableTimerForm`. As such, its `title` and `project` fields will be rendered empty.

We're using a ternary operator again here to either return `TimerForm` or render a "+" button. You could make a case that this should be its own component (say `PlusButton`) but at present we'll keep the code inside `ToggleableTimerForm`.

Timer

Time for the `Timer` component.

As with all projects in this book, the sample code for this project comes with a `utils/` directory that contains various functions that will aid in the construction of this app. We'll be using one of those functions now. If you haven't already, go ahead and copy over `time-tracking/utils/` from the sample code to your project directory now.

With `utils/` in place, let's take a look at our first version of `Timer`:

time-tracking/1/components/Timer.js

```
import React from 'react';
import { StyleSheet, View, Text } from 'react-native';

import { millisecondsToHuman } from '../utils/TimerUtils';
import TimerButton from './TimerButton';

export default function Timer({ title, project, elapsed }) {
  const elapsedString = millisecondsToHuman(elapsed);

  return (
```

```
    <View style={styles.timerContainer}>
      <Text style={styles.title}>{title}</Text>
      <Text>{project}</Text>
      <Text style={styles.elapsedTime}>{elapsedString}</Text>
      <View style={styles.buttonGroup}>
        <TimerButton color="blue" small title="Edit" />
        <TimerButton color="blue" small title="Remove" />
      </View>
      <TimerButton color="#21BA45" title="Start" />
    </View>
  );
}

const styles = StyleSheet.create({
  timerContainer: {
    backgroundColor: 'white',
    borderColor: '#d6d7da',
    borderWidth: 2,
    borderRadius: 10,
    padding: 15,
    margin: 15,
    marginBottom: 0,
  },
  title: {
    fontSize: 14,
    fontWeight: 'bold',
  },
  elapsedTime: {
    fontSize: 26,
    fontWeight: 'bold',
    textAlign: 'center',
    paddingVertical: 15,
  },
  buttonGroup: {
    flexDirection: 'row',
    justifyContent: 'space-between',
```

```
  },
});
```

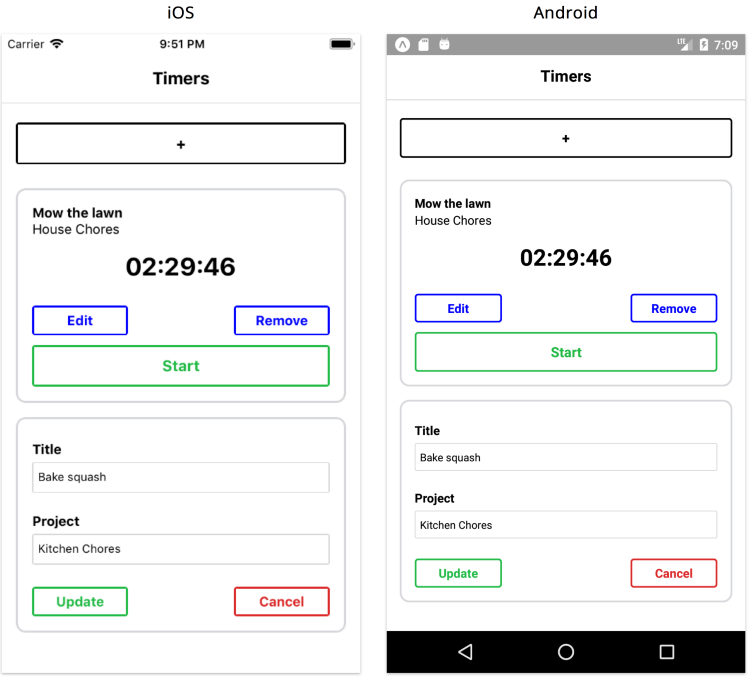
The `elapsed` prop in this app is in milliseconds. This is the representation of the data that React will keep. This is a good representation for machines, but we want to show our users a more human-readable format.

We use a function defined in `./utils/TimerUtils`, `millisecondsToHuman()`. You can pop open that file if you're curious about how it's implemented. The string it renders is in the format 'HH:MM:SS'.

Note that we could store `elapsed` in seconds as opposed to milliseconds, but JavaScript's time functionality is all in milliseconds. We keep `elapsed` consistent with this for simplicity.

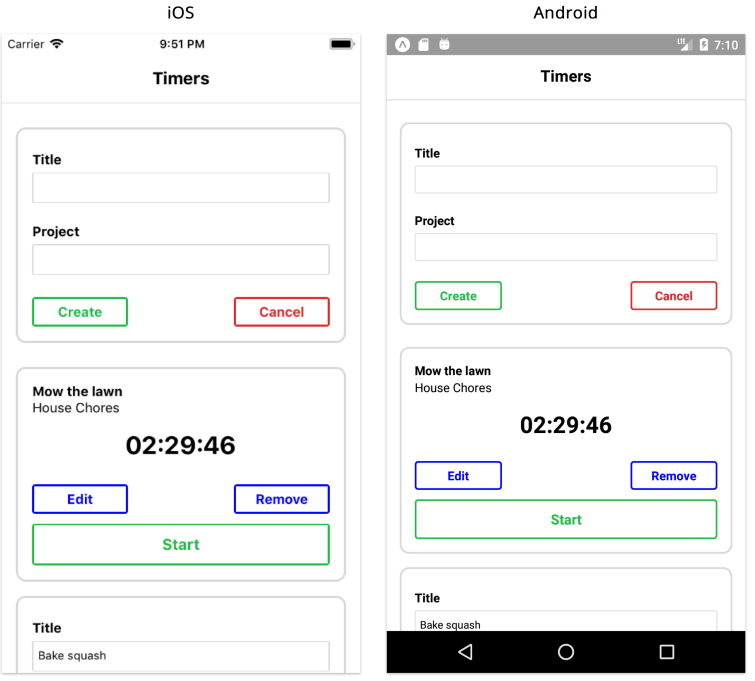
Try it out

With all of our components laid out, let's boot up the React Native packager to see our app so far:

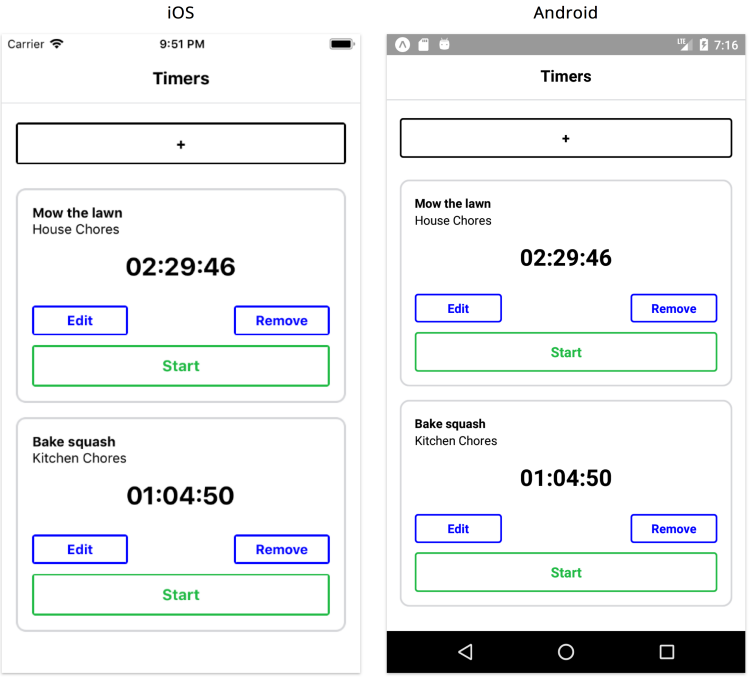


Tweak some of the props and refresh to see the results. For example:

- Flip the prop passed down to `ToggleableTimerForm` from `false` to `true` and see the timer form render in the place of the "+" button:



- Remove the `editFormOpen` prop in the second `EditableTimer` component within `App` and witness the component flip the child it renders accordingly:



To review, our `App` component currently renders a `ToggleableTimerForm` component and two `EditableTimer` components.

`ToggleableTimerForm` renders either a "+" or a `TimerForm` based on the prop `isOpen`.

`EditableTimer` renders either `Timer` or `TimerForm` based on the prop `editFormOpen`. `Timer` and `TimerForm` are our app's bottom-level components. They hold the majority of the screen's UI. The components above them are primarily concerned with orchestration.

So far, we've used hardcoded props to pass data around our app. But in order to enhance our app with interactivity, we must evolve it from its static existence to a mutable one. As we saw in the last chapter, in React we use state to accomplish this.

Step 3: Determine what should be stateful

Before introducing state, we need to determine *what*, exactly, should be stateful. Let's start by collecting all of the data that's consumed by each component in our static

app. In our static app, data will be wherever we are defining or using props. We will then determine which of that data should be stateful.

`App`

This declares two child components. It sets one prop, which is the `isOpen` boolean that is passed down to `ToggleableTimerForm`.

`EditableTimer`

This uses the prop `editFormOpen` and also accepts all the attributes of a timer.

`Timer`

This uses all the attributes for a timer.

`TimerForm`

This has two interactive input fields, one for `title` and one for `project`. When editing an existing timer, these fields are initialized with the timer's current values.

State criteria

We can apply criteria to determine if data should be stateful:

These questions are from the excellent article by Facebook called "Thinking In React." You can read the original article here[44].

1. Is it passed in from a parent via props? If so, it probably isn't state.

A lot of the data used in our child components are already listed in their parents. This criterion helps us de-duplicate.

For example, "timer properties" is listed multiple times. When we see the properties declared in `EditableTimer`, we can consider it state. But when we see it elsewhere, it's not.

2. Does it change over time? If not, it probably isn't state.

This is a key criterion of stateful data: **it changes**.

[44] https://facebook.github.io/react/docs/thinking-in-react.html

3. Can you compute it based on any other state or props in your component? If so, it's not state.

For simplicity, we want to strive to represent state with as few data points as possible.

Applying the criteria

`App`

- `isOpen` boolean for `ToggleableTimerForm` and timer properties for `EditableTimer`

Stateful. The data is defined here. It changes over time. And it cannot be computed from other state or props.

- timer attributes

Stateful. We define the data on each `EditableTimer` here. This data is mutable. And it cannot be computed from other state or props.

`EditableTimer`

- `editFormOpen` for a given timer

Stateful. The data is defined here. It changes over time. And it cannot be computed from other state or props.

`Timer`

- Timer properties

In this context, **not stateful**. Properties are passed down from the parent.

`TimerForm`

We might be tempted to conclude that `TimerForm` doesn't manage any stateful data, as `title` and `project` are props passed down from the parent. However, as saw with our `SearchInput` component in the previous chapter, components that use `TextInput` can be special state managers in their own right – these components often maintain the value of the input field as state.

So, outside of `TimerForm`, we've identified our stateful data:

- The list of timers and properties of each timer
- Whether or not the edit form of a timer is open
- Whether or not the create form is open

Step 4: Determine in which component each piece of state should live

While the data we've determined to be stateful might live in certain components in our static app, this does not indicate the best position for it in our stateful app. Our next task is to determine the optimal place for each of our three discrete pieces of state to live.

This can be challenging at times but, again, we can apply the following steps from Facebook's guide "Thinking in React[45]" to help us with the process:

> For each piece of state:
>
> - Identify every component that renders something based on that state.
> - Find a common owner component (a single component above all the components that need the state in the hierarchy).
> - Either the common owner or another component higher up in the hierarchy should own the state.
> - If you can't find a component where it makes sense to own the state, create a new component simply for holding the state and add it somewhere in the hierarchy above the common owner component.

Let's apply this method to our application:

The list of timers and attributes of each timer

At first glance, we may be tempted to conclude that `App` does not appear to use this state. Instead, the first component that uses this state is `EditableTimer`. We might think it would be wise to move timer attributes into the `EditableTimer` component's state as opposed to passing them down as props.

[45] https://facebook.github.io/react/docs/thinking-in-react.html

While this may be the case for displaying timers, modifying them, and deleting them, what about *creating* them? `ToggleableTimerForm` does not need the state to render, but it *can* affect state. It needs to be able to insert a new timer. It will propagate the data for the new timer up to the root `App`.

Therefore, `App` is truly the common owner. It renders `EditableTimer` components by passing down timer state. It can handle modifications from `EditableTimer` and creates from `ToggleableTimerForm`, mutating the state. The new state will then flow downward through `EditableTimer` via props.

Whether or not the edit form of a timer is open

In our static app, `App` specifies whether or not an `EditableTimer` should be rendered with its edit form open. Technically, though, this state could just live in each individual `EditableTimer`. No parent component in the hierarchy depends on this data.

Storing the state in `EditableTimer` will be fine for our current needs. But there are a few requirements that might require us to "hoist" this state up higher in the component hierarchy in the future.

For instance, what if we wanted to impose a restriction such that only one form, including the create form, could be open at a time? Then it would make sense for `App` to own the state, as it would need to inspect it to determine whether to allow for another form to open.

Visibility of the create form

`App` doesn't appear to care about whether `ToggleableTimerForm` is open or closed. It feels safe to reason that the state can just live inside `ToggleableTimerForm` itself.

So, in summary, we'll have three pieces of state each in three different components:

- **Timer data** will be owned and managed by `App`.
- Each `EditableTimer` will manage the state of its **timer edit form**.
- The `ToggleableTimerForm` will manage the state of its **form visibility**.

Step 5: Hardcode initial states

We're now well prepared to make our app stateful. We'll define our initial states within the components themselves. This means hardcoding a list of timers in the top-level component, `App`. For our two other pieces of state, we'll have the components' forms closed by default.

After we've added initial state to a parent component, we'll make sure our props are properly established in its children.

Adding state to `App`

Let's start by modifying `App` to hold the timer data in state.

We'll be using the npm library `uuid`[46] to generate ids for each of our timers. The library's function `uuidv4()` will randomly generate a Universally Unique IDentifier[47] for each of our timers.

A UUID is a string that looks like this:

```
2030efbd-a32f-4fcc-8637-7c410896b3e3
```

First, in your console, install the library:

```
yarn add uuid
```

Then, at the top of `App.js`, import the `uuidv4()` function:

[46] https://www.npmjs.com/package/uuid
[47] https://en.wikipedia.org/wiki/Universally_unique_identifier

time-tracking/2/App.js

```
import uuidv4 from 'uuid/v4';
```

Next, we'll initialize the component's state to an array of two timer objects. This will give us a list of timers to play with when we open the app:

time-tracking/2/App.js

```
export default class App extends React.Component {
  state = {
    timers: [
      {
        title: 'Mow the lawn',
        project: 'House Chores',
        id: uuidv4(),
        elapsed: 5456099,
        isRunning: true,
      },
      {
        title: 'Bake squash',
        project: 'Kitchen Chores',
        id: uuidv4(),
        elapsed: 1273998,
        isRunning: false,
      },
    ],
  };
```

We set the initial state to an object with the key `timers`. `timers` points to an array with two hardcoded timer objects.

As in the previous chapter, we're leaning on the Babel plugin `transform-class-properties` to help simplify how we define our initial state.

Below, in `render`, we'll use `state.timers` to generate an array of `EditableTimer` components. Each will be derived from an individual object in the `timers` array that's being passed in as a prop. We'll use `map` to do so:

time-tracking/2/App.js

```
  render() {
    const { timers } = this.state;

    return (
      <View style={styles.appContainer}>
        <View style={styles.titleContainer}>
          <Text style={styles.title}>Timers</Text>
        </View>
        <ScrollView style={styles.timerList}>
          <ToggleableTimerForm />
          {timers.map(
            ({ title, project, id, elapsed, isRunning }) => (
              <EditableTimer
                key={id}
                id={id}
                title={title}
                project={project}
                elapsed={elapsed}
                isRunning={isRunning}
              />
            ),
          )}
        </ScrollView>
      </View>
    );
  }
```

The rendered UI of the component ends up being an array of `EditableTimer` components:

```
[
  <EditableTimer
    timer={{
      title: 'Mow the lawn',
      project: 'House Chores',
      id: // random UUID,
      elapsed: 5456099,
      isRunning: true,
    }}
  />,
  <EditableTimer
    timer={{
      title: 'Bake squash',
      project: 'Kitchen Chores',
      id: // random UUID,
      elapsed: 1273998,
      isRunning: false,
    }}
  />
]
```

Notably, we're able to represent the `EditableTimer` component instance in JSX inside of `return`. It might seem odd at first that we're able to have a JavaScript array of JSX elements, but remember that Babel will transpile the JSX representation of each `EditableTimer` (`<EditableTimer />`) into regular JavaScript.

If you're interested in how this compiles, please refer to the Appendix.

Note the use of the `key={timer.id}` prop. The `key` prop is not used by our `EditableTimer` component but by the React Native framework. It's a special property that we discuss deeper in the next chapter "Core Components." For the time being, it's enough to note that this property needs to be unique per React Native component in a list.

Array's `map()`

If you're unfamiliar with the `map` method, it takes a function as an argument and calls it with each item inside of the array and builds a **new** array by using the return value from each function call.

Since the `timers` array has two items, `map` will call this function twice, once for each timer. When `map` calls this function, it passes in as the first argument an item. The return value from this function call is inserted into the new array that `map` is constructing. After handling the last item, `map` returns this new array. Here, we're rendering this new array within our `render()` method.

Props vs. state

Let's take a step back and reflect on the difference between props and state again. What existed as mutable state in `App` is **passed down as immutable props** to `EditableTimer`.

We talked at length about what qualifies as state and where state should live. Mercifully, we do not need to have an equally lengthy discussion about props. Once you understand state, you can see how props act as its **one-way data pipeline**. State is managed in some select parent components and then that data flows down through children as props.

If state is updated, the component managing that state re-renders by calling `render()`. This, in turn, causes any of its children to re-render as well. And the children of those children. And on and on down the chain.

Let's continue our own march down the chain.

Adding state to `EditableTimer`

In the static version of our app, `EditableTimer` relied on `editFormOpen` as a prop to be passed down from the parent. We decided that this state could actually live here in the component itself.

Because this component will actually manage state, we'll need to change it from a functional component to a class component.

We'll set the initial value of `editFormOpen` to `false`, which means that the form starts off as closed:

time-tracking/2/components/EditableTimer.js

```
export default class EditableTimer extends React.Component {
  state = {
    editFormOpen: false,
  };

  render() {
    const { id, title, project, elapsed, isRunning } = this.props;
    const { editFormOpen } = this.state;

    if (editFormOpen) {
      return <TimerForm id={id} title={title} project={project} />;
    }
    return (
      <Timer
        id={id}
        title={title}
        project={project}
        elapsed={elapsed}
        isRunning={isRunning}
      />
    );
  }
}
```

`Timer` remains stateless

If you look at `Timer`, you'll see that it does not need to be modified to include state. It has been using exclusively props and is so far unaffected by our current refactor.

Adding state to `ToggleableTimerForm`

We know that we'll need to tweak `ToggleableTimerForm` as we've assigned it some stateful responsibility. We want to have the component manage the state `isOpen`.

We'll initialize the state to a "closed" state at the top of the component:

time-tracking/2/components/ToggleableTimerForm.js

```
export default class ToggleableTimerForm extends React.Component {
  state = {
    isOpen: false,
  };
```

Next, we'll define a function that toggles the state of the form to open:

time-tracking/2/components/ToggleableTimerForm.js

```
  handleFormOpen = () => {
    this.setState({ isOpen: true });
  };
```

Finally, we'll modify the component's `render()` method to include our app's first piece of interactivity. We'll switch off of `isOpen` to determine whether we should render the "+" button or a `TimerForm`. We'll set `handleFormOpen` as the `onPress` handler for `TimerButton`:

time-tracking/2/components/ToggleableTimerForm.js

```
  render() {
    const { isOpen } = this.state;

    return (
      <View
        style={[styles.container, !isOpen && styles.buttonPadding]}
      >
        {isOpen ? (
          <TimerForm />
```

```
        ) : (
          <TimerButton
            title="+"
            color="black"
            onPress={this.handleFormOpen}
          />
        )}
      </View>
    );
  }
```

If you remember, we created `TimerButton` to accept an `onPress` prop which is passed down to the `onPress` action of the `TouchableOpacity` within. `TouchableOpacity` is a built-in React Native component. When it is pressed, it will invoke its `onPress` handler. `TimerButton` passes along its own `onPress` prop directly to `TouchableOpacity`.

Therefore, when the `TimerButton` is pressed, the function `handleFormOpen()` will be invoked. `handleFormOpen()` modifies the state, setting `isOpen` to `true`. This causes the `ToggleableTimerForm` component to re-render. When `render()` is called this second time around, `this.state.isOpen` is `true` and `ToggleableTimerForm` renders `TimerForm`. Neat.

As we explored in the last chapter, we are writing the `handleFormOpen()` function as a property initializer (i.e. using an *arrow* function) in order to ensure `this` inside the function is bound to the component. React will automatically bind class methods corresponding to the component API (like `render` and `componentDidMount`) to the component for us.

Our updated `ToggleableTimerForm`, in full:

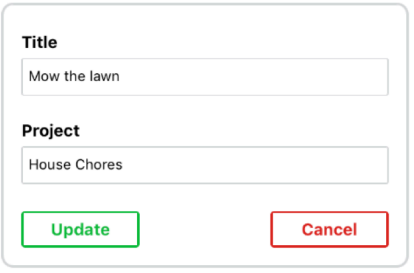
time-tracking/2/components/ToggleableTimerForm.js

```
export default class ToggleableTimerForm extends React.Component {
  state = {
    isOpen: false,
  };

  handleFormOpen = () => {
    this.setState({ isOpen: true });
  };

  render() {
    const { isOpen } = this.state;

    return (
      <View
        style={[styles.container, !isOpen && styles.buttonPadding]}
      >
        {isOpen ? (
          <TimerForm />
        ) : (
          <TimerButton
            title="+"
            color="black"
            onPress={this.handleFormOpen}
          />
        )}
      </View>
    );
  }
}
```

Adding state to `TimerForm`

We mentioned earlier that `TimerForm` would manage state as it includes a form. In React Native, **forms are stateful**.

Recall that `TimerForm` includes two input fields:



These input fields are modifiable by the user. In React Native, **all** modifications that are made to a component should be handled and kept in state. This includes changes like the modification of an input field. The best way to understand this is to see what it looks like.

To make these input fields stateful, we can make our component stateful and initialize `state` at the top of our component:

time-tracking/2/components/TimerForm.js

```
export default class TimerForm extends React.Component {
  constructor(props) {
    super(props);

    const { id, title, project } = props;

    this.state = {
      title: id ? title : '',
      project: id ? project : '',
    };
  }
```

Our state object has two properties, each corresponding to an input field that `TimerForm` manages. If `TimerForm` is *creating* a new timer as opposed to editing an existing one, the `id` prop will be `undefined`. In that case, we initialize both properties to a blank string (`''`) using ternary operators. Otherwise, when this form is *editing* a timer, we'll want to set both values to their respective prop values.

Note that because we're checking and defining our state based on props, we're using the `constructor()` for state initialization instead of defining state as a class property.

We want to avoid initializing `title` or `project` to `undefined`. That's because the value of an input field can't technically ever be `undefined`. If it's empty, its value in JavaScript is a blank string.

In our first pass at building this component, we used `defaultValue` to set the initial state of the `TextInput` fields based on props. But the `defaultValue` prop only sets the value of the `TextInput` for the *initial* render. Instead of using `defaultValue`, we can connect our input fields directly to our component's state using `value`. We could do something like this:

```
<TextInput value={this.state.title} />
```

With this, our input fields would be driven by state. Whenever either of our state properties change, our input fields would be updated to reflect the new value.

However, this misses a key ingredient: **We don't currently have any way for the user to *modify* this state**. The input field will start off in-sync with the component's state. But the moment the user makes a modification, **the input field will become out-of-sync with the component's state**.

We can fix this by using React Native's **`onChangeText`** prop for `TextInput` components. Like `onPress` for a `button` component, we can set `onChangeText` to a function like we did in our previous chapter. Whenever the input field is changed, React will invoke the function specified.

Let's set the `onChangeText` attributes on both input fields to functions we'll define next. For our *title* input field:

time-tracking/2/components/TimerForm.js

```
<TextInput
  style={styles.textInput}
  underlineColorAndroid="transparent"
  onChangeText={this.handleTitleChange}
  value={title}
/>
```

And similarly for *project*:

time-tracking/2/components/TimerForm.js

```
<TextInput
  style={styles.textInput}
  underlineColorAndroid="transparent"
  onChangeText={this.handleProjectChange}
  value={project}
/>
```

The functions `handleTitleChange` and `handleProjectChange` will both modify their respective properties in state. Here's what they look like:

time-tracking/2/components/TimerForm.js

```
handleTitleChange = title => {
  this.setState({ title });
};

handleProjectChange = project => {
  this.setState({ project });
};
```

When React Native invokes the function passed to `onChangeText`, it invokes the function with the changed text passed as the argument. With this, we update the state to the new value of the input field.

Using a combination of state, the `value` attribute, and the `onChangeText` attribute is the canonical method we use to write form elements in React Native.

Our updated `TimerForm` component, in full:

time-tracking/2/components/TimerForm.js

```
export default class TimerForm extends React.Component {
  constructor(props) {
    super(props);

    const { id, title, project } = props;

    this.state = {
      title: id ? title : '',
      project: id ? project : '',
    };
  }

  handleTitleChange = title => {
    this.setState({ title });
  };

  handleProjectChange = project => {
    this.setState({ project });
  };

  render() {
    const { id } = this.props;
    const { title, project } = this.state;

    const submitText = id ? 'Update' : 'Create';

    return (
      <View style={styles.formContainer}>
        <View style={styles.attributeContainer}>
          <Text style={styles.textInputTitle}>Title</Text>
          <View style={styles.textInputContainer}>
```

```
            <TextInput
              style={styles.textInput}
              underlineColorAndroid="transparent"
              onChangeText={this.handleTitleChange}
              value={title}
            />
          </View>
        </View>
        <View style={styles.attributeContainer}>
          <Text style={styles.textInputTitle}>Project</Text>
          <View style={styles.textInputContainer}>
            <TextInput
              style={styles.textInput}
              underlineColorAndroid="transparent"
              onChangeText={this.handleProjectChange}
              value={project}
            />
          </View>
        </View>
        <View style={styles.buttonGroup}>
          <TimerButton small color="#21BA45" title={submitText} />
          <TimerButton small color="#DB2828" title="Cancel" />
        </View>
      </View>
    );
  }
}
```

To recap, here's an example of the lifecycle of `TimerForm`:

1. On the page is a timer with the title "Mow the lawn."
2. The user toggles open the edit form for this timer, mounting `TimerForm` to the screen.
3. `TimerForm` initializes the state property `title` to the string `"Mow the lawn"`.
4. The user modifies the `title` input field, changing it to the value `"Cut the grass"`.

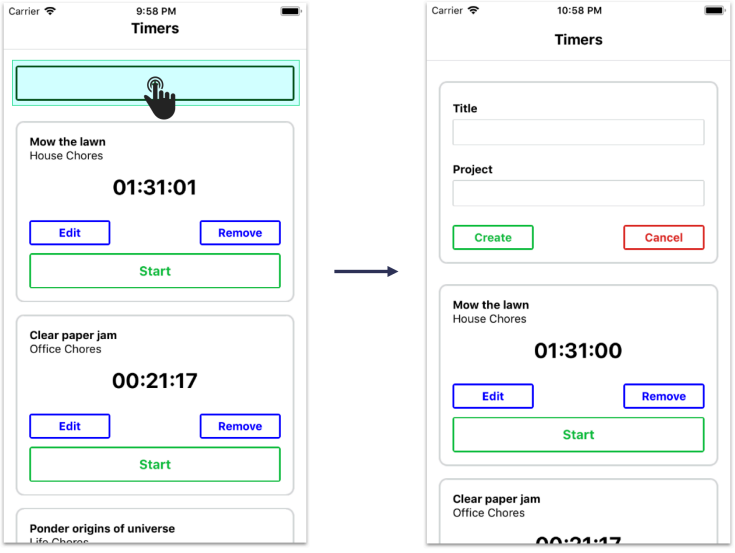
5. With every keystroke, React invokes `handleTitleChange`. The internal state of `title` is kept in-sync with what the user sees on the page.

With `TimerForm` refactored, we've finished establishing our stateful data inside our components. And we've assembled our downward data pipeline, props.

We're ready — and perhaps a bit eager — to build out interactivity using inverse data flow. But before we do, let's save and reload the app to ensure everything is working.

Try it out

We expect to see new example timers based on the hardcoded data in `App`. We also expect pressing the "+" button toggles open a form:



Step 6: Add inverse data flow

As we saw in the last chapter, children communicate with parents by calling functions that are provided to them via props. In our weather app, when our search field was submitted with a value, `SearchInput` didn't do any data management.

Instead, it called a function given to it by `App`, which was then able to manage state accordingly.

We are going to need inverse data flow in two areas:

- `TimerForm` needs to propagate **create** and **update** events (create while under `ToggleableTimerForm` and update while under `EditableTimer`). Both events will eventually reach our top level `App`.
- `Timer` has a fair amount of behavior. It needs to handle **delete** and **edit** press, as well as the **start** and **stop** timer logic.

Let's start with `TimerForm`.

`TimerForm`

To get a clear idea of what exactly `TimerForm` will require, we'll start by adding event handlers to it and then we'll work our way backwards up the hierarchy.

`TimerForm` needs two **event handlers**:

- When the form is submitted (creating or updating a timer)
- When the "Cancel" button is pressed (closing the form)

`TimerForm` will receive two functions as props to handle each event. The parent component that uses `TimerForm` is responsible for providing these functions:

- `props.onFormSubmit()`: called when the form is submitted
- `props.onFormClose()`: called when the "Cancel" button is pressed

As we'll see soon, this enables the parent component to determine what the behavior should be when these events occur.

Let's first add `onFormClose` to the props being destructured in the component's render method:

time-tracking/3/components/TimerForm.js

```
  render() {
    const { id, onFormClose } = this.props;
```

We'll then modify the buttons on `TimerForm` by specifying `onPress` props for each:

time-tracking/3/components/TimerForm.js

```
        <View style={styles.buttonGroup}>
          <TimerButton
            small
            color="#21BA45"
            title={submitText}
            onPress={this.handleSubmit}
          />
          <TimerButton
            small
            color="#DB2828"
            title="Cancel"
            onPress={onFormClose}
          />
        </View>
```

The `onPress` prop for the "Submit" button specifies the function `this.handleSubmit`, which we'll define next. The `onPress` prop for the "Cancel" button specifies the prop `onFormClose` directly.

Now that we've seen how we'll use `handleSubmit`, let's write it. Declare this function above `render()`:

time-tracking/3/components/TimerForm.js

```
  handleSubmit = () => {
    const { onFormSubmit, id } = this.props;
    const { title, project } = this.state;

    onFormSubmit({
      id,
      title,
      project,
    });
  };
```

Again, we're working bottom-up right now. So the `handleSubmit()` method calls the anticipated function `onFormSubmit()` which we'll write in a moment. It passes in a data object with `id`, `title`, and `project` attributes.

Notice that we're reading `id` via props and reading `title` and `project` from state. This is because we want to supply the function with the up-to-date values of `title` and `project` (in state) as opposed to the initial values (supplied as props).

`ToggleableTimerForm`

Let's follow the submit event from `TimerForm` as it bubbles up the component hierarchy. First, we'll modify `ToggleableTimerForm`. We need it to define and pass down two prop-functions to `TimerForm`: `onFormClose()` and `onFormSubmit()`.

Let's update the component's `render()` method first:

time-tracking/4/components/ToggleableTimerForm.js

```
  render() {
    const { isOpen } = this.state;

    return (
      <View
        style={[styles.container, !isOpen && styles.buttonPadding]}
      >
        {isOpen ? (
          <TimerForm
            onFormSubmit={this.handleFormSubmit}
            onFormClose={this.handleFormClose}
          />
        ) : (
          <TimerButton
            title="+"
            color="black"
            onPress={this.handleFormOpen}
          />
        )}
      </View>
    );
  }
```

We pass in two functions as props to `TimerForm`. As we've seen, functions are just like any other prop.

Let's write `handleFormClose()` first:

time-tracking/4/components/ToggleableTimerForm.js

```
  handleFormClose = () => {
    this.setState({ isOpen: false });
  };
```

Now, what might `handleFormSubmit()` look like? `ToggleableTimerForm` is not the manager of timer state. So `ToggleableTimerForm` should expect a new prop, `onFormSubmit()`

from `App`. `ToggleableTimerForm` should, in turn, pass this down to `TimerForm`. When the user submits a form down in `TimerForm`, they'll be invoking a function defined up in `App` that modifies the timer state. `ToggleableTimerForm` is just a proxy of this function.

So, we might be tempted to just pass this anticipated prop-function directly to `TimerForm` like this:

```
<TimerForm
  onFormSubmit={this.props.onFormSubmit}
  onFormClose={this.handleFormClose}
/>
```

However, consider this: after the user clicks "Create" to create a timer, we actually want to close `ToggleableTimerForm`. We'll want to *intercept* this event so that we can set `isOpen` to `false`.

To do this, here's what `handleFormSubmit()` looks like:

time-tracking/4/components/ToggleableTimerForm.js

```
  handleFormSubmit = timer => {
    const { onFormSubmit } = this.props;

    onFormSubmit(timer);
    this.setState({ isOpen: false });
  };
```

The `handleFormSubmit()` method accepts the argument `timer` and passes it along to `onFormSubmit()`. Recall that in `TimerForm` this argument is an object containing the desired timer properties. After invoking `onFormSubmit()`, `handleFormSubmit()` calls `setState()` to close its form.

Although we're not adding server communication in this chapter, let's try and visualize how submitting the form would work if we did.

The *result* of `onFormSubmit()` will not impact whether or not the form is closed. We invoke `onFormSubmit()`, which may eventually create an **asynchronous** call to a server. Execution will continue before we hear back from the server which means `setState()` will be called.

If `onFormSubmit()` fails — such as if the server is temporarily unreachable — we'd ideally have some way to display an error message and re-open the form.

App

We've reached the top of the hierarchy, our root `App` component. As this component will be responsible for the data for the timers, it is here that we will define the logic for handling the events we're capturing down at the lowest-level components.

The first event we're concerned with is the submission of a form (i.e. events from `TimerForm`). When this happens, either a new timer is being *created* or an existing one is being *updated*. We'll create two separate functions to handle these two distinct events:

- `handleCreateFormSubmit()` will handle creating timers and will be the function passed to `ToggleableTimerForm`
- `handleFormSubmit()` will handle updating timers and will be the function passed to `EditableTimer`

Both functions travel down their respective component hierarchies until they reach `TimerForm` as the prop `onFormSubmit()`.

Let's start with `handleCreateFormSubmit()`.

Handling creates

`handleCreateFormSubmit()` will be the function `App` will supply to `ToggleableTimerForm`. Let's set that prop now:

time-tracking/3/App.js

```
          <ToggleableTimerForm
            onFormSubmit={this.handleCreateFormSubmit}
          />
```

Next, we'll define the function.

For creating timers, we'll be using the function `newTimer()` from `utils/TimerUtils.js`. This just hides some logic, like generating ids. Here's what it looks like:

time-tracking/utils/TimerUtils.js

```
export const newTimer = (attrs = {}) => {
  const timer = {
    title: attrs.title || 'Timer',
    project: attrs.project || 'Project',
    id: uuidv4(),
    elapsed: 0,
    isRunning: false,
  };

  return timer;
};
```

The function accepts an object with `timer` and `project` properties and returns a new object with the rest of the properties properly initialized.

Import that function at the top of `App.js`:

time-tracking/3/App.js

```
import { newTimer } from './utils/TimerUtils';
```

Inside `handleCreateFormSubmit()`, we'll use `newTimer()` to insert a new timer object into state. Declare this function above `render()`:

time-tracking/3/App.js

```
  handleCreateFormSubmit = timer => {
    const { timers } = this.state;

    this.setState({
      timers: [newTimer(timer), ...timers],
    });
  };
```

Note that we set `this.state.timers` to a *new* array of timers. The first element in the array is our new timer, created with `newTimer()`. Then, we use JavaScript's **spread syntax** to add the rest of our existing timers to this new array. We do this to avoid mutating state.

The tempting alternative is to write `handleCreateFormSubmit()` like this:

```
handleCreateFormSubmit = timer => {
    const { timers } = this.state;

    this.setState({
        timers: timers.push(newTimer(timer)), // mutates state!
    });
};
```

But `.push()` *appends* the new timer to the existing array in state. It's subtle, but this *mutates state*. And we never want to mutate state outside of the `this.setState()` method.

We always want to treat the state object (and the objects and arrays inside state) as immutable. Writing immutable JavaScript can be tricky at first. A simple strategy is to just avoid using certain Array and Object methods. `.push()` is one method to avoid, as it always mutates the array it is called on.

If you still find the distinction between `.push()` and the spread syntax confusing, don't worry. We'll be showcasing strategies for how to avoid accidental state mutations throughout the book.

Spread syntax

In arrays, the ellipsis (...) will expand the array that follows into the parent array. The spread operator enables us to succinctly construct new arrays as a composite of existing arrays:

```
const a = [ 1, 2, 3 ];
const b = [ 4, 5, 6 ];
const c = [ ...a, ...b, 7, 8, 9 ];

console.log(c);  // [ 1, 2, 3, 4, 5, 6, 7, 8, 9 ]
```

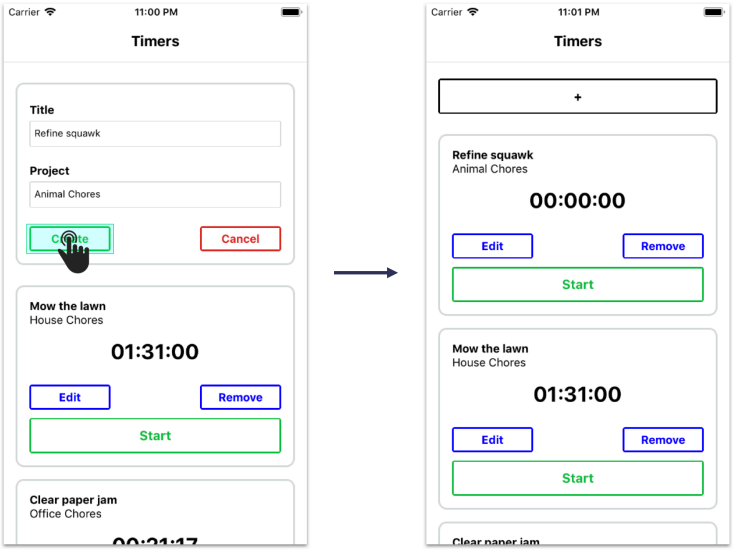
In objects, the ellipsis (...) will allow you to create a modified version of an existing object:

```
const coffee = { milk: false, cream: false };
const coffeeWithMilk = { ...coffee, milk: true };
console.log(coffeeWithMilk);  // { milk: true, cream: false }
```

This can be useful when working with immutable JavaScript objects.

Try it out

Now we've finished wiring up the create timer flow from the form down in `TimerForm` up to the state managed in `App`. Save `App.js` and your app should reload. Toggle open the create form and create some new timers:



Updating timers

Our app is setup for creating timers. Let's add updates next.

We know we'll eventually want `App` to define a handler, `onFormSubmit()`, for when `TimerForm` submits a timer update. However, as you can see in the current state of the app, we haven't yet added the ability for a timer to be edited. We don't yet have a way to display an edit form which will be a prerequisite to submitting one.

To display an edit form, the user will press on the edit button on a `Timer`. This should propagate an event up to `EditableTimer` and tell it to flip its child component, opening the form.

We'll work from the bottom-up again. We'll start with `Timer`, specify the prop-functions that it needs, then move up the component hierarchy.

Adding editability to `Timer`

Since we'll be adding a fair bit of functionality to `Timer`, we'll first convert it into a class component:

time-tracking/4/components/Timer.js

```
export default class Timer extends React.Component {
```

`EditableTimer` manages the state of whether or not the edit form is open. So, we'll expect `Timer` to receive a prop from its parent, `onEditPress()`. We'll set the `onPress` prop on the "Edit" `TimerButton` to this prop:

time-tracking/4/components/Timer.js

```
  render() {
    const { elapsed, title, project, onEditPress } = this.props;
    const elapsedString = millisecondsToHuman(elapsed);

    return (
      <View style={styles.timerContainer}>
        <Text style={styles.title}>{title}</Text>
        <Text>{project}</Text>
        <Text style={styles.elapsedTime}>{elapsedString}</Text>
        <View style={styles.buttonGroup}>
          <TimerButton
            color="blue"
            small
            title="Edit"
            onPress={onEditPress}
          />
          <TimerButton color="blue" small title="Remove" />
        </View>
        <TimerButton color="#21BA45" title="Start" />
      </View>
    );
  }
```

Updating `EditableTimer`

Now we're prepared to update `EditableTimer`. Again, it will display either the `TimerForm` (if we're editing) or an individual `Timer` (if we're not editing).

Let's add event handlers for both possible child components. For `TimerForm`, we want to handle the form being closed or submitted. For `Timer`, we want to handle the edit button being pressed:

time-tracking/4/components/EditableTimer.js

```
export default class EditableTimer extends React.Component {
  state = {
    editFormOpen: false,
  };

  handleEditPress = () => {
    this.openForm();
  };

  handleFormClose = () => {
    this.closeForm();
  };

  handleSubmit = timer => {
    const { onFormSubmit } = this.props;

    onFormSubmit(timer);
    this.closeForm();
  };

  closeForm = () => {
    this.setState({ editFormOpen: false });
  };

  openForm = () => {
    this.setState({ editFormOpen: true });
  };
```

We pass these event handlers down as props:

time-tracking/4/components/EditableTimer.js

```
  render() {
    const { id, title, project, elapsed, isRunning } = this.props;
    const { editFormOpen } = this.state;

    if (editFormOpen) {
      return (
        <TimerForm
          id={id}
          title={title}
          project={project}
          onFormSubmit={this.handleSubmit}
          onFormClose={this.handleFormClose}
        />
      );
    }
    return (
      <Timer
        id={id}
        title={title}
        project={project}
        elapsed={elapsed}
        isRunning={isRunning}
        onEditPress={this.handleEditPress}
      />
    );
  }
```

Look a bit familiar? `EditableTimer` handles the same events emitted from `TimerForm` in a similar manner as `ToggleableTimerForm`. This makes sense. Both `EditableTimer` and `ToggleableTimerForm` are just intermediaries between `TimerForm` and `App`. `App` is the one that defines the submit function handlers.

Like `ToggleableTimerForm`, `EditableTimer` doesn't do anything with the incoming `timer`. In `handleSubmit()`, it just blindly passes this object along to its prop-function `onFormSubmit()`. It then closes the form with `closeForm()`.

We pass along our new prop to `Timer`, `onEditPress`. The behavior for this function is defined in `handleEditPress`, which modifies the state for `EditableTimer`, opening the form.

Defining `handleFormSubmit()` in `App`

Like we did with `handleCreateFormSubmit()`, the last step with this pipeline is to define a handler for edit form submits up in `App`, `handleFormSubmit()`.

For creating timers, we have a function that creates a new timer object with the specified attributes and we prepend this new object to the beginning of the `timers` array in state.

For updating timers, we need to hunt through the `timers` array until we find the timer object that is being updated. As always, the state object **cannot** be updated directly. We have to use `setState()`.

Therefore, we'll use `map()` to traverse the array of timer objects. If the timer's `id` matches that of the form submitted, we'll return a new object that contains the timer with the updated attributes. Otherwise we'll just return the original timer. This new array of timer objects will be passed to `setState()`:

time-tracking/4/App.js

```
  handleFormSubmit = attrs => {
    const { timers } = this.state;

    this.setState({
      timers: timers.map(timer => {
        if (timer.id === attrs.id) {
          const { title, project } = attrs;

          return {
            ...timer,
            title,
            project,
          };
        }
```

```
        return timer;
      }),
    });
  };
```

Note that we call `map()` on `timers` from *within* the JavaScript object we're passing to `setState()`. This is an often used pattern. The call is evaluated and then the property `timers` is set to the result. Inside of the `map()` function we check if the `timer` matches the one being updated by comparing their `id` attributes. If not, we just return the `timer`. Otherwise, we use the spread operator again to return a new object with the timer's updated attributes.

Remember, it's important here that we treat state as immutable. By creating a *new* timers object and then using the spread operator to populate it, we're not modifying any of the objects sitting in state.

We pass this method down as a prop inside `render()` to `EditableTimer`:

time-tracking/4/App.js

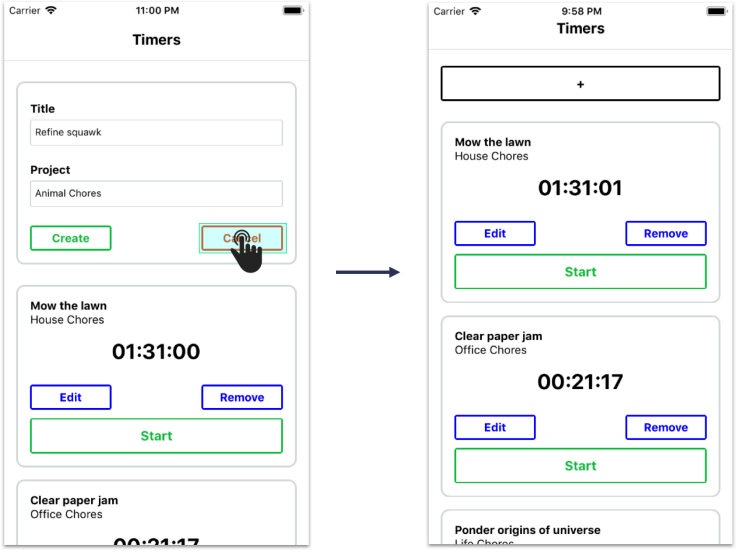
```
          {timers.map(
            ({ title, project, id, elapsed, isRunning }) => (
              <EditableTimer
                key={id}
                id={id}
                title={title}
                project={project}
                elapsed={elapsed}
                isRunning={isRunning}
                onFormSubmit={this.handleFormSubmit}
              />
            ),
          )}
```

As we did with `ToggleableTimerForm` and `handleCreateFormSubmit`, we pass down `handleFormSubmit` as the prop `onFormSubmit`. `TimerForm` calls this prop, oblivious

to the fact that this function is entirely different when it is rendered underneath `EditableTimer` as opposed to `ToggleableTimerForm`.

Try it out

Both of the forms are wired up! Save `App.js`, and after your app reloads, try both creating and updating timers. You can also press "Cancel" on an open form to close it:



Note that the keyboard might get in the way when you're typing into an edit form. We'll address this at the end of the chapter by using the `KeyboardAvoidingView` component in `App`.

The rest of our work resides within the timer. We need to:

- Wire up the "Remove" button
- Implement the start/stop buttons and the timing logic itself

Try it yourself

Feeling ambitious? Before moving on to the next section, see how far you can get wiring up the "Remove" button by yourself. Move ahead afterwards and verify your solution is sound.

Deleting timers

Adding the event handler to `Timer`

As with adding create and update functionality, we'll work from the bottom-up. We'll start in `Timer` and work our way up to `App`. In `App` is where we'll define the function that removes the targeted timer from state.

In `Timer`, we'll begin by defining the function for handling "Remove" button press events:

time-tracking/5/components/Timer.js

```
  handleRemovePress = () => {
    const { id, onRemovePress } = this.props;

    onRemovePress(id);
  };
```

We've yet to define the function that will be set as the prop `onRemovePress()`. But you can imagine that when this event reaches the top (`App`), we're going to need the `id` to sort out which timer is being deleted. The `handleRemovePress()` method provides the `id` to this function.

We use `onPress` to connect that function to the "Remove" `TimerButton`:

time-tracking/5/components/Timer.js

```
          <TimerButton
            color="blue"
            small
            title="Remove"
            onPress={this.handleRemovePress}
          />
```

Routing through `EditableTimer`

In `EditableTimer`, we include `onRemovePress` in the destructured props in the component's `render` method:

time-tracking/5/components/EditableTimer.js

```
  render() {
    const {
      id,
      title,
      project,
      elapsed,
      isRunning,
      onRemovePress,
    } = this.props;
```

We then pass the function along to `Timer`:

time-tracking/5/components/EditableTimer.js

```
      <Timer
        id={id}
        title={title}
        project={project}
        elapsed={elapsed}
        isRunning={isRunning}
        onEditPress={this.handleEditPress}
        onRemovePress={onRemovePress}
      />
```

Implementing the remove function in `App`

The last step is to define the function in `App` that removes the desired timer from the state array. There are many ways to accomplish this in JavaScript. If you attempted to implement this solution on your own, don't sweat it if your solution was not the same.

We add our handler function that we will ultimately pass down as a prop:

time-tracking/5/App.js

```
  handleRemovePress = timerId => {
    this.setState({
      timers: this.state.timers.filter(t => t.id !== timerId),
    });
  };
```

Here, we use the Array `filter()` method to return a new array without the timer object that has an `id` matching `timerId`.

Finally, we pass down `handleRemovePress()` as a prop:

time-tracking/5/App.js

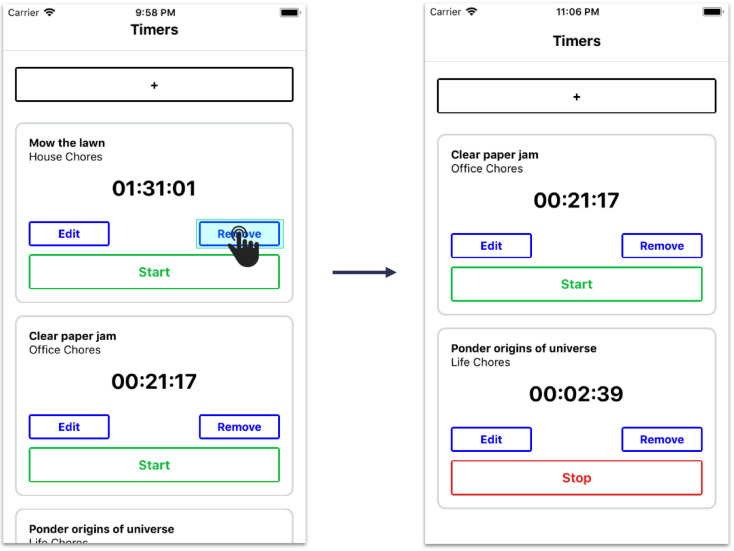
```
              <EditableTimer
                key={id}
                id={id}
                title={title}
                project={project}
                elapsed={elapsed}
                isRunning={isRunning}
                onFormSubmit={this.handleFormSubmit}
                onRemovePress={this.handleRemovePress}
              />
```

Array `filter()`

Array `filter()` accepts a function that is used to "test" each element in the array. It returns a new array containing all the elements that "passed" the test. If the function returns `true`, the element is kept.

Try it out

Save `App.js` and reload the app. Now you can delete timers:



Adding timing functionality

Functionality for creating, updating, and deleting is now in place for our timers. The next challenge: making these timers actually track time.

There are several different ways we can implement a timer system. The simplest approach would be to have a function update the `elapsed` property on each timer every second. This is why we've included the timer property `isRunning`. We can do something like this:

```
this.setState({
  timers: timers.map(timer => {
    const { elapsed, isRunning } = timer;

    return {
      ...timer,
      elapsed: isRunning ? elapsed + 1000 : elapsed,
    };
  }),
});
```

We map through all the timers in state and check the value of `isRunning`. If `isRunning` is true, we can add 1000 milliseconds (or 1 second) to `elapsed`.

Now, to make this work we'll need to do this every second. We can use JavaScript's `setInterval()` to execute this function on an interval.

Let's set up our interval in `componentDidMount`:

time-tracking/6/App.js

```
  componentDidMount() {
    const TIME_INTERVAL = 1000;

    this.intervalId = setInterval(() => {
      const { timers } = this.state;

      this.setState({
        timers: timers.map(timer => {
          const { elapsed, isRunning } = timer;

          return {
            ...timer,
            elapsed: isRunning ? elapsed + TIME_INTERVAL : elapsed,
          };
        }),
      });
    }, TIME_INTERVAL);
  }
```

`setInterval()` accepts two arguments. The first argument is the function we'd like executed on an interval. Here, we're performing the logic to update `elapsed`. The second argument is the length of the interval (or the delay between function invocations). We set that to `TIME_INTERVAL`, 1000 milliseconds.

We also capture the return value of `setInterval()`, setting the component variable `this.intervalId`. This special identifier allows us to stop the interval at any point in the future using JavaScript's corresponding `clearInterval()`. We'll want to cancel (or "clear") this interval if the timer component is ever unmounted (deleted).

Otherwise, our function will run on indefinitely and cause errors. We can use the `componentWillUnmount` lifecycle hook for this:

time-tracking/6/App.js

```
componentWillUnmount() {
  clearInterval(this.intervalId);
}
```

This is the first time we're using `componentWillUnmount`. Like the name suggests, this method fires right before a component is unmounted or removed. In this example, we use `clearInterval()` to cancel the logic that updates our timers.

Using `setInterval()` when a component mounts and `clearInterval()` when a component unmounts is a common pattern in React apps that require interval events.

In our version of the app, `App` will never be unmounted. However, it is still best practice to clear any intervals when a component unmounts. This "future proofs" our app. There are many libraries, like "hot reloading" libraries, that would cause even the app's main component to be unmounted and re-mounted.

Although this timer implementation works for our purposes, it is not the most accurate. There is no guarantee that timers will be updated precisely every 1000 milliseconds and we lose accuracy around starts and stops.

An example of a more precise approach would be defining a separate timer attribute, like `runningSince`. We could then derive how long a timer has been running by calculating the difference between the value of `runningSince` and the current time. If we saved this value somewhere, it would also allow our timers to continue "running" even while the app is closed.

Add start and stop functionality

With our interval in place, we just need to add the ability to flip the `isRunning` boolean on a given timer.

The action button at the bottom of each timer should display "Start" if the timer is paused and "Stop" if the timer is running. These presses will invoke functions defined in `App` that will modify `isRunning`.

Add timer action events to `Timer`

We'll start at the bottom again with `Timer`.

We'll anticipate two prop-functions, `onStartPress()` and `onStopPress()`. Let's write the button press event handlers that will call these functions first:

time-tracking/6/components/Timer.js

```
  handleStartPress = () => {
    const { id, onStartPress } = this.props;

    onStartPress(id);
  };

  handleStopPress = () => {
    const { id, onStopPress } = this.props;

    onStopPress(id);
  };
```

We're propagating the `id` property up to `App` so it knows which timer to start or stop.

Inside `render()`, we'll anticipate a `renderActionButton()` method that conditionally shows the correct button based on whether the timer is running or has stopped:

time-tracking/6/components/Timer.js

```
  render() {
    const { elapsed, title, project, onEditPress } = this.props;
    const elapsedString = millisecondsToHuman(elapsed);

    return (
      <View style={styles.timerContainer}>
        <Text style={styles.title}>{title}</Text>
        <Text>{project}</Text>
        <Text style={styles.elapsedTime}>{elapsedString}</Text>
        <View style={styles.buttonGroup}>
          <TimerButton
            color="blue"
            small
            title="Edit"
            onPress={onEditPress}
          />
          <TimerButton
            color="blue"
            small
            title="Remove"
            onPress={this.handleRemovePress}
          />
        </View>
        {this.renderActionButton()}
      </View>
    );
  }
```

Now let's set up the JSX rendered within this method:

time-tracking/6/components/Timer.js

```
  renderActionButton() {
    const { isRunning } = this.props;

    if (isRunning) {
      return (
        <TimerButton
          color="#DB2828"
          title="Stop"
          onPress={this.handleStopPress}
        />
      );
    }

    return (
      <TimerButton
        color="#21BA45"
        title="Start"
        onPress={this.handleStartPress}
      />
    );
  }
```

We could write this conditional inside of the component's `render()` method. But, as we briefly mentioned in the previous chapter, a common pattern in React is to use helper methods to do this. Sometimes this helps with code clarity and readability. In `renderActionButton()`, we specifically render one button or another based on `this.props.isRunning`.

Now we'll need to run these events up the component hierarchy, all the way up to `App` where we're managing state.

Run the events through `EditableTimer`

In `EditableTimer`, we'll need to pass `onStartPress` and `onStopPress` to `Timer`:

time-tracking/6/components/EditableTimer.js

```
  render() {
    const {
      id,
      title,
      project,
      elapsed,
      isRunning,
      onRemovePress,
      onStartPress,
      onStopPress,
    } = this.props;
    const { editFormOpen } = this.state;

    if (editFormOpen) {
      return (
        <TimerForm
          id={id}
          title={title}
          project={project}
          onFormSubmit={this.handleSubmit}
          onFormClose={this.handleFormClose}
        />
      );
    }
    return (
      <Timer
        id={id}
        title={title}
        project={project}
        elapsed={elapsed}
        isRunning={isRunning}
        onEditPress={this.handleEditPress}
        onRemovePress={onRemovePress}
        onStartPress={onStartPress}
        onStopPress={onStopPress}
```

```
      />
    );
  }
```

We can define a single function that handles these props in `App`. It should hunt through the state timers array using `map`, flipping `isRunning` when it finds the matching timer:

time-tracking/6/App.js

```
  toggleTimer = timerId => {
    this.setState(prevState => {
      const { timers } = prevState;

      return {
        timers: timers.map(timer => {
          const { id, isRunning } = timer;

          if (id === timerId) {
            return {
              ...timer,
              isRunning: !isRunning,
            };
          }

          return timer;
        }),
      };
    });
  };
```

When `toggleTimer` comes across the relevant timer within its `map` call, it sets the property `isRunning` to the opposite of its value. This means it will *stop* a running timer and *start* a stopped timer.

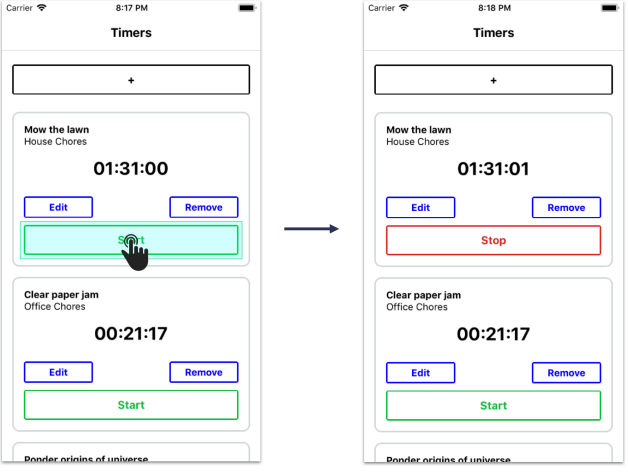
Finally, we pass this function down to `EditableTimer` in the render method:

time-tracking/6/App.js

```
<EditableTimer
  key={id}
  id={id}
  title={title}
  project={project}
  elapsed={elapsed}
  isRunning={isRunning}
  onFormSubmit={this.handleFormSubmit}
  onRemovePress={this.handleRemovePress}
  onStartPress={this.toggleTimer}
  onStopPress={this.toggleTimer}
/>
```

Try it out

Save `App.js`, wait for the app to reload, and behold: you can now create, update, and delete timers as well as actually use them to time things!



Again, for this app we won't add server communication. Without it, our app's data is ephemeral. If we reload the app, the timers will reset.

Wrapping `App` in `KeyboardAvoidingView`

A behavioral quirk in our app so far has been that the keyboard can get in the way when we edit a timer. As we saw in the first chapter, we can wrap our app in a `KeyboardAvoidingView` component to address this.

In `App.js`, first import the component:

time-tracking/6/App.js

```
import React from 'react';
import uuidv4 from 'uuid/v4';

import {
  StyleSheet,
  View,
  ScrollView,
  Text,
  KeyboardAvoidingView,
```

Next, wrap the `ScrollView` component with it:

time-tracking/6/App.js

```
  render() {
    const { timers } = this.state;

    return (
      <View style={styles.appContainer}>
        <View style={styles.titleContainer}>
          <Text style={styles.title}>Timers</Text>
        </View>
        <KeyboardAvoidingView
          behavior="padding"
          style={styles.timerListContainer}
        >
          <ScrollView contentContainerStyle={styles.timerList}>
            <ToggleableTimerForm
```

```
            onFormSubmit={this.handleCreateFormSubmit}
          />
          {timers.map(
            ({ title, project, id, elapsed, isRunning }) => (
              <EditableTimer
                key={id}
                id={id}
                title={title}
                project={project}
                elapsed={elapsed}
                isRunning={isRunning}
                onFormSubmit={this.handleFormSubmit}
                onRemovePress={this.handleRemovePress}
                onStartPress={this.toggleTimer}
                onStopPress={this.toggleTimer}
              />
            ),
          )}
        </ScrollView>
      </KeyboardAvoidingView>
    </View>
  );
}
```

Finally, add this style to the `styles` object:

time-tracking/6/App.js

```
  timerListContainer: {
    flex: 1,
  },
```

Our `ScrollView` will now accommodate the keyboard when we start typing into text inputs.

To finish up, let's add `PropTypes` to our components. As discussed in the previous chapter, `PropTypes` are nice to have in place when making additions or changes to a React Native app.

PropTypes

Let's add `PropTypes` to each of our components beginning with `EditableTimer`:

time-tracking/components/EditableTimer.js

```
export default class EditableTimer extends React.Component {
  static propTypes = {
    id: PropTypes.string.isRequired,
    title: PropTypes.string.isRequired,
    project: PropTypes.string.isRequired,
    elapsed: PropTypes.number.isRequired,
    isRunning: PropTypes.bool.isRequired,
    onFormSubmit: PropTypes.func.isRequired,
    onRemovePress: PropTypes.func.isRequired,
    onStartPress: PropTypes.func.isRequired,
    onStopPress: PropTypes.func.isRequired,
  };
```

For this component, all our props are required as we're expecting `App` to always set them. Now let's take a look at `Timer`:

time-tracking/components/Timer.js

```
export default class Timer extends Component {
  static propTypes = {
    id: PropTypes.string.isRequired,
    title: PropTypes.string.isRequired,
    project: PropTypes.string.isRequired,
    elapsed: PropTypes.number.isRequired,
    isRunning: PropTypes.bool.isRequired,
    onEditPress: PropTypes.func.isRequired,
    onRemovePress: PropTypes.func.isRequired,
    onStartPress: PropTypes.func.isRequired,
    onStopPress: PropTypes.func.isRequired,
  };
```

Similarly, we know each of the props for `Timer` should always be provided by `EditableTimer`. Let's add `PropTypes` and `defaultProps` for `TimerButton`:

time-tracking/components/TimerButton.js

```
TimerButton.propTypes = {
  color: ColorPropType.isRequired,
  title: PropTypes.string.isRequired,
  small: PropTypes.bool,
  onPress: PropTypes.func.isRequired,
};

TimerButton.defaultProps = {
  small: false,
};
```

`small` is an optional prop with a default value of `false`. Our other props are all required. We're also using `ColorPropType` for our `color` prop in order to correctly validate if an appropriate color[48] is passed in. We'll need to import it at the top of our file from `react-native` as well.

Our last two components that need prop validations are our form components. Let's begin with `TimerForm`:

time-tracking/components/TimerForm.js

```
export default class TimerForm extends React.Component {
  static propTypes = {
    id: PropTypes.string,
    title: PropTypes.string,
    project: PropTypes.string,
    onFormSubmit: PropTypes.func.isRequired,
    onFormClose: PropTypes.func.isRequired,
  };

  static defaultProps = {
    id: null,
```

[48] https://facebook.github.io/react-native/docs/next/colors.html

```
    title: '',
    project: '',
  };
```

For this component, we only pass in timer attributes (`id`, `title`, and `project`) if we're editing a timer form and not creating one. We've added appropriate default values for each. Now for `ToggleableTimerForm`:

time-tracking/components/ToggleableTimerForm.js

```
export default class ToggleableTimerForm extends Component {
  static propTypes = {
    onFormSubmit: PropTypes.func.isRequired,
  };
```

This component only takes a single required prop, `onFormSubmit`, which fires when we submit our timer form.

Methodology review

While building our time-tracking app, we learned and applied a methodology for building React apps. Again, those steps were:

1. Break the app into components

   We mapped out the component structure of our app by examining the app's working UI. We then applied the single-responsibility principle to break components down so that each had minimal viable functionality.
2. Build a static version of the app

   Our bottom-level (user-visible) components rendered JSX based on static props, passed down from parents.
3. Determine what should be stateful

   We used a series of questions to deduce what data should be stateful. This data was represented in our static app as props.

4. Determine in which component each piece of state should live

   We used another series of questions to determine which component should own each piece of state. `App` owned timer state data and `ToggleableTimerForm` and `EditableTimer` both held state pertaining to whether or not to render a `TimerForm`.
5. Hardcode initial states

   For the components that own state, we initialized `state` properties with hardcoded values.
6. Add inverse data flow

   We added interactivity by decorating buttons with `onPress` handlers. These called functions that were passed in as props down the hierarchy from whichever component owned the relevant state being manipulated.

If we were planning to add server communication to our application, it would make sense to do it now given we've completed setting up the base of our entire application.

Up next

With the first chapter, we explored the basics of React Native by building a weather app. In this chapter, we dove deeper into the fundamentals of the React API by creating a more interactive application with more components. Although we covered a number of important concepts including a useful pattern for building React Native apps from scratch, we've so far only briefly covered each of React Native's built-in components, like `View` and `Text`. Over the next two chapters, we'll examine a number of React Native's core components in greater detail.

Core Components, Part 1

What are components?

Components are the building blocks of any React Native application. We used components like `View` and `Text` throughout the previous chapters to create the UI for our weather app and our timer app. Out-of-the-box, React Native includes components for everything from form controls to rich media.

Up to this point, we've been *using* React Native components without fully exploring *how they work*. In this chapter, we'll study the most common built-in React Native components. Just as in the previous chapters, we'll build an application as we go. When we come across a new topic, we'll deep dive into that topic before we keep building. At the end of the chapter, you should have a solid foundation of knowledge for using *any* React Native component – even the ones we don't cover will follow many of the same patterns.

UI abstraction

Components are an abstraction layer on top of the underlying native platform. On an iOS device, a React Native component is ultimately rendered as a `UIView`. On Android, the same component would be rendered as an `android.view`. As React Native expands to new platforms, the same code should be able to render correctly on more and more devices.

React Native is already supported on the universal Windows platform[49], Apple TV (part of the main react-native repository[50]), React VR[51], and the web[52].

[49] https://github.com/Microsoft/react-native-windows
[50] https://github.com/facebook/react-native
[51] https://facebook.github.io/react-vr/
[52] https://github.com/necolas/react-native-web

As you start building complex apps, you'll likely run into cases where you want to use a feature that exists on one platform but not the other. Platform-specific components exist for cases like these. Generally, the component's name will end with the name of the platform e.g. `NavigatorIOS`. As we mentioned in the "Getting Started", there are several ways to run different code on different platforms – you will need to do this for platform-specific components.

Building an Instagram clone

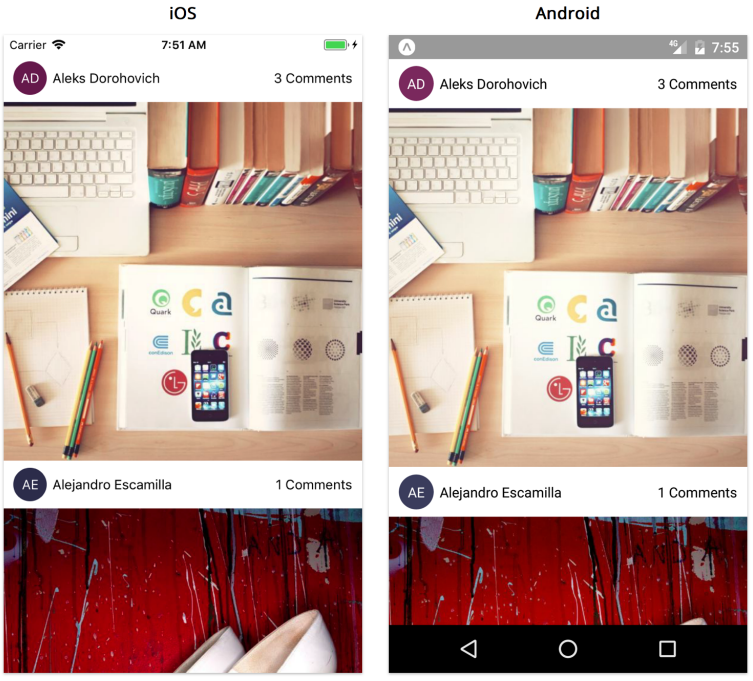
In this chapter, we'll use the most common React Native components to build an app that resembles Instagram. We'll build the main image feed with the components `View`, `Text`, `Image` and `FlatList`. We'll also build a comments screen using `TextInput` and `ScrollView`.

To try the completed app on your phone:

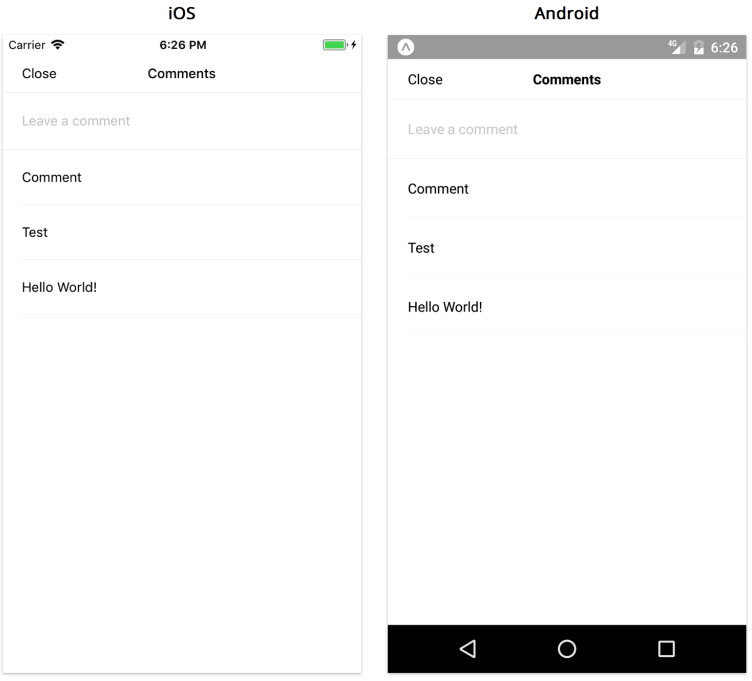
- On Android, you can scan this QR code from within the Expo app:

- On iOS, you can navigate to the `image-feed/` directory within our sample code folder and build the app using the same process in previous chapters. You can either preview it using the iOS simulator or send the link of the project URL to your device.

Our app will have two screens. The first screen is the image feed:



The second screen opens when we tap “3 comments” to display comments for that image:



Project setup

Just as we did in the previous chapters, let's create a new app with the following command:

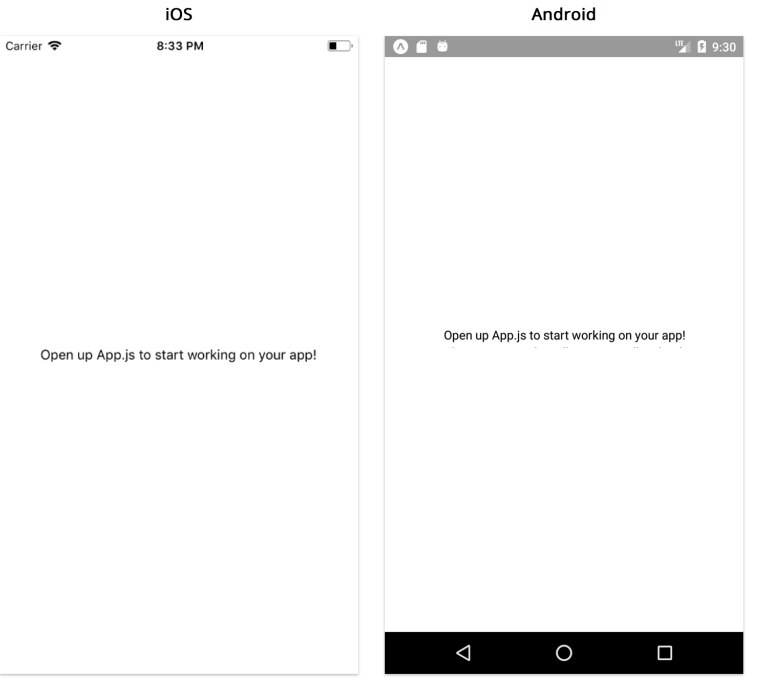
```
$ expo init image-feed --template blank@sdk-33 --yarn
```

Once this finishes, navigate into the `image-feed` directory.

Choose one of the following to start the app:

- **`yarn start`** - Start the Packager and display a QR code to open the app on your Android phone
- **`yarn ios`** - Start the Packager and launch the app on the iOS simulator
- **`yarn android`** - Start the Packager and launch the app on the Android emulator

You should see the default `App.js` file running, which looks like this:



Now's a good time to copy over the `image-feed/utils` directory from the sample code into your own project. Copy the `utils` directory into the `image-feed` directory we just created.

How we'll work

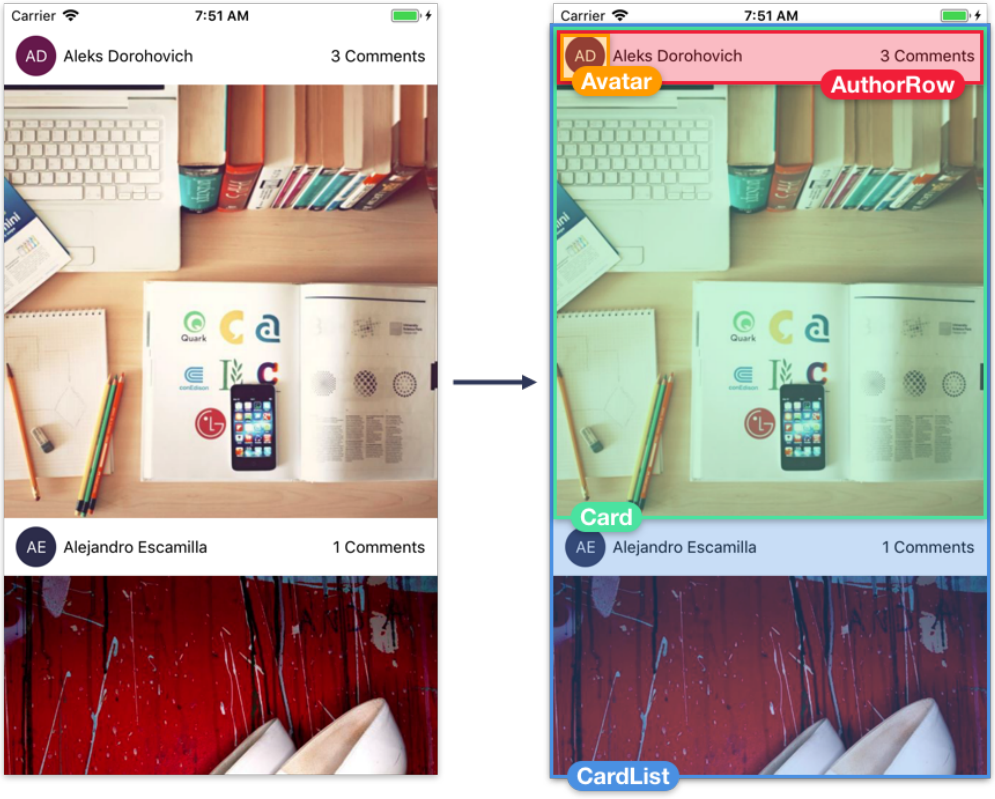
In this chapter, we'll build our app following the same methodology as the previous chapter. We'll break the app into components, build them statically, and so on. We won't specifically call out each step, since it isn't necessary to follow them *exactly*. They're most useful as a reference for when you're unsure what to do next.

If at any point you get stuck when building an app of your own, consider identifying which steps you've completed, and following the steps more closely until you're back on track.

Breaking down the feed screen

We want to start thinking about our app in terms of the different components of our UI. Ultimately our app will render built-in components like `View` and `Text`, but as we learned in the previous chapter, it's useful to build higher levels of abstraction on top of these. Let's start by figuring out how our main image feed might break down into components.

A good component is generally concise and self-contained. By looking at the screenshot we are trying to build, we can identify which pieces are reasonably distinct from others and reused in multiple places. Since we're only building a couple screens, we won't be able to make fully informed decisions about which parts of the screenshots are most reusable as we don't know what the other screens in the app will look like. But we can make some pretty good guesses. Here's one way we can break down the main feed:



- `Avatar` - The profile photo or initials of the author of the image
- `AuthorRow` - The horizontal row containing info about the author: their avatar and their name
- `Card` - The item in the image feed containing the image and info about its author
- `CardList` - The list of cards in the feed

Each of these build upon one another: `CardList` contains a list of `Card` components, which each contain an `AuthorRow`, which contains an `Avatar`.

Top-down vs. bottom-up

When it comes to building the UI components of an app, there are generally two approaches: top-down and bottom-up. In a top-down approach, we would start by

building the `CardList` component, and then we would build the components within the `CardList`, and then the components within those, and so on until we reach the inner-most component, `Avatar`. In a bottom-up approach, we would start with the innermost components like `Avatar`, and keep building up higher levels of abstraction until we get to the `CardList`. Choosing between these two approaches is mostly personal preference, and it's common to do a little of both.

For this app, we're going to work bottom-up. We'll start with the `Avatar` component, and then build the `AuthorRow` which uses it, and so on.

Unlike the last chapter, we'll focus on building one component at a time, testing each one as we go. We can modify `App.js` to render just the component we're currently working on.

As an example, if we were to do this for the `Avatar` component, we might modify the `App.js` file to render just the `Avatar`:

```
// Inside App.js
render() {
  return <Avatar />;
}
```

We might also hardcode different kinds of `props` for testing:

```
// Inside App.js
render() {
  return (
    <Avatar
      initials="FL"
      size={35}
      backgroundColor={'blue'}
    />
  );
}
```

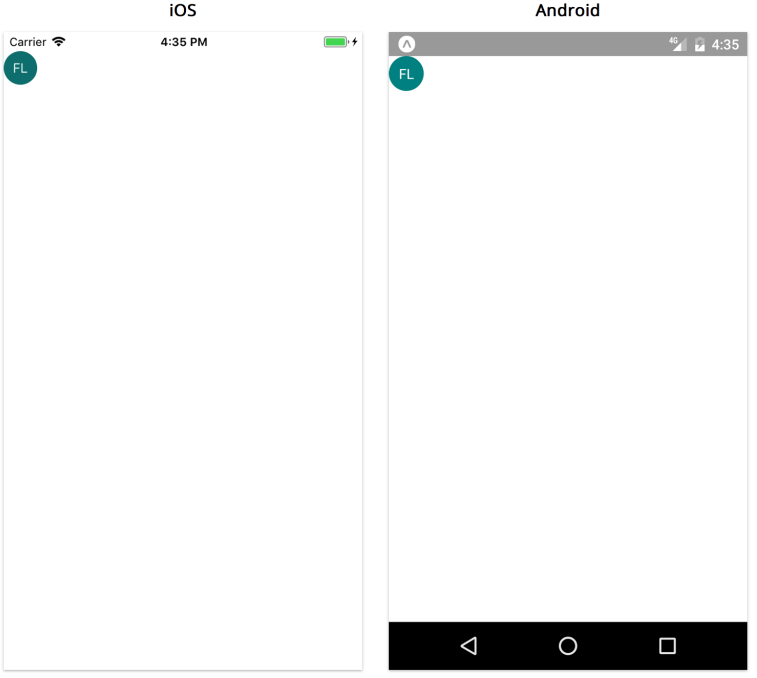
Isolating individual components like this is a useful technique when working with styles. A component's layout can change based on its parent – if we build a

component within a specific parent, we may end up with styles that closely couple the parent and child. This isn't ideal, since we want our components to look accurate within *any* parent for better reusability. We can easily ensure that components work well anywhere by building components at the top level of the view hierarchy, since the top level has the default layout configuration.

Now that we have our strategy locked down, let's start with the `Avatar` component.

`Avatar`

Here's what the Avatar should look like, when rendered in isolation:



For simple apps, it's easiest to keep all of our components together in a `components` directory. For more advanced apps, we might create directories within `components` to categorize them more specifically. Since this app is pretty simple, let's use a flat `components` directory, just like we did in the previous chapters.

Let's create a new directory called `components` and create a new file within that called `Avatar.js`.

Our avatar component is going to render the components `View` and `Text`. It's going to use `StyleSheet`, and it's going to validate strings, numbers, and color props with `PropTypes`. Let's import these things at the top of the file. We also have to import `React`.

We'll import `React` in this file, even though we don't reference it anywhere. Behind-the-scenes, babel compiles JSX elements into calls to `React.createElement`, which reference the `React` variable.

Add the following imports to `Avatar.js`:

image-feed/1/components/Avatar.js

```
import { ColorPropType, StyleSheet, Text, View } from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';
```

We import `ColorPropType` from `react-native` rather than `PropTypes`. The `PropTypes` package contains validators for primitive JavaScript types like numbers and strings. While colors in React Native are strings, they follow a specific format that can be validated – React Native provides a handful of validators like `ColorPropType` for validating the contents of a value rather than just its primitive type.

Now we can export the skeleton of our component:

image-feed/1/components/Avatar.js

```
export default function Avatar({ /* ... */ }) {
  // ...
}
```

Since this component won't need to store any local `state`, we'll use the stateless functional component style that we learned about in the previous chapter.

What should the `props` be for our avatar? We definitely need the initials to render. We also probably want the size and background color to be configurable. With that in mind, we can define our `propTypes` like this:

image-feed/1/components/Avatar.js

```
// ...

export default function Avatar({ size, backgroundColor, initials }) {
  // ...
}

Avatar.propTypes = {
  initials: PropTypes.string.isRequired,
  size: PropTypes.number.isRequired,
  backgroundColor: ColorPropType.isRequired,
};

// ...
```

In this app, we'll make most of our props *required* using `isRequired`, since we'll always pass every prop. If we wanted to make our component more reusable, we could instead make its props *optional* – but it's hard to know *which* props should be optional until we actually try to reuse it!

It's time to render the contents of our `Avatar`. For the colored circular background, we'll render a `View`. The `View` is the most common and versatile component. We've already used it throughout the previous chapters, but now let's take a closer look at how it works and how to style it.

`View`

There are two fairly distinct things we use `View` for:

- First, we use `View` for layout. A `View` is commonly used as a container for other components. If we want to arrange a group of components vertically or horizontally, we will likely wrap those components in a `View`.
- Second, we use `View` for styling our app. If we want to render a simple shape like a circle or rectangle, or if we want to render a border, a line, or a background color, we will likely use a `View`.

React Native components aim to be as consistent as possible – many components use similar `props` as the `View`, such as `style`. Because of this, if you learn how to work with `View`, you can reuse that knowledge with `Text`, `Image`, and nearly every other kind of component.

`Avatar` background

Let's use `View` to create the circular background for our `Avatar`:

image-feed/1/components/Avatar.js

```
// ...

export default function Avatar({ size, backgroundColor, initials }) {
  const style = {
    width: size,
    height: size,
    borderRadius: size / 2,
    backgroundColor,
  }

  return (
    <View style={style} />
  )
}

// ...
```

As we saw in previous chapters, we can use the `style` prop to customize the dimensions and colors of our `View` component. Here, we instantiate a new object that we pass to the `style` prop of our `View`. We can assign the `size` prop to the `width` and `height` attributes to specify that our `View` should always be rendered as a perfect square. Adding a `borderRadius` that's half the size of the `width` and `height` will render our `View` as a circle. Lastly, we set the background color.

In this style object, the attributes are computed dynamically: `width`, `height`, `borderRadius`, and `backgroundColor` are all derived from the component's `props`. When we compute

style objects dynamically (i.e. when rendering our component), we define them *inline* – this means we create a new style object every time the component is rendered, and pass it directly to the `style` prop of our component.

When there are a lot of style objects defined inline, it can clutter the render method, making the code harder to follow. For styles which aren't computed dynamically, we should use the `StyleSheet` API. We'll practice this more in the next few sections.

Before that, let's make sure what we have so far is working correctly.

Try it out

Let's add our `Avatar` component to `App`. We haven't finished `Avatar` yet, but it's useful to test as we go in case we've introduced any errors.

Open up `App.js` and import our `Avatar` after our other imports:

image-feed/1/App.js

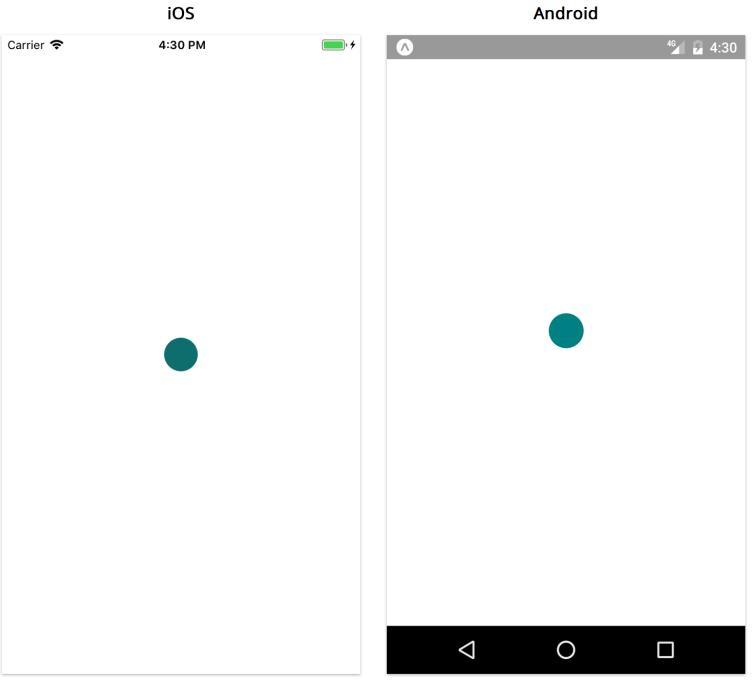
```
import Avatar from './components/Avatar';
```

Next, modify the render function to render an `Avatar`:

image-feed/1/App.js

```
// ...

export default class App extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <Avatar initials={'FL'} size={35} backgroundColor={'teal'} />
      </View>
    );
  }
}

// ...
```

For any `props` we didn't include, the `Avatar` will use its `defaultProps`. We should see a 35px teal circle in the center of the screen:



Regardless of the size of your screen, the teal circle will render in the center. This means React Native is calculating the center of the screen, calculating the dimensions of the `Avatar`, and using these calculations to properly position the `View` component. As we learned in the "Getting Started" chapter, the React Native layout engine is based on the **flexbox** algorithm. Let's start digging into how layout works: how does React Native know the dimensions for each component and where to render it on the screen?

Dimensions

The first thing we want to think about when understanding the layout of a screen is the dimensions of each component. A component must have both a non-zero `width` and `height` in order to render anything on the screen. If the `width` is `0`, then nothing will render on the screen, no matter how large the `height` is.

In our `Avatar` example, we rendered our `View` with fixed dimensions by specifying an exact `width` and `height` as part of the `style` prop. This is the simplest way to specify component dimensions. Our `View` will always render at exactly 35px by 35px, regardless of the screen size or the components within it.

In the case of `Avatar`, this is exactly the behavior we want. However, in many cases we want our layout to automatically adapt to different screen sizes.

Our `App` renders a `View` that fills the entire screen, yet we never specified a fixed `width` or `height`. If you look at the `StyleSheet.create` call at the bottom of `App.js`, you'll see the style attribute `flex: 1`.

image-feed/1/App.js

```
const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: '#fff',
    alignItems: 'center',
    justifyContent: 'center',
  },
});
```

We can use `flex` to adapt our layout to different screen sizes.

Flex

The `flex` style attribute gives us the ability to define layouts that can expand and shrink automatically based on screen size. The `flex` value is a number that represents the ratio of space that a component should take up, relative to its siblings.

If a component has no siblings, as in the case of the top-level `View` rendered by `App`, things are straightforward:

- with a `flex` of `1`, the component will expand to fill its parent entirely
- with a `flex` value of `0`, the component will shrink to the minimum space possible (just large enough for the component's children to be visible, if it has any)

Since the `View` in `App` has a `flex` value of `1`, it expands to fill its parent, which in this case is the entire screen. Now we know why this `View` expands to fill the screen, but how does React Native know to render the `Avatar` (and its underlying `View`) in the center of the screen?

Layout

We can apply three style attributes to a *parent* component in order to specify the layout of its *children*. That is, we can specify *where* children render within a parent. The attributes are:

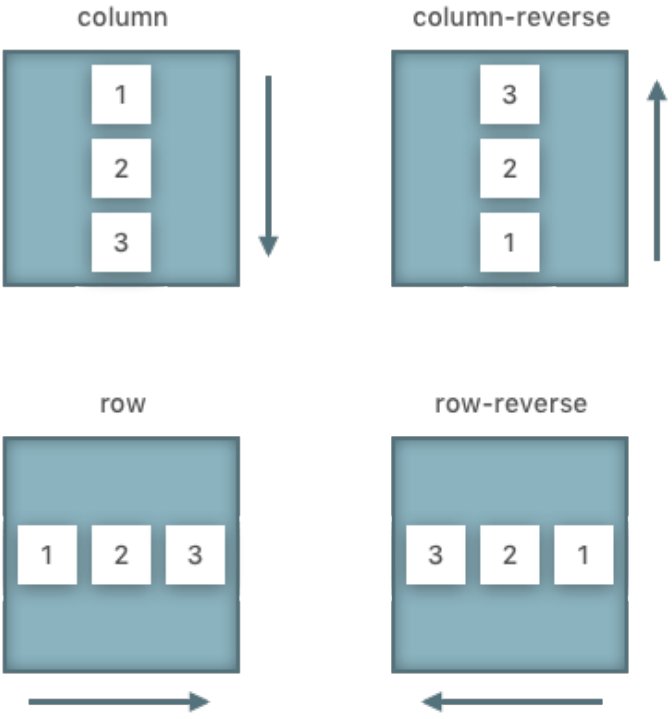
- **`flexDirection`**
- **`justifyContent`**
- **`alignItems`**

With these attributes, we can achieve nearly any kind of layout.

`flexDirection`

The first attribute is **`flexDirection`**. The flexDirection we choose defines the **primary axis**. Children components are laid out along the primary axis. The *orthogonal* axis is called the **secondary axis**. The possible values for `flexDirection` are:

- **`column`**: for a vertical layout (the default)
- **`row`**: for a horizontal layout
- **column-reverse**: the same as `column` but flipped vertically
- **row-reverse**: the same as `row` but flipped horizontally



The names are a little confusing at first, because when you hear "row", you might think we'll get a layout with multiple rows – but in fact, this is saying that our layout *is* a row.

`justifyContent`

Next we'll use the `justifyContent` attribute to *distribute* children along the primary axis. The possible values are:

- `flex-start`: Distribute children at the start of the primary axis (the default)
- `flex-center`: Distribute children at the center of the primary axis
- `flex-end`: Distribute children at the end of the primary axis
- `space-around`: Distribute children evenly, including space at the edges

- **`space-between`**: Distribute children evenly, without any space at the edges

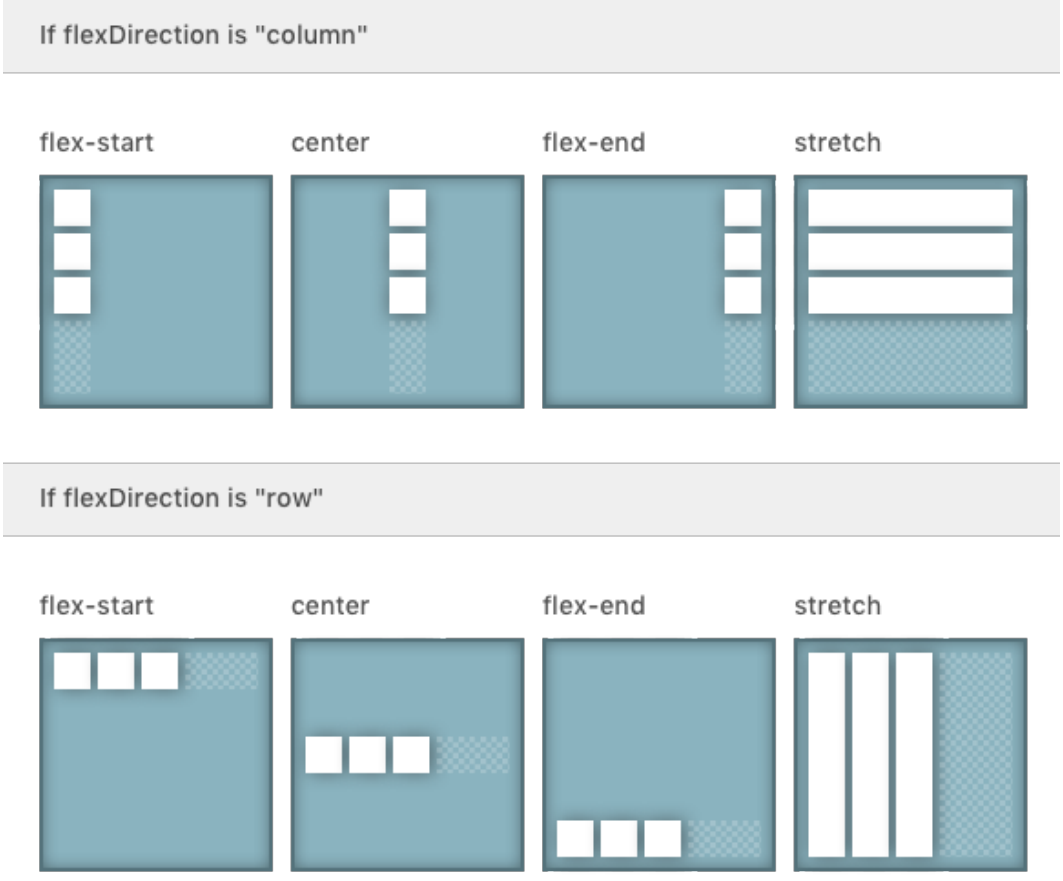
The following diagram depicts the possible values for `justifyContent` in both `row` and `column` layouts. Remember, the `flexDirection` sets the primary and orthogonal axes, so our choice of `flexDirection` will determine the meaning of `justifyContent`.

`alignItems`

Lastly, we'll use the **alignItems** attribute to *align* children along the secondary axis. Possible values are:

- **`flex-start`**: Align children at the start (the default)
- **`flex-center`**: Align children at the center
- **`flex-end`**: Align children at the end
- **`stretch`**: Stretch children to fill the entire width/height of the secondary axis

The following diagram depicts the possible values for `alignItems`, in both `row` and `column` layouts.



Take another look at the `container` style in `StyleSheet.create` at the bottom of `App.js`:

image-feed/1/App.js

```
const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: '#fff',
    alignItems: 'center',
    justifyContent: 'center',
  },
});
```

Let's figure out how this style centers the `Avatar` within the `View`. This style object doesn't contain a value for the `flexDirection` attribute, so instead it'll use the default value, `column`. This means the primary axis is the vertical axis and the secondary axis is the horizontal axis. The `justifyContent: 'center'` distributes the `Avatar` to the center of the vertical axis. The `alignItems: 'center'` aligns the `Avatar` in the center of the horizontal axis.

Flex and the primary axis

Now that we know how `flexDirection` and axes work, let's revisit how this top-level `View` uses `flex` to fill the entire screen.

The `flex` attribute of a component determines only its dimension along the *primary axis*. This means that, just like for `justifyContent` and `alignItems`, we need to know what the `flexDirection` is in order to use `flex` correctly.

In the case of our `View` in `App`, it's best to imagine this `View` is actually the child of another wrapper `View` that fills the entire screen. This wrapper `View` has the default style attributes for `flexDirection`, `justifyContent`, and `alignItems`. In other words, the top-level `View` that we render is actually inside a parent with style:

```
{
  flexDirection: 'column',
  justifyContent: 'flex-start',
  alignItems: 'stretch'
}
```

Our top-level `View` has a fullscreen `height` because we specify `flex: 1`, which stretches it across the vertical axis. It has a fullscreen `width` because its parent uses `alignItems: 'stretch'`, which stretches the `View` across the horizontal axis.

What to do if a component doesn't show up

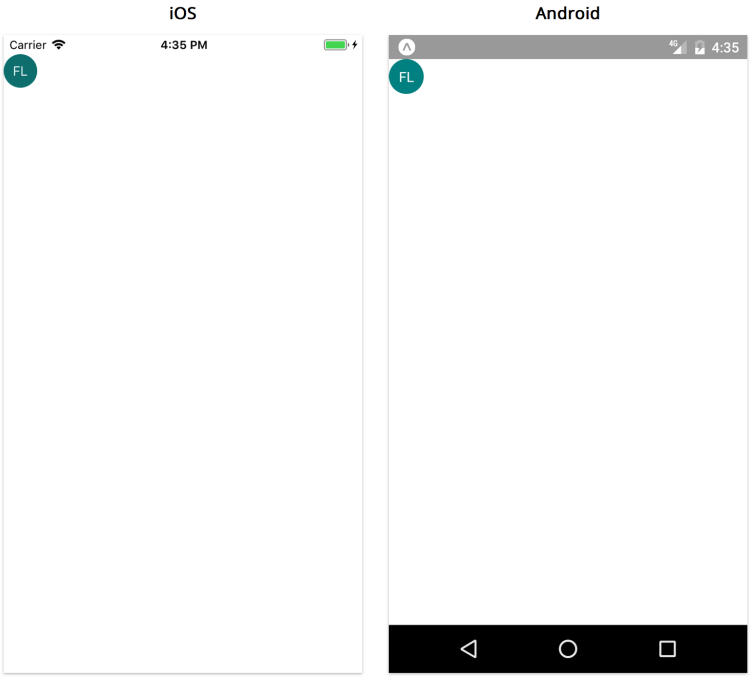
Beginners and experts alike frequently run into the problem where a component doesn't render anything on the screen. The most common reason for this is that the component has dimensions equal to `0`.

When using `flex: 0` or no `flex` attribute, a component will only have a dimension greater than `0` along the primary axis if given explicitly (using a `width` or `height` attribute) or if its children have dimensions greater than `0`. Similarly, when using `alignItems: 'stretch'`, a child will only have dimensions greater than `0` along the secondary axis if given explicitly or if the parent has dimensions greater than `0`.

Thus, when a component doesn't show up on the screen, the first thing we should do is pass an explicit `width` and `height` style attribute (and also a `backgroundColor`, just to make sure something is visible). Once a component appears on the screen, we can start understanding the component hierarchy and evaluating how to tweak our styles.

`StyleSheet`

Now that we have a better understanding of layouts, lets get back to creating our `Avatar` component. As a reminder, here's what we're aiming for:



The next thing we'll want to add is the text within the circular `View`. The text should be centered, which we now know how to do using `justifyContent` and `alignItems`. Let's do that now.

We previously used an *inline* style object for the `style` prop of `View`. For styles which don't need to be computed dynamically based on `props`, such as centering the content within the `View`, we generally use a `StyleSheet` at the bottom of the file. Let's go ahead and update `Avatar.js` with the following:

image-feed/1/components/Avatar.js

```
// ...

export default function Avatar({ size, backgroundColor, initials }) {
  const style = {
    width: size,
    height: size,
    borderRadius: size / 2,
    backgroundColor,
  };

  return (
    <View style={[styles.container, style]} />
  );
}

const styles = StyleSheet.create({
  container: {
    alignItems: 'center',
    justifyContent: 'center',
  },
});
```

In React Native, styles are most often defined below the component code in the same file. When reading a file, generally the component is the primary concern, and styles are secondary – this is why we put the component code first. This *works* because the variable name `styles` is hoisted to the top of the file, and the code which defines its value is executed before the code that accesses its value. As you may have noticed, we've been doing this since the start of the book, and we'll continue to do it throughout.

In this case, we always want the text to be centered on both axes, so we'll use `justifyContent: 'center'` and `alignItems: 'center'`. As we saw in the "Getting Started" chapter, we can merge both of our style objects together by passing an array as the `style` prop of `View`.

When centering a single child component within a `View` like this, any `flexDirection` will result in the same layout, so we can use either.

Now that we've centered the contents of our `View`, let's add the text for the initials. We'll use `Text` for this. We've used `Text` before, but let's take a step back and look at it in-depth before we add it to our avatar.

`Text`

We use the `Text` component to render text on the screen. Text can be styled with font-specific attributes such as `fontSize`. It can use nearly all of the same styles as `View`, such as `backgroundColor` and `width`. However, `Text` has some key differences when it comes to layout.

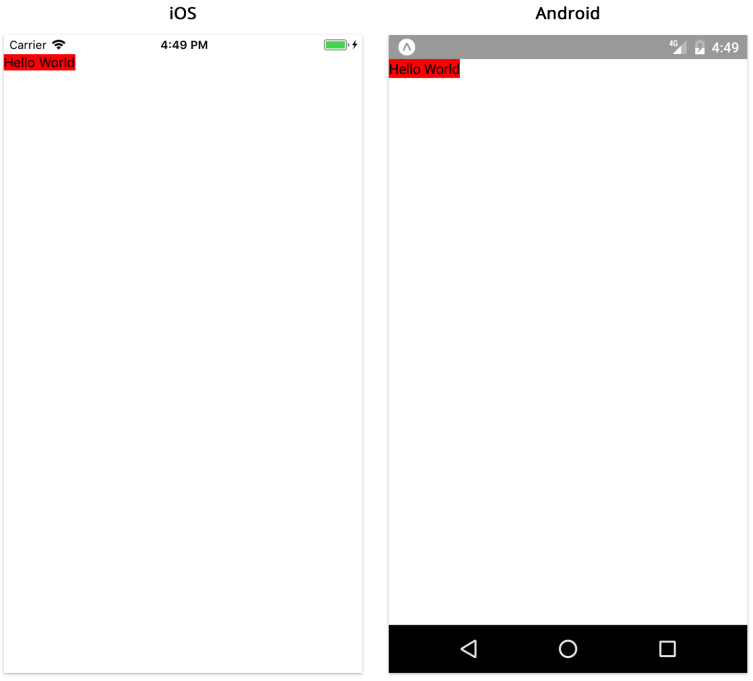
`Text` dimensions

Unlike the `View` component, `Text` components have an intrinsic size. In other words, if we don't specify a `width` or `height`, a `Text` component will still show up on the screen. If we were to put a background color behind it to visualize the `width` and `height`, we could see that the background is exactly the size of the text we see (plus or minus a little space, depending on the line height).

Rendering a `Text` component with:

```
<Text style={{ backgroundColor: 'red' }}>
  Hello World
</Text>
```

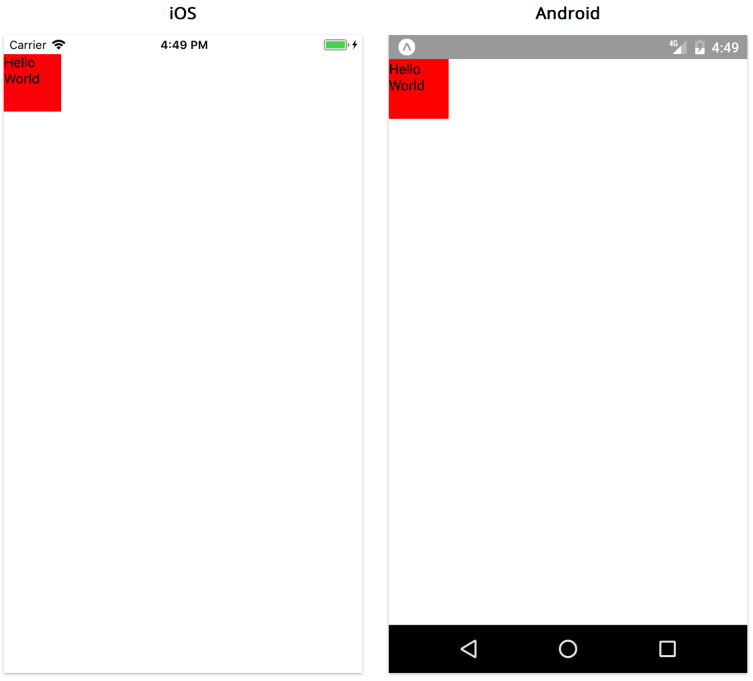
Gives us:



Specifying a `width`, `height`, or `flex` attribute as part of the style will override the intrinsic dimensions of the `Text`. Rendering a `Text` component with:

```
<Text style={{ backgroundColor: 'red', width: 60, height: 60 }}>
  Hello World
</Text>
```

Gives us:



Text context will automatically wrap around by default when it fills the width of the component. This is configurable with the `numberOfLines` prop.

Common `Text` props and styles

Here are a few common style attributes that you might want to use with text:

- **`color`** - A string representing the color of the text.
- **`fontFamily`** - A string with the name of the font family (this font family must already exist on the device).
- **`fontSize`** - A number value equal to the size of the font in points.
- **`fontStyle`** - Either `'normal'` or `'italic'`.
- **`fontWeight`** - The thickness of each character. One of `'normal'`, `'bold'`, `'100'`, `'200'`, `'300'`, `'400'`, `'500'`, `'600'`, `'700'`, `'800'`, or `'900'`. If the chosen weight isn't available on the device, the nearest available weight will be used instead).
- **`textAlign`** - The text alignment. One of `'left'`, `'right'`, `'center'`, `'justify'` (iOS only), `'auto'`.

In addition, we use the following props frequently:

- **`numberOfLines`** - The number of lines to allow before truncating the text.
- **`ellipsizeMode`** - How text should be truncated when it exceeds `numberOfLines`. One of `'head'`, `'middle'`, `'tail'`, `'clip'` (iOS only).

You can find the full list of props and styles for Text in the official docs[53].

Like `View` elements, `Text` elements can have `children`. This is useful when you want to have multiple styles of text within the same paragraph. The `Text` element will inherit styles from its parent. If the parent has a `fontSize` of `16` and `color` of `blue`, a child `Text` element will have the same styles by default. The child `Text` element can be styled to override its parent's styles as needed.

Adding `Text` to `Avatar`

Let's render and style a `Text` component to display the initials in the `Avatar` component:

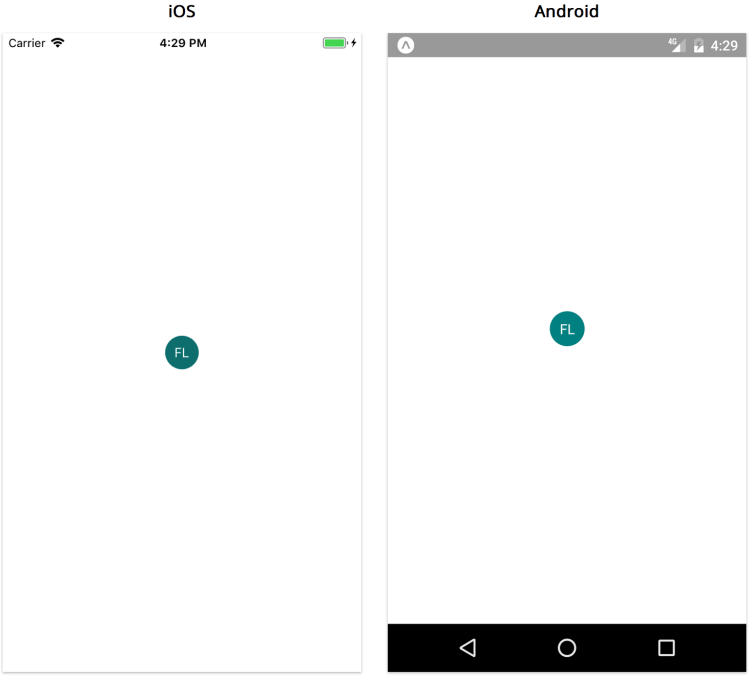
image-feed/1/components/Avatar.js

```
// ...

export default function Avatar({ size, backgroundColor, initials }) {
  const style = {
    width: size,
    height: size,
    borderRadius: size / 2,
    backgroundColor,
  }

  return (
    <View style={[styles.container, style]}>
      <Text style={styles.text}>{initials}</Text>
    </View>
```

[53] https://facebook.github.io/react-native/docs/text.html

```
  );
}

// ...

const styles = StyleSheet.create({
  container: {
    alignItems: 'center',
    justifyContent: 'center',
  },
  text: {
    color: 'white',
  },
});
```

After saving `Avatar.js`, you should see the following:



Since we don't want our content centered on the screen, let's update the styles in `App.js` to render content starting at the top left. We can do this by removing `alignItem` and `justifyContent`. Since we're in a `View` with `flexDirection: "column"` (the default), we can use `justifyContent: "flex-start"` (also the default) to distribute content starting at the top of the screen.

We also want to leave room at the top of the screen for the status bar. We'll install and import `expo-constants` so we can use the constant `statusBarHeight`.

Since we used `expo-init` to create our app, we can use any expo-prefixed libraries within it. There's usually a similar library available for use outside of expo if needed, e.g. react-native-status-bar[54] in this case.

To install `expo-constants`, run:

```
$ yarn add expo-constants
```

Add the following import to the top of `App.js`:

image-feed/1/App.js

```
import Constants from 'expo-constants';
```

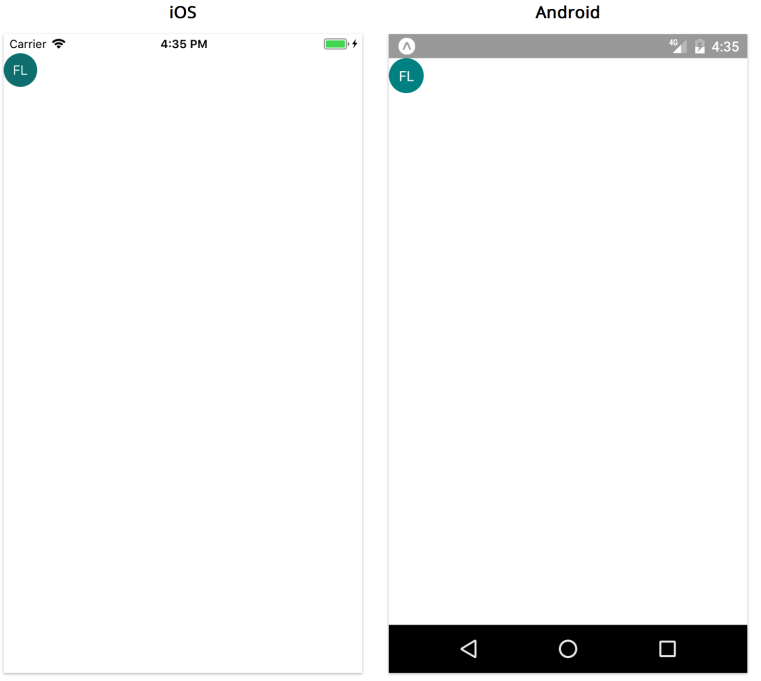
Then update the `container` style at the bottom of the file to:

image-feed/1/App.js

```
// ...

const styles = StyleSheet.create({
  container: {
    marginTop: Constants.statusBarHeight,
    flex: 1,
    backgroundColor: '#fff',
  },
});
```

[54] https://www.npmjs.com/package/react-native-status-bar-height

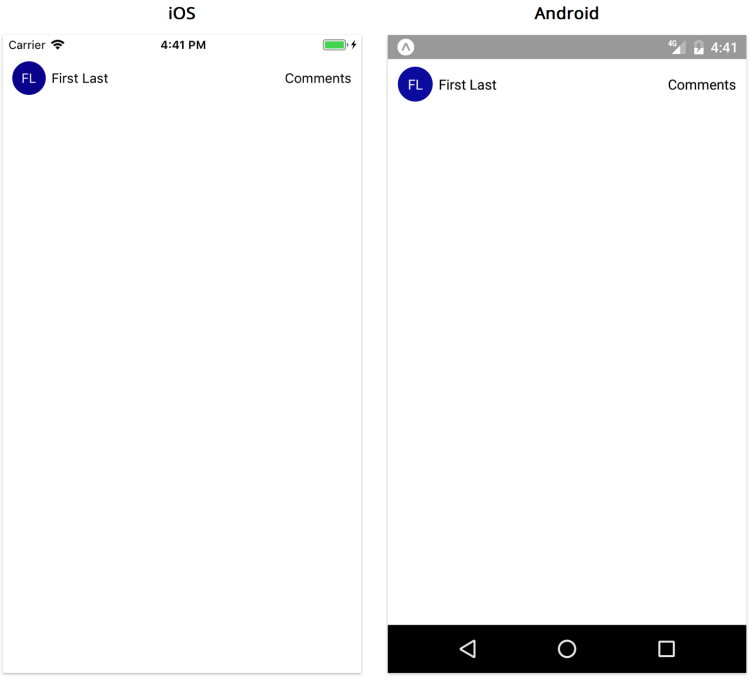
Now we should see our avatar at the top left of the screen, sitting just below the status bar.



In order to create the `Avatar`, we covered `View`, `Text`, `StyleSheet`, and layout with flexbox. These are the built-in components and APIs required to build nearly any custom component in React Native. We'll spend most of the rest of the chapter using them to build other components in our image feed app.

`AuthorRow`

Now that we've completed the `Avatar`, let's move on to the next component! Let's create the horizontal row containing our `Avatar` and the full name of the photo author.



Create a new file `AuthorRow.js` in our `components` directory.

In this file, we'll import mostly things we've seen already: `StyleSheet`, `View`, `Text`, `PropTypes`, and `React`. We'll also import a `TouchableOpacity` so that we can handle taps on the "Comments" text to take us to the comments screen. We'll also need to import the `Avatar` component we just made, and a few of the utility functions we copied into this project at the start of the chapter.

If you haven't copied over the `utils` directory from our sample code, you should do so now.

image-feed/1/components/AuthorRow.js

```
import {
  StyleSheet,
  Text,
  TouchableOpacity,
  View,
} from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

import Avatar from './Avatar';
import getAvatarColor from '../utils/getAvatarColor';
import getInitials from '../utils/getInitials';
```

Now let's figure out the `propTypes` for the component. We'll want to configure the full name we display next to the Avatar and the text we use for the "Comments" link on the right side. We'll also want to propagate press events when the user taps the link.

image-feed/1/components/AuthorRow.js

```
// ...

export default function AuthorRow({
  fullname,
  linkText,
  onPressLinkText
}) {

}

AuthorRow.propTypes = {
  fullname: PropTypes.string.isRequired,
  linkText: PropTypes.string.isRequired,
  onPressLinkText: PropTypes.func.isRequired,
};
```

```
// ...
```

Thinking about the layout of the component, we'll want to have a `View` with `flexDirection: 'row'`. Within this we'll render an `Avatar`, a `Text`, and a `TouchableOpacity`.

Let's start with the styles for the `View` and `Text`. Add this to the bottom of the file:

image-feed/1/components/AuthorRow.js

```
// ...

const styles = StyleSheet.create({
  container: {
    height: 50,
    flexDirection: 'row',
    alignItems: 'center',
    paddingHorizontal: 10,
  },
  text: {
    flex: 1,
    marginHorizontal: 6,
  },
});
```

We use `flex: 1` so that `Text` expands to fill any remaining space in the `View`. This will push the `TouchableOpacity` to the right side.

Now we can fill out the component function:

image-feed/1/components/AuthorRow.js

```
// ...

export default function AuthorRow({
  fullname,
  linkText,
  onPressLinkText
}) {
  return (
    <View style={styles.container}>
      <Avatar
        size={35}
        initials={getInitials(fullname)}
        backgroundColor={getAvatarColor(fullname)}
      />
      <Text style={styles.text} numberOfLines={1}>
        {fullname}
      </Text>
      {/* ... */}
    </View>
  );
}

// ...
```

We'll use `numberOfLines={1}` so that the `Text` is truncated when it reaches the end of the line, rather than wrapping around to multiple lines.

Now let's render a `TouchableOpacity` to add the "Comments" link text and handle taps.

`TouchableOpacity`

The `TouchableOpacity` component is similar to `View`, but lets us easily respond to tap gestures in a performant way. The `TouchableOpacity` component fades out when

pressed, and fades back in when released. The opacity animation happens on the native side (it doesn't trigger a re-render), so the animation is extremely smooth and the interaction is low latency. The opacity value when pressed can be configured with the `activeOpacity` prop by providing a number from `0` to `1`.

If you don't like the opacity animation, you can instead use a `TouchableHighlight` for a background color changing animation.

One minor inconvenience with both `TouchableOpacity` and `TouchableHighlight`: these components can only have a single child element, so if we want multiple children, we will need to wrap them in a `View`.

Adding `TouchableOpacity` to `AuthorRow`

Let's render a `TouchableOpacity` for "Comments" to the right of the `Text` in our `AuthorRow`. We'll use the `onPress` prop of the `TouchableOpacity` to call our `onPressLinkText` prop.

image-feed/1/components/AuthorRow.js

```
export default function AuthorRow({
  fullname,
  linkText,
  onPressLinkText,
}) {
  return (
    <View style={styles.container}>
      <Avatar
        size={35}
        initials={getInitials(fullname)}
        backgroundColor={getAvatarColor(fullname)}
      />
      <Text style={styles.text} numberOfLines={1}>
        {fullname}
      </Text>
      {!!linkText && (
        <TouchableOpacity onPress={onPressLinkText}>
          <Text numberOfLines={1}>{linkText}</Text>
```

```
        </TouchableOpacity>
      )}
    </View>
  );
}
```

We use `!!linkText` to conditionally render the `<TouchableOpacity>` element. The double negation with `!!` lets us make sure we're dealing with a boolean value.

Since `linkText` is a string, the `&&` expression would evaluate to a string type when `linkText` is the empty string `''` – in React Native (unlike on the web), we're not allowed to render string values outside of `Text` (even empty strings).

Try it out

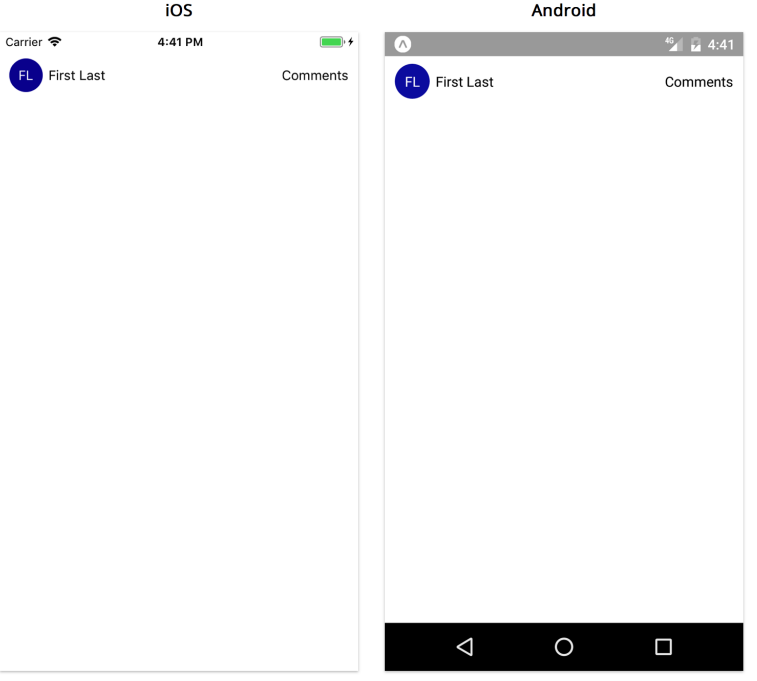
Let's update `App.js` to render our `AuthorRow` component in order to test it:

image-feed/1/App.js

```
// ...

import AuthorRow from './components/AuthorRow';

export default class App extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <AuthorRow
          fullname={'First Last'}
          linkText={'Comments'}
          onPressLinkText={() => {
            console.log('Pressed link!');
          }}
        />
```

```
      </View>
    );
  }
}

// ...
```

Here's what our AuthorRow should look like:



You can also try pressing the "Comments" text. The text's opacity should animate and you'll see "Pressed link!" logged to the terminal.

In our `AuthorRow`, as in earlier chapters, we used the style attributes `paddingHorizontal` and `marginHorizontal` to adjust the spacing between the different components we rendered. Let's dive into how these attributes work.

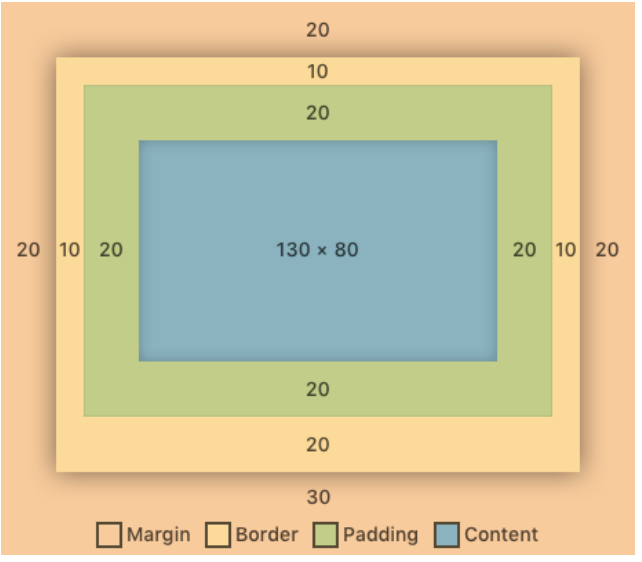
Padding, margin, borders, and the box model

The React Native layout engine uses what's known as the *box model* for customizing spacing. You might be familiar with the box model if you've developed for the web. There are three main style attributes we can use:

- **margin**: This is the amount of space between a component and its siblings or the edge of its parent's content area.
- **border**: This is the border drawn around the component, which can vary in width, style (e.g. a dashed line), and color.
- **padding**: this is the spacing within a component before its children components.

Each of these style attributes can have a different size on each side of the component: top, right, bottom, and left. For example, if we wanted to set a top margin of `10` pixels, we would write `marginTop: 10` in the styles object. For convenience, we can set all four sides to have the same size with `margin: 10`. We can also set vertical and horizontal margin with `marginVertical: 10` and `marginHorizontal: 10`. The more specific style attributes will override the more generic ones – if we write `margin: 10, marginTop: 20`, the top will have a margin of `20`, while the rest of the sides will have a margin of `10`. All of the same rules apply to `padding` and `border` too (except that for border, the attribute is called `borderWidth` instead of `border`).

Here is an illustration of the box model:



In this example, there's a `margin` of `20`, a `borderWidth` of `10`, `padding` of `20`, and a content area of `130` wide by `80` tall. The `borderWidth` and `margin` on the bottom side are different than the rest: the border on the bottom is `20`, and the margin on the bottom is `30`. Here's how we might write the style for this:

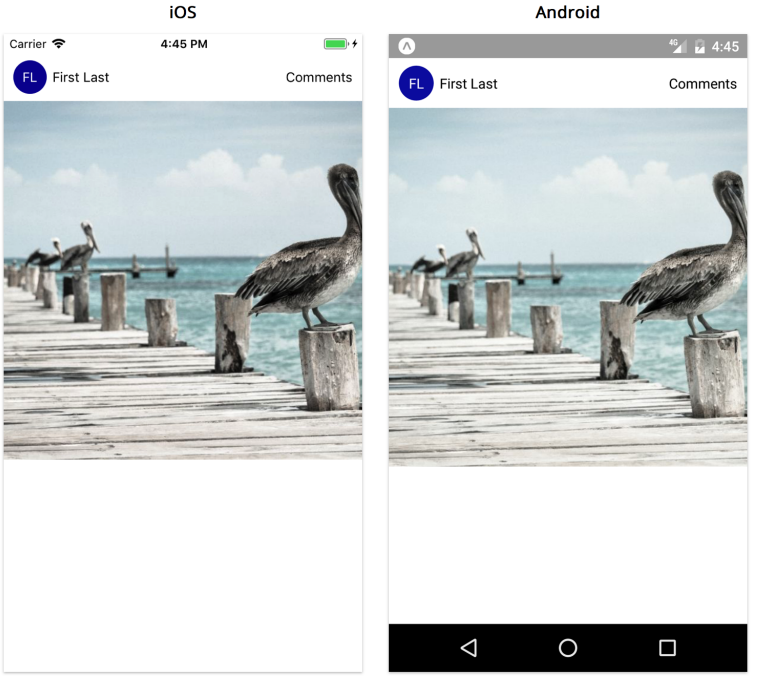
```
{
  margin: 20,
  borderWidth: 10,
  padding: 20,
  borderBottomWidth: 20
  marginBottom: 30
};
```

When we use a fixed `width` or `height`, this includes the content area, the padding area, and the border width. Margin is not counted in the `width` or `height`, since it is space outside of the component's edges. The width in this example is `10 + 20 + 130 + 20 + 10 = 190`, and the height is `10 + 20 + 80 + 20 + 20 = 150`.

We'll continue using these spacing style attributes and the box model as we build the rest of the components in our app.

`Card`

Next up, we'll make the card containing `AuthorRow` and the `Image` component.



Since rendering `Image` components will be an important part of our app, let's look at how images work in more detail.

`Image`

We use the `Image` component to render images on the screen. There are two ways to include images in an app: we can bundle an image asset with our code (which will then get stored on the device), or we can download an image from a URI.

Bundling image assets

To bundle an image asset, we can `require` the image by name from our project directory just like any other file. The React Native packager will give us a reference

to this image (a number) that represents the image's metadata. The packager will automatically bundle images for multiple pixel densities if we name them with the `@` suffix: `.png` for standard resolution, `@2x.png` for 2x resolution, and `@3x.png` for 3x resolution. We can pass an image reference to the `source` prop of an `Image` to render it.

For example, if we had a file called `foo.png` in the root directory of our app, we could use:

```
<Image source={require('./foo.png')} />
```

We won't bundle any images in this app, however, since the images we want to display come from the web. Instead, we'll load remote images assets.

Remote image assets

To display an image from a URI, we must pass an object to the `source` prop of the `Image` component. The object should contain a string value `uri`, and may optionally contain number values for `width` and `height` (representing the image's intrinsic dimensions, pre-calculated). The `Image` component will automatically download the data from the URI and display it once loaded.

```
<Image source={{ uri: 'https://unsplash.it/600/600' }} />
```

Since large images may take a while to download, we'll often show a loading indicator of some sort before the download has finished. We can pass a callback function to the `onLoad` prop of `Image` to determine when the image has loaded. We'll explore this shortly.

> In this chapter, we'll use the open API, `https://unsplash.it`, to fetch images for our image feed. This API is very useful for testing apps that need placeholder images. We'll use two API endpoints:
>
> - `https://unsplash.it/${width}/${height}`: This endpoint gives us a random image. We can use the query parameter `image` and pass the `id` of an image to fetch a specific image, e.g. `?image=10`. We can specify the dimensions

of the image by putting the desired width and height in the URL. We'll choose an arbitrary size, 600 x 600, for this app.
- `https://unsplash.it/list`: This endpoint gives us a list of image metadata objects. The metadata object for each image contains an `id` which we can use for the `image` query parameter of the previous endpoint.

We'll be using two utility functions in `utils/api.js`: `getImageFromId(id)` and `fetchImages()`. These functions correspond to the two `unsplash.it` APIs, respectively.

Common image styles

We can use the `resizeMode` style (or prop – both work) to determine how the image is cropped in the case where the image data's intrinsic dimensions are different than the dimensions of the `Image` component.

The options for `resizeMode` are:

- **`cover`**: The image scales uniformly to fill the `Image` component. The image will be cropped by the bounding box of the component if they have different aspect ratios.
- **`contain`**: The image scales uniformly to fit within the component. The component's background color will show if they have different aspect ratios.
- **`stretch`**: The image stretches to fill the component.
- **`repeat`**: The image repeats itself at its intrinsic dimensions to fill the component (iOS-only).
- **`center`**: The image maintains its intrinsic dimensions, and is centered within the component.

We can use the `aspectRatio` style to render the image at a specific aspect ratio, regardless of its intrinsic dimensions. We provide a number value which represents the ratio of width to height. For example, if we set `aspectRatio: 2`, this means the ratio of width to height is 2 to 1 – the image will render twice as wide as it is tall.

While most commonly used with images, the `aspectRatio` style can be used on any component, such as `View` or `Text`.

If you're coming from the web, you'll likely find this style surprising since there's no equivalent style in CSS. The React Native layout engine, Yoga, added this style to its flexbox implementation.

Yoga

React Native uses the Yoga layout engine (also from Facebook). This is a cross-platform implementation of the flexbox algorithm. It matches the algorithm used by web browsers pretty closely, but with two important differences:

- The default values are different
- Yoga adds a couple new features that don't exist in the browser (like `aspectRatio`)

If you want to read more about the algorithm and all of the styles available to use, check out the Yoga docs[a].

[a] https://facebook.github.io/yoga/

Adding `Image` to `Card`

Let's set up the outline for our `Card` component and render an `Image`.

Create a new file `Card.js` in the `components` directory. Add the following to this file:

image-feed/1/components/Card.js

```
import { Image, StyleSheet, View } from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

import AuthorRow from './AuthorRow';

export default class Card extends React.Component {
  static propTypes = {
    fullname: PropTypes.string.isRequired,
    image: Image.propTypes.source.isRequired,
    linkText: PropTypes.string,
    onPressLinkText: PropTypes.func,
  };

  static defaultProps = {
    linkText: '',
    onPressLinkText: () => {},
  };

  // ...

  render() {
    // ...
  }
}
```

Most of the `props` we use here should look familiar: `fullname`, `linkText`, and `onPressLinkText` will all get passed into the `AuthorRow` we created earlier. The interesting one is `image` – we use `Image.propTypes.source` as the type, so that we can pass this directly into the `source` prop of the `Image` we'll render.

Let's fill out the component function:

image-feed/1/components/Card.js

```
// ...

  render() {
    const { fullname, image, linkText, onPressLinkText } = this.props;

    return (
      <View>
        <AuthorRow
          fullname={fullname}
          linkText={linkText}
          onPressLinkText={onPressLinkText}
        />
        <Image style={styles.image} source={image} />
      </View>
    );
  }

// ...

const styles = StyleSheet.create({
  image: {
    aspectRatio: 1,
    backgroundColor: 'rgba(0,0,0,0.02)',
  },
});
```

We'll render a `View` (with the default style `flexDirection: 'column'`) in order to vertically stack our `AuthorRow` and `Image` component. Since the `View` style defaults to `alignItems: 'stretch'`, the image stretches horizontally to fill the screen. We use `aspectRatio: 1` to make the height of the `Image` match its full-screen width, rendering as a perfect square. We put a `backgroundColor` on the `Image` which will show before the image loads, or behind the image if the image is transparent.

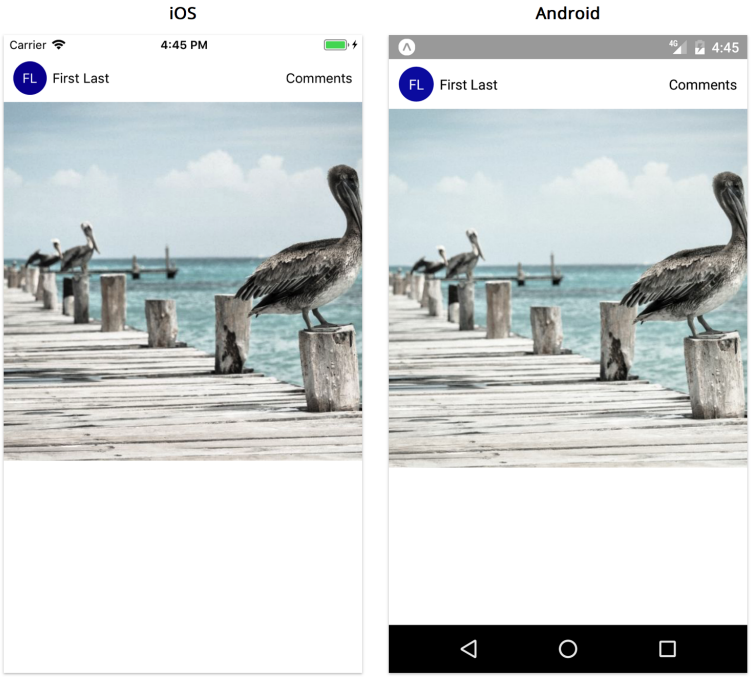
Try it out

To test this, let's render our new `Card` from `App`. Update the component in `App.js` to the following:

image-feed/1/App.js

```
// ...

import Card from './components/Card';

export default class App extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <Card
          fullname={'First Last'}
          linkText={'Comments'}
          onPressLinkText={() => {
            console.log('Pressed link!');
          }}
          image={{ uri: 'https://unsplash.it/600/600' }}
        />
      </View>
    );
  }
}

// ...
```

When you save `App.js`, you should see our `AuthorRow` from earlier plus a random image on your device:



Loading status

You might notice that we see the background color behind our image as we wait for it to load. Let's add a loading indicator before the image has fully loaded, to provide more feedback to the user.

We can pass a callback to the `onLoad` prop of `Image` in order to monitor the loading status. Let's keep track of the `Image` loading status in the state of our `Card` component. Update `Card.js` to include the following:

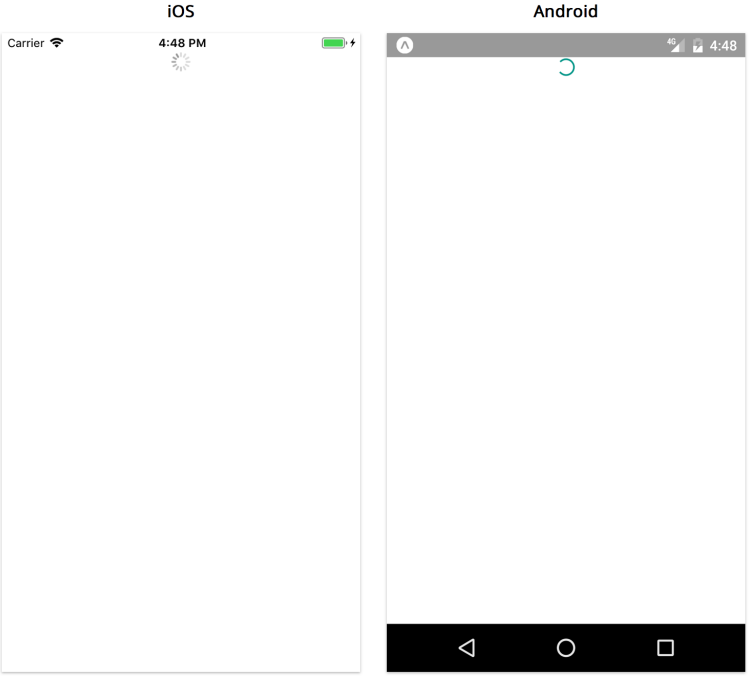
image-feed/1/components/Card.js

```
export default class Card extends React.Component {
  // ...

  state = {
    loading: true,
  };

  handleLoad = () => {
    this.setState({ loading: false });
  };

  render() {
    const { fullname, image, linkText, onPressLinkText } = this.props;
    const { loading } = this.state;

    return (
      <View>
        <AuthorRow
          fullname={fullname}
          linkText={linkText}
          onPressLinkText={onPressLinkText}
        />
        <Image
          style={styles.image}
          source={image}
          onLoad={this.handleLoad}
        />
      </View>
    );
  }
}
```

Now we're tracking when the image has fully loaded with `state.loaded`. Next we'll render the loading indicator when `state.loaded` is `true`.

ActivityIndicator

We can render a loading indicator using the `ActivityIndicator` component.



This component accepts all the same `props` as `View`, plus a few more:

- **`animating`**: A bool indicating whether to show or hide the indicator (defaults to `true`).
- **`color`**: The color of the spinner (defaults to gray).
- **`size`**: One of `'small'` or `'large'` (defaults to small).

We want to position the `ActivityIndicator` in the center of the image. Unlike `View`, the `Image` component doesn't accept a `children` prop, so we can't put the `ActivityIndicator` inside it. We could use the `ImageBackground` component like we did in the "Getting Started" chapter, but let's instead look at a more generic way we can stack components: `position`.

Position

So far we've mostly used the style attributes `flexDirection`, `justifyContent`, and `alignItems` in our layouts. React Native gives us another powerful style attribute we can use to adjust layout: `position`. Position can be either `'relative'` or `'absolute'`.

relative

When set to `'relative'` (which is the default), we're able to tweak the `position` of a component after it has already been laid out according to its `flex`, `width`, `height`, etc. We can use a combination of `top`, `right`, `bottom`, and `left`. For example, if we want to move a component down on the screen by 20 pixels, we could say `top: 20` to indicate that its top should be 20 pixels greater than it is currently. Unlike specifying `padding`, `margin`, or `borderWidth`, the style attributes like `top` don't affect other elements in the layout. In other words, adding `top: 20` will change the position of the element it was applied to, but not the position of the element's siblings or parent (even if this causes them to overlap).

absolute

When set to `'absolute'`, the layout of the parent and the component's `flex` style are completely ignored. Instead we use `top`, `right`, `bottom`, and `left` to specify exactly how the component should be placed within its parent. For example, if we want the component to be 10 pixels from the bottom and 20 pixels from the right side of its parent, we can say `bottom: 20`, `right: 10`. As always, we need to make sure the component has dimensions greater than 0. Since `flex` is ignored, we may need to specify a fixed width and height. We can also ensure the component has dimensions greater than 0 by specifying both top and bottom, or both left and right. For example, if we say `left: 10`, `right: 10`, the component will stretch horizontally to fill the space from 10 pixels from the left of its parent to 10 pixels from the right. Components positioned with `position: 'absolute'` don't affect the layout of their siblings or parent components.

It's common to use `position: 'absolute'` to make elements overlap. Suppose we want two sibling elements to overlap, filling their parent completely. We can add a style like this to both siblings:

```
const absoluteFillStyle = {
  position: 'absolute',
  top: 0,
  right: 0,
  bottom: 0,
  left: 0,
};
```

This style will cause an element to fill its parent completely, since its top will match its parent's top, its right side will match its parent's right side, and so on. This technique is so common that there's a predefined style to do the same thing: `StyleSheet.absoluteFill`. This value can be passed directly to the `style` prop of an element. Alternately, you can use `...StyleSheet.absoluteFillObject`, copying each of these properties into another style – this is useful if you want to override one or two properties but keep the rest.

This overlapping behavior is exactly what we want for positioning our `ActivityIndicator` in the center of our `Image`.

Adding `ActivityIndicator` to `Card`

We'll use `StyleSheet.absoluteFill` to ensure that our `ActivityIndicator` matches the dimensions of our `Image`. To do this, we'll need to create a common ancestor `View` for both.

First, in `Card.js`, make sure to import `ActivityIndicator`:

image-feed/1/components/Card.js

```
  ActivityIndicator,
```

Then, update the `render` method of `Card` to the following:

image-feed/1/components/Card.js

```
  render() {
    const { fullname, image, linkText, onPressLinkText } = this.props;
    const { loading } = this.state;

    return (
      <View>
        <AuthorRow
          fullname={fullname}
          linkText={linkText}
          onPressLinkText={onPressLinkText}
        />
        <View style={styles.image}>
          {loading && (
            <ActivityIndicator
              style={StyleSheet.absoluteFill}
              size={'large'}
            />
          )}
          <Image
            style={StyleSheet.absoluteFill}
            source={image}
            onLoad={this.handleLoad}
          />
        </View>
      </View>
    );
  }
```

If you save `Card.js` and look at your device, you should see the `ActivityIndicator` positioned in the center of the `Image` before it loads.

It can be a little confusing to see how this works at first, so let's walk through it. We moved the `styles.image` style to the inner `View` that's the parent of the `Image`. This inner `View` is inside a parent `View` with `alignItems: 'stretch'` (the default) and it has `aspectRatio: 1`, so we know the inner `View` will have the same width as

its parent (in this case, the width of the screen) and a height equal to its width. The `Image` and `ActivityIndicator` will have the same `top`, `right`, `bottom`, and `left` of the inner `View` – in other words, they'll will match the dimensions of the `View`.

The order we render components in our code matters here: within the inner `View`, we render the `ActivityIndicator` *before* the `Image`. The component rendered *last* in the code will render on top of its siblings visually. This normally isn't something we have to think about, since components don't stack on top of one another. With `position` however, sibling components may overlap, and the order we render them determines their order on screen. In this case, our image `Image` renders on top of our `ActivityIndicator`. The `onLoad` event may get called after the image has been drawn, so this way the `Image` covers up the `ActivityIndicator` even if both are rendered at the same time.

> If you're coming from the web, you may be wondering about the `zIndex` style attribute. React Native has a attribute `zIndex`, but it behaves a little differently and can have somewhat unpredictable effects. It's generally safer to render components in the correct order, if possible.

There are many other ways to achieve the same layout. Another approach would be to set the `Image` style to `flex: 1` to fill the `View` completely.

```
<View style={styles.image}>
  {loading && (
    <ActivityIndicator
      style={StyleSheet.absoluteFill}
      size={'large'}
    />
  )}
  <Image
    style={{ flex: 1 }}
    source={image}
    onLoad={this.handleLoad}
  />
</View>
```

We could also leave `styles.image` on the `Image`, and rely on the fact that its parent `View` will resize along the vertical axis to contain its children:

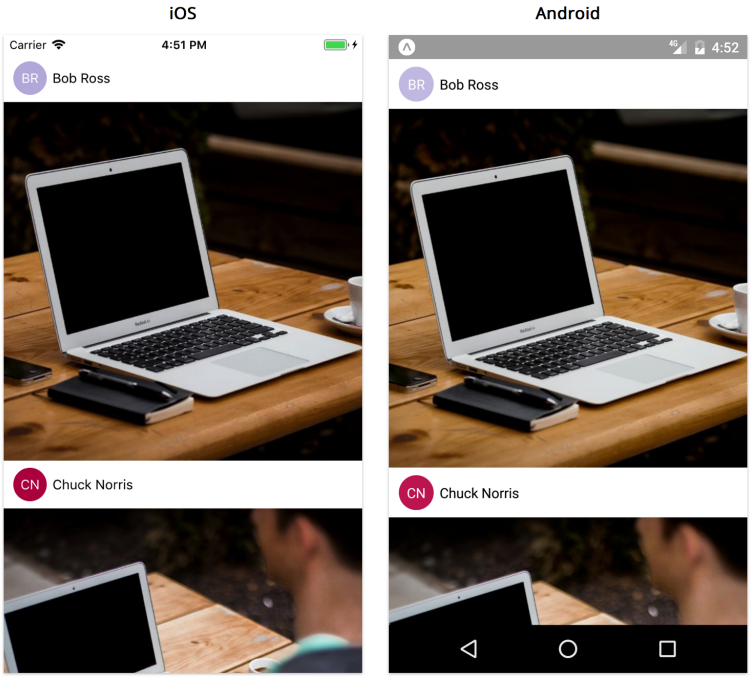
```
<View>
  {loading && (
    <ActivityIndicator
      style={StyleSheet.absoluteFill}
      size={'large'}
    />
  )}
  <Image
    style={styles.image}
    source={image}
    onLoad={this.handleLoad}
  />
</View>
```

All of these approaches are reasonable, so deciding which to use mostly comes down to preference. We chose our approach for this chapter because it's easier to understand at first glance: both children of the `View` have `StyleSheet.absoluteFill`, so it's clear that they will overlap completely just by reading the code.

Now that we have our `Card` component, we can render a list of these to create the main feed.

`CardList`

The `CardList` component will render the infinitely scrolling list of authors and images.



We'll render this list of cards using the `FlatList` component.

`FlatList`

`FlatList` components are used for rendering large quantities of scrollable content. Instead of rendering a `children` prop, the `FlatList` renders each item in an input `data` array using the `renderItem` prop. The `renderItem` prop is a function which takes an item from the `data` array and maps it to a React Element. Each item in `data` should be an object with a unique id, so that React can determine when items have been rearranged.

The `FlatList` is generally performant: it only renders the content on screen (clipping offscreen content), and only updates rows that have changed. The `FlatList` is built using a more generic component, the `ScrollView`, which we'll use later in the chapter.

Adding `FlatList` to `CardList`

Let's create a new file, `CardList.js`, in our `components` directory. We'll import the `FlatList`, our `Card`, a utility for building an image url from an id, and a few other things at the top of the file:

image-feed/1/components/CardList.js

```
import { FlatList } from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

import { getImageFromId } from '../utils/api';
import Card from './Card';
```

Ultimately we'll use `https://unsplash.it` to fetch the data for our feed, but for now let's pretend our `data` looks like:

```
[
  { id: 0, author: "Bob Ross" },
  { id: 1, author: "Chuck Norris" }
];
```

It's important that the `id` field is unique, since we'll use it to determine the identity of each card in the feed. If it weren't unique, we would start to see quirky behavior where some items don't render. Fortunately the API we'll call later has unique `id` values (as most APIs should!).

We'll need to provide a function to the `FlatList` which maps each element in our `data` array to its unique key. Let's define a utility function to do this at the top of the file, which we'll then pass to the `FlatList` as the `keyExtractor` prop. Our function, `keyExtractor`, will take an item from our array and return the `id` for that item as a string. Define this function below the imports:

image-feed/1/components/CardList.js

```
const keyExtractor = ({ id }) => id.toString();
```

We'll use this function in a moment when we render the `FlatList`.

Moving on to the `propTypes`, we'll want to ensure our input data matches the format we defined above. We can use a combination of `PropTypes.arrayOf` and `PropTypes.shape`. Let's set up our component skeleton as follows:

image-feed/1/components/CardList.js

```
// ...

export default class CardList extends React.Component {
  static propTypes = {
    items: PropTypes.arrayOf(
      PropTypes.shape({
        id: PropTypes.number.isRequired,
        author: PropTypes.string.isRequired,
      }),
    ).isRequired,
  };

  render() {
    // ...
  }
}
```

We'll use a class component instead of a functional component, since we'll add a few methods which need to access `props` when we add commenting later.

> So far we've seen how we can validate primitive values with `PropTypes.bool`, `PropTypes.string`, etc. We can use `PropTypes.shape()` to validate an object, passing the keys of the values we want to validate. We can use `PropTypes.array()` to validate an array, passing the type of the element.
>
> If we were planning to use this `items` data structure in multiple places, we might

want to define its type in a separate file, such as `ItemsPropType.js`. That way we can define it once and import it from multiple files, rather than defining it in multiple places. React Native exports a few built-in types this way, such as `ViewPropTypes`.

Now let's render the `FlatList`:

image-feed/1/components/CardList.js

```
  renderItem = ({ item: { id, author } }) => (
    <Card
      fullname={author}
      image={{
        uri: getImageFromId(id),
      }}
    />
  );

  render() {
    const { items } = this.props;

    return (
      <FlatList
        data={items}
        renderItem={this.renderItem}
        keyExtractor={keyExtractor}
      />
    );
  }
```

Destructuring assignments, revisited

In the previous chapter, we covered destructuring assignments. Destructuring assignments can also be nested, as in the example above:

```
renderItem = ({ item: { id, author } }) => {}
```

This is equivalent to:

```
renderItem = (obj) => {
  const id = obj.item.id;
  const author = obj.item.author;
}
```

We provide the prop `keyExtractor` to instruct the `FlatList` how to uniquely identify items – this helps the `FlatList` determine when it needs to re-render items as they go in and out of the visible portion of the screen.

Each time the `FlatList` decides to render a new item, it will call the `renderItem` function we provide it with, with an object as a parameter. The object contains some rendering metadata, along with the `item` from the array we passed as the `data` prop.

Within `renderItem`, we can then return a `Card` component based on the item. We can use the item's `id` to construct a URI for an image, leveraging our `getImageFromId()` utility function.

Save `CardList.js` and let's test it out.

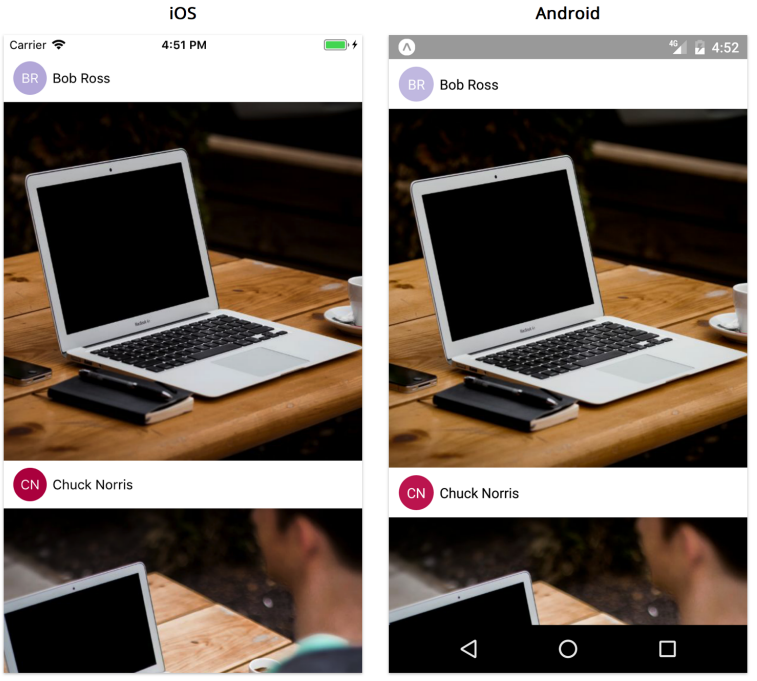
Try it out

Update `App.js` to render the `CardList` using the hardcoded data we mentioned earlier:

image-feed/1/App.js

```
// ...

import CardList from './components/CardList';

const items = [
  { id: 0, author: 'Bob Ross' },
  { id: 1, author: 'Chuck Norris' },
];

export default class App extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <CardList items={items} />
      </View>
    );
  }
}

// ...
```

Save `App.js` and you should see this:



Now that we've finished our last custom UI component for the image feed, we can use it to create our `Feed` screen.

Adding a screen

Our app will have two screens:

- **`Feed`**: The image feed
- **`Comments`**: The list of comments for a specific image

In React Native, screens are components just like any other. However, it's useful to think about screens slightly differently. Screens are components that fill the entire device screen. They often handle non-visual concerns, like fetching data and handling navigation to other screens.

It's common to keep all of the screen components in an app together in a `screens` directory. For more advanced apps, we might create directories within `screens` to

categorize them more specifically. Since this app is pretty simple, let's use a flat `screens` directory.

Create a new directory called `screens` within our top level `image-feed` directory, and create a new file within `screens` called `Feed.js`.

The `Feed` screen

This screen will fetch live data from `https://unsplash.it` and pass the data into our `CardList`. The data we fetch will follow the same format as the hardcoded list we're using currently.

Now that we're fetching remote data asynchronously, we need to consider loading and error states. This screen will show a simple loading indicator and error status.

Add the following imports to `Feed.js`:

image-feed/1/screens/Feed.js

```
import {
  ActivityIndicator,
  Text,
  ViewPropTypes,
  SafeAreaView,
} from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

import { fetchImages } from '../utils/api';
import CardList from '../components/CardList';
```

Often screens are configured with props just like other components. In this case, we'll allow a `style` prop, which we'll use for the top level `View` within this screen. This allows a lot of flexibility for our screen to be styled however we need. The type of this prop will be the same as the `style` prop of `View` – React Native provides this validator as a separate import, `ViewPropTypes`.

You might be tempted to use `PropTypes.object` to represent a style, but this doesn't work very well. Styles created with `StyleSheet.create` are represented as numbers, so this will cause a warning. Also, `ViewPropTypes.style` provides in-depth type-checking of each key and value, which is very valuable.

image-feed/1/screens/Feed.js

```
// ...

export default class Feed extends React.Component {
  static propTypes = {
    style: ViewPropTypes.style,
  };

  static defaultProps = {
    style: null,
  };

  // ...
}

// ...
```

It's common to allow a `style` prop for creating extremely flexible custom components. We could technically use this `style` prop however we want, such as styling a deeply nested component – however, when naming a prop the same as a built-in `View` prop, we'll generally try to keep the behavior similar. Following built-in component conventions makes it easier for other developers to understand how to use our custom components without reading the source code.

We'll keep track of three things in the `state` of our `Feed`: `loading`, `error`, and `items`.

image-feed/1/screens/Feed.js

```
  state = {
    loading: true,
    error: false,
    items: [],
  };
```

We can use these to decide what to render. We'll fetch data in `componentDidMount`, updating component `state` when we get a response.

image-feed/1/screens/Feed.js

```
  async componentDidMount() {
    try {
      const items = await fetchImages();

      this.setState({
        loading: false,
        items,
      });
    } catch (e) {
      this.setState({
        loading: false,
        error: true,
      });
    }
  }
```

We made `componentDidMount` an `async` function so that we can use the `await` syntax within it. This means the function will return a promise. React doesn't use the return value of `componentDidMount` for anything, so this is safe.

Now, let's update our `render` method to make use of this new `state`:

image-feed/1/screens/Feed.js

```
  render() {
    const { style } = this.props;
    const { loading, error, items } = this.state;

    if (loading) {
      return <ActivityIndicator size="large" />;
    }

    if (error) {
      return <Text>Error...</Text>;
    }

    return (
      <SafeAreaView style={style}>
        <CardList items={items} />
      </SafeAreaView>
    );
  }
```

We're ready to render our `Feed` screen from `App`!

Adding `Feed` to `App`

Let's update `App.js` to render our new screen. First we'll need to update the imports at the top of the file:

image-feed/1/App.js

```
import { Platform, StyleSheet, View } from 'react-native';
import Constants from 'expo-constants';
import React from 'react';

import Feed from './screens/Feed';

export default class App extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <Feed style={styles.feed} />
      </View>
```

Then we can render our `Feed` within a wrapper `View`:

image-feed/1/App.js

```
export default class App extends React.Component {
  render() {
    return (
      <View style={styles.container}>
        <Feed style={styles.feed} />
      </View>
    );
  }
}
```

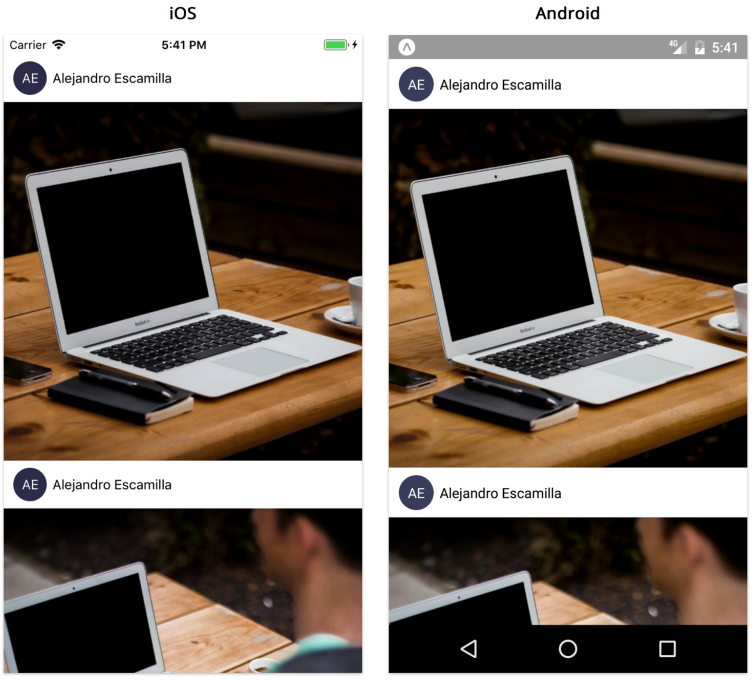
Since our `Feed` uses a `SafeAreaView` at the top level, we'll also need to update our styles from before. We only want to add a `marginTop` on Android, or on iOS versions less than 11, since the top margin is added automatically by the `SafeAreaView` on iOS 11+ now.

We can use `Platform.Version` to detect the native operating system version. On iOS, this is a string like `'10.3'`, while on Android it's a number.

image-feed/1/App.js

```
const platformVersion =
  Platform.OS === 'ios'
    ? parseInt(Platform.Version, 10)
    : Platform.Version;

const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: '#fff',
  },
  feed: {
    flex: 1,
    marginTop:
      Platform.OS === 'android' || platformVersion < 11
        ? Constants.statusBarHeight
        : 0,
  },
});
```

And with that, we're finished with the feed! Here's the final result with live data:



List Performance

If you're running a version of React Native greater than 0.55, you may see the following warning after scrolling through a hundred or so images:

```
VirtualizedList: You have a large list that is slow to update - make su\
re your
renderItem function renders components that follow React performance be\
st practices
like PureComponent, shouldComponentUpdate, etc.
```

React Native is letting us know that our list is taking a long time to render once it gets to a certain length. We can address this by reducing the amount of cards we re-render.

The `FlatList` re-renders our cards while we scroll. Most of the time, however, a card's data doesn't change, so we don't need to update the component after the

initial render – the only time the data might change is if the number of comments to display changes. We can add a `shouldComponentUpdate` method to `Card.js` to reduce re-renders and thus improve the performance of our `FlatList`. We could add the following `shouldComponentUpdate` method:

```
shouldComponentUpdate(nextProps) {
  return this.props.linkText !== nextProps.linkText
}
```

Then our cards would only re-render if absolutely necessary. You may still get the same warning at a certain point, but it should take several times more scrolling than before.

Most of the time using `shouldComponentUpdate` is a premature optimization. Even when it comes to large lists like this, often the performance will be good enough in the production build without any other optimizations. However, if you get a warning, it's an optimization worth considering.

What we've built so far

Let's recap what we've done so far. We used the components `View`, `Text`, `Image`, and `FlatList` to build a cross-platform, infinitely scrolling list of images and authors. We created 4 components, each one building on top of the previous: `Avatar`, `AuthorRow`, `Card`, and `CardList`. We tested each component as we built it, by rendering from our top-level component, `App`. We used a variety of techniques for layout:

- Setting the `width` and `height` explicitly
- Using `flex` to stretch elements
- Using `flexDirection`, `justifyContent`, and `alignItems` for children layout
- Using `padding` and `margin` to define spacing between elements
- Using `position: 'absolute'` to stack elements on top of one another
- Creating optimized styles with `StyleSheet.create`

These are the fundamental building blocks of any React Native UI. We'll continue to use these throughout the rest of the book, as we add more components and APIs to our repertoire.

Core Components, Part 2

Picking up where we left off

We successfully built an awesome infinitely-scrolling image feed. Next, we're going to add a new screen to the same app for commenting on images.

This is a **code checkpoint**. If you haven't been coding along with us but would like to start now, we've included a snapshot of our current progress in the sample code for this book.

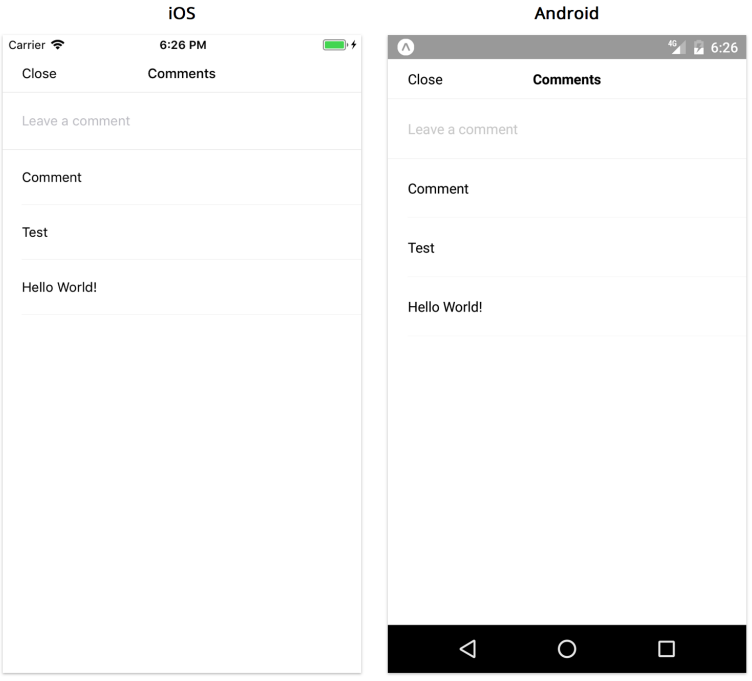
If you haven't created a project yet, you'll need to do so with:

```
$ expo init image-feed --template blank@sdk-33 --yarn
```

Then, copy the contents of the directory `image-feed/1` from the sample code into your new `image-feed` project directory.

Comments

Here's what the comments screen will look like:

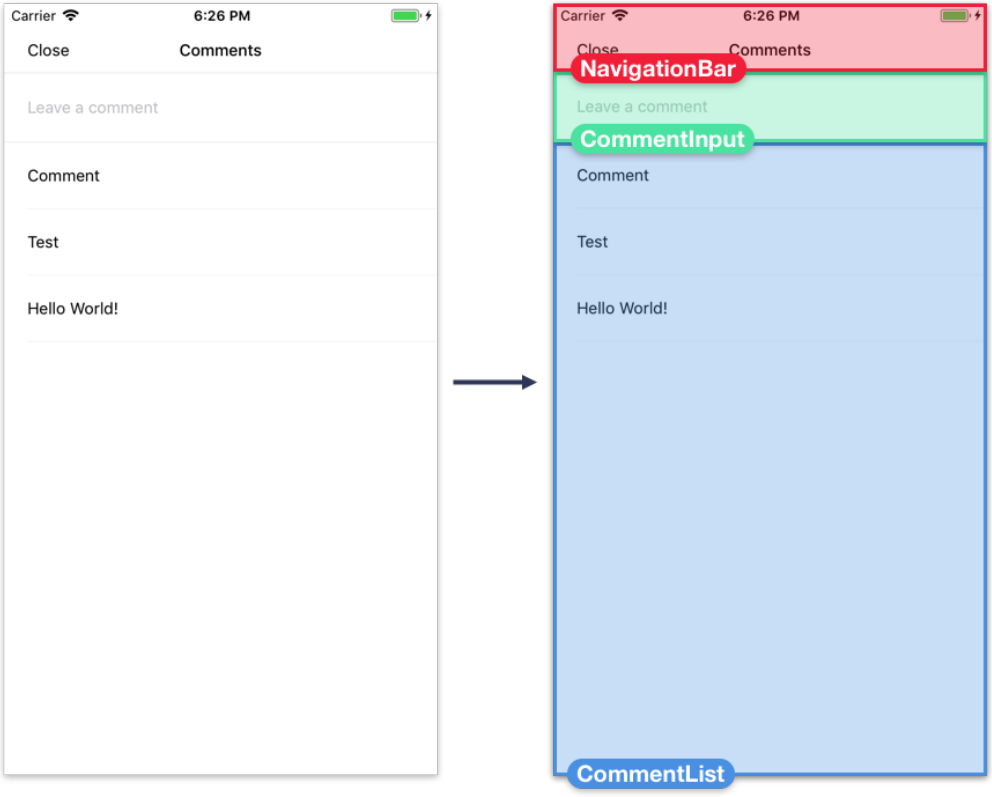


To build this portion of the app, we'll learn how to use the `TextInput`, `ScrollView`, and `Modal` components. We'll also cover a few other topics like `AsyncStorage`. We'll make a few assumptions so we can focus on built-in components:

- we won't use a navigation library even though we have multiple screens (more on navigation in later chapters)
- we only want to store comments locally on the device, rather than remotely via an API
- comments can be saved as simple strings (no `id`, `author`, or other metadata)
- the comment input field is at the top of the screen, to avoid complexities around keyboard and scrolling (which we'll cover in the next chapter)
- there are few enough comments that a `ScrollView` will be performant enough (rather than using a `FlatList`)

Breaking down the comments screen

The first thing we'll want to do is break the screen down into components. Here's one way we can break it down:



- `NavigationBar` - A simple navigation bar for the top of the screen with a title and a "close" button
- `CommentInput` - The input field for adding new comments
- `CommentList` - The scrollable list of comments

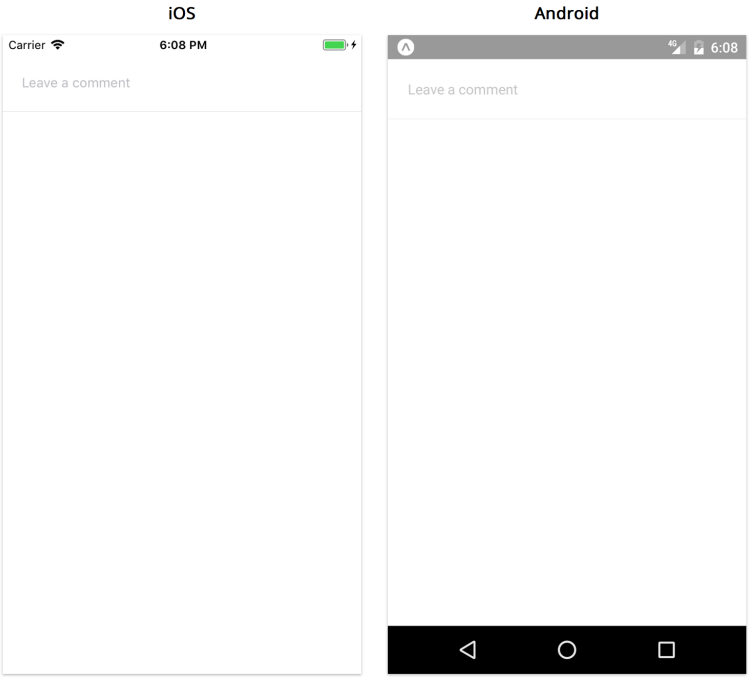
The `App` component will be responsible for handling comment data in our app, since both the `Feed` screen and `Comments` screen need to render this data. We'll render the `Comments` screen component from `App`, passing the comment data for the selected card as a prop. We'll render the built-in `Modal` component to open and close this new screen based on the `state` of `App`.

We'll continue building bottom-up, starting with the `CommentInput` component, working our way up to the screen component. We won't test every component

individually by rendering it from `App` like we did in the first half of the chapter, but you're welcome to continue to do this if you liked having a quicker feedback loop while developing.

`CommentInput`

First, let's create the input field for new comments.



`TextInput`

As we saw in the "Getting Started" chapter, we can use a `TextInput` component to create an editable text field for the user to type in.

When working with `TextInput`, we'll generally use the following `props` to capture user input:

- **`value`** - The current text in the input field.

- **`onChangeText`** - A function called each time the text changes. The new value is the first argument.
- **`onSubmitEditing`** - A function called when the user presses the return/next key to submit/move to the next field.

It's common to store the current text in the `state` of the component that renders the `TextInput`. Each time the function we pass to `onChangeText` is called, we call `setState` to update the current text. When the user presses return, the function we passed to `onSubmitEditing` is called – we can then perform some action with the current text, and use `setState` to reset the current text to the empty string.

Common `TextInput` props and styles

When working with `TextInput`, we can use most of the same styles as `Text` (which includes the styles for `View`). A few styles don't work quite as well as they do on `Text` though: borders tend not to render correctly, and padding and line height can conflict in unusual ways. If you're having trouble styling a `TextInput`, you may want to wrap the `TextInput` in a `View` and style the `View` instead.

A few other common `props`:

- **`autoCapitalize`** - For capitalizing characters as they're typed. One of `'none'`, `'sentences'`, `'words'`, `'characters'`.
- **`autoCorrect`** - Enable/disable auto-correct.
- **`editable`** - Enable/disable the text field.
- **`keyboardType`** - The type of keyboard to display. Cross-platform values are `'default'`, `'numeric'`, `'email-address'`, `'phone-pad'`.
- **`multiline`** - Allow multiple lines of input text.
- **`placeholder`** - The text to show when the text field is empty
- **`placeholderTextColor`** - The color of the placeholder text
- **`returnKeyType`** - The text of the return key on the keyboard. Cross-platform values are `'done'`, `'go'`, `'next'`, `'search'`, `'send'`.

Many more props are available in the docs for TextInput[55]

[55] https://facebook.github.io/react-native/docs/textinput.html

Adding `TextInput` to `CommentList`

While we could render a `TextInput` component directly from our `Comments` screen, it's often better to create a wrapper component that encapsulates state, styles, edge cases, etc, and has a smaller API. That's what we'll do in our `CommentInput` component. The result will be very similar to our `TextInput` wrapper components from previous chapters.

Create a new file, `CommentInput.js`, in the `components` directory. We'll import the usual `React`, `PropTypes`, etc, along with the `TextInput` component:

image-feed/components/CommentInput.js

```
import { StyleSheet, TextInput, View } from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';
```

We want this component to have two props:

- `onSubmit` - we'll call this with the comment text when the user presses the "return" key.
- `placeholder` - a passthrough to the `placeholder` prop of the `TextInput`.

Add the following to `CommentInput.js`:

image-feed/components/CommentInput.js

```
// ...

export default class CommentInput extends React.Component {
  static propTypes = {
    onSubmit: PropTypes.func.isRequired,
    placeholder: PropTypes.string,
  };

  static defaultProps = {
    placeholder: '',
```

```
  };

  // ...
}

// ...
```

We'll add a `text` value to `state` and methods for updating this value when the value of the `TextInput` changes:

image-feed/components/CommentInput.js

```
  state = {
    text: '',
  };

  handleChangeText = text => {
    this.setState({ text });
  };

  handleSubmitEditing = () => {
    const { onSubmit } = this.props;
    const { text } = this.state;

    if (!text) return;

    onSubmit(text);
    this.setState({ text: '' });
  };
```

We don't want to allow empty comments, so when `handleSubmitEditing` is called, we'll return immediately if `state.text` is empty.

Last, we'll render the `TextInput`. We want to add a border on the bottom, but adding borders to `TextInput` can be a bit unreliable as sometimes they don't show up. So we'll wrap the `TextInput` in a `View` and style the `View` instead:

image-feed/components/CommentInput.js

```
  render() {
    const { placeholder } = this.props;
    const { text } = this.state;

    return (
      <View style={styles.container}>
        <TextInput
          style={styles.input}
          value={text}
          placeholder={placeholder}
          underlineColorAndroid="transparent"
          onChangeText={this.handleChangeText}
          onSubmitEditing={this.handleSubmitEditing}
        />
      </View>
    );
  }
```

image-feed/components/CommentInput.js

```
const styles = StyleSheet.create({
  container: {
    borderBottomWidth: StyleSheet.hairlineWidth,
    borderBottomColor: 'rgba(0,0,0,0.1)',
    paddingHorizontal: 20,
    height: 60,
  },
  input: {
    flex: 1,
  },
});
```

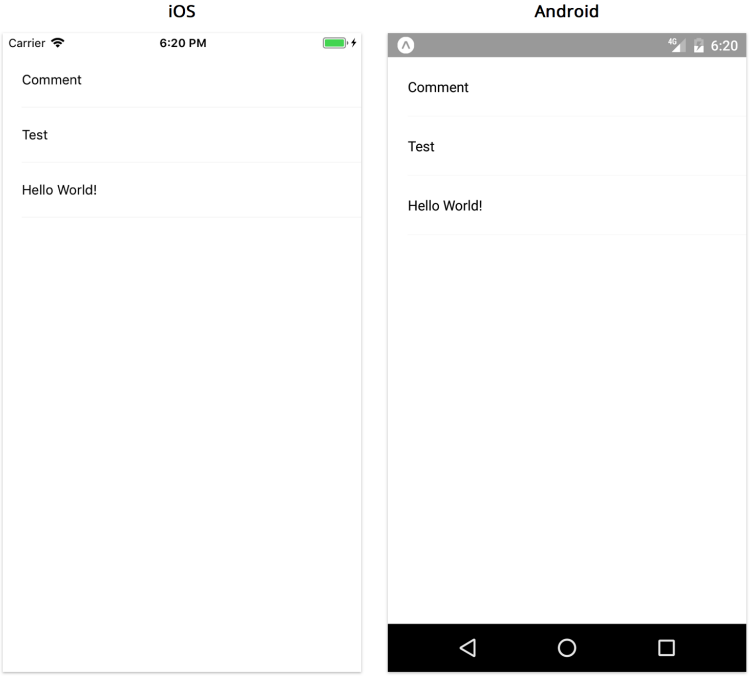
This is where we pass our state management methods `handleChangeText` and `handleSubmitEditing` to the `TextInput`, to keep track of changes to the `value`.

We can use `StyleSheet.hairlineWidth` as the border width to render the thinnest possible line on any given device. On a retina device for example, this would be less than `1`.

If you want to see what this component looks like to check your work, consider rendering it from within `App` for testing.

`CommentList`

Next, we'll render a list of comments for each image:



We'll render these comments in a `ScrollView`. In reality, we'd probably want to use a `FlatList` for performance, but let's use a `ScrollView` for practice.

`ScrollView`

The `ScrollView` is simpler than the `FlatList`: it will render all of its children in a vertically or horizontally scrollable list, without the additional complexity of the `keyExtractor` or `renderItem` props.

The `ScrollView` is well suited for scrolling through small quantities of content (fewer than 20 items or so). Content within a `ScrollView` is rendered even when it isn't visible on the screen. For large quantities of items, or cases where many children of the `ScrollView` are offscreen, you will likely want to use a `FlatList` component for better performance.

`ScrollView` dimensions and layout

You can think of a `ScrollView` as two separate views, one inside the other. The outer view has a bounded size, while the inner view can exceed the size of the outer view. If the inner view exceeds the size of the outer view, only a portion of it will be visible. When we pass children elements to the `ScrollView`, they are rendered inside this inner view. We call the inner view the "content container view", and can style it separately from the outer view.

Debugging a `ScrollView`

While building an app, it's common to render a `ScrollView` but see nothing on the screen. There are two common causes for this, based on how the outer view and the content container view work (assuming vertical scrolling):

- The content container view has `flex: 0` by default, so it starts with a `height` of `0` and expands to the minimum size needed to contain its children elements. If a child has `flex: 1`, this child won't be visible, since the content container has an intrinsic `height` of `0`. While we *could* set the `contentContainerStyle` to `flex: 1`, this probably isn't what we want, since then we'll never have content larger than the outer view. Instead, we should make sure the children we pass to the `ScrollView` have intrinsic `height` values greater than `0` (either by using an explicit `height`, or by containing children that have `height` greater than `0`).

- The outer view does not change size based on the content container view. In addition to ensuring that the children of a `ScrollView` have non-zero `height`, we have to make sure our `ScrollView` has non-zero dimensions – a fixed `width` and `height`, `flex: 1` and a parent with `alignItems: stretch`, or absolute positioning.

Most likely, if the `ScrollView` doesn't appear, we need to add `flex: 1` to each parent and to the `ScrollView` itself. To debug, you can try setting a background color on each parent to see where `flex: 1` stopped getting propagated down the component hierarchy.

Adding `ScrollView` to `CommentList`

Let's render a `ScrollView` that contains a list of comments. We'll call this component `CommentList`.

Create a file `CommentList.js` in the `components` directory.

This component will take an `items` array prop of comment strings, mapping these into `View` and `Text` elements. We'll set up the outline for this component in `CommentList.js` as follows:

image-feed/components/CommentList.js

```
import { ScrollView, StyleSheet, Text, View } from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

export default class CommentList extends React.Component {
  static propTypes = {
    items: PropTypes.arrayOf(PropTypes.string).isRequired,
  };

  // ...
}
```

Unlike `FlatList`, we don't need to deal with the `keyExtractor` and `data` props. We can simply render the `children` of the `ScrollView` as we would for a `View`:

image-feed/components/CommentList.js

```
  renderItem = (item, index) => (
    <View key={index} style={styles.comment}>
      <Text>{item}</Text>
    </View>
  );

  render() {
    const { items } = this.props;

    return <ScrollView>{items.map(this.renderItem)}</ScrollView>;
  }
```

image-feed/components/CommentList.js

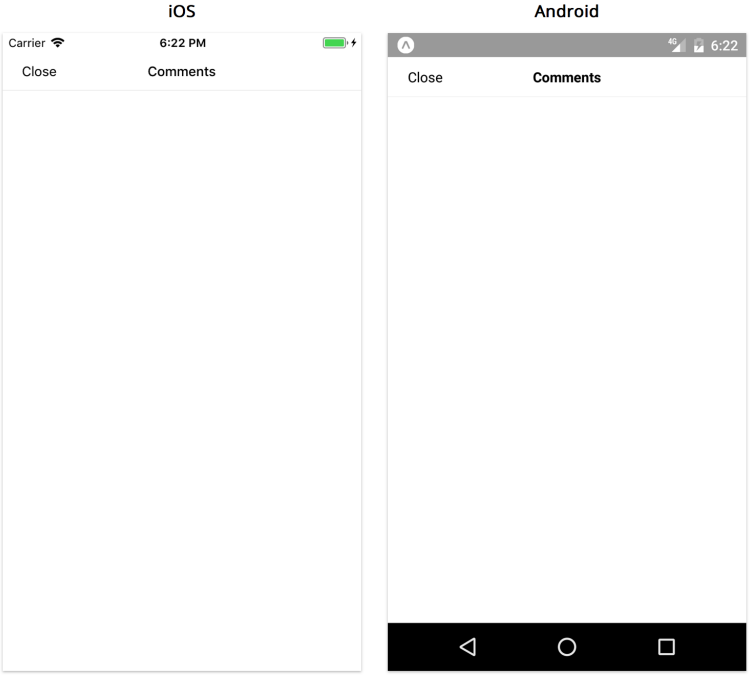
```
const styles = StyleSheet.create({
  comment: {
    marginLeft: 20,
    paddingVertical: 20,
    paddingRight: 20,
    borderBottomWidth: StyleSheet.hairlineWidth,
    borderBottomColor: 'rgba(0,0,0,0.05)',
  },
});
```

Since comments are stored as strings, we don't have a convenient value to use as the unique React `key`. Using the comment text as the `key` wouldn't work, since comments don't have to be unique. Using the `index` as the key *works here*, but is generally a pattern to be wary of, since it can cause problems when rearranging items. A better solution would be to augment our comment data with ids: we could store comments as objects, and use the `uuid` library from the previous chapter to assign each comment a unique id for use as the key.

Now that we have a scrolling list of comments, we can move on to the navigation bar, which will be the last component we make before assembling our comments screen.

`NavigationBar`

Since our comments screen is going to open in a modal, we want to render a navigation bar with a title and close button.



In a real app, we would likely use a navigation library for this, but for simplicity, let's write something small of our own.

Create `NavigationBar.js` in the `components` directory and add the following outline:

image-feed/components/NavigationBar.js

```
import {
  StyleSheet,
  Text,
  TouchableOpacity,
  View,
} from 'react-native';

export default function NavigationBar({
  title,
  leftText,
  onPressLeftText,
}) {
  // ...
}

NavigationBar.propTypes = {
  title: PropTypes.string,
  leftText: PropTypes.string,
  onPressLeftText: PropTypes.func,
};

NavigationBar.defaultProps = {
  title: '',
  leftText: '',
  onPressLeftText: () => {},
};

// ...
```

We won't use `isRequired` on our props, since this component would likely be used without some of them, e.g. `leftText` and `onPressLeftText`, if we were to add more screens to this app.

This component will be fairly straightforward, using only concepts we've covered

already. We'll use a `TouchableOpacity` for the close button on the left. We'll position it with `position: 'absolute'`, since we don't want the text on the left to push the title off-center (remember, using `position: 'absolute'` means the component no longer affects other siblings in the layout). A real navigation library takes into account many more cases such as text on the right, icons on either side, and long text that may bump into the title. Let's keep things simple and just handle the one case at hand.

The component function and styles should look like this:

image-feed/components/NavigationBar.js

```
export default function NavigationBar({
  title,
  leftText,
  onPressLeftText,
}) {
  return (
    <View style={styles.container}>
      <TouchableOpacity
        style={styles.leftText}
        onPress={onPressLeftText}
      >
        <Text>{leftText}</Text>
      </TouchableOpacity>
      <Text style={styles.title}>{title}</Text>
    </View>
  );
}
```

image-feed/components/NavigationBar.js

```
const styles = StyleSheet.create({
  container: {
    height: 40,
    borderBottomWidth: StyleSheet.hairlineWidth,
    borderBottomColor: 'rgba(0,0,0,0.1)',
    alignItems: 'center',
    justifyContent: 'center',
  },
  title: {
    fontWeight: '500',
  },
  leftText: {
    position: 'absolute',
    left: 20,
    top: 0,
    bottom: 0,
    justifyContent: 'center',
  },
});
```

Despite generally representing a numeric value, `fontWeight` must be a string!

We now have all of the building blocks we need: `CommentInput`, `CommentList`, and `NavigationBar`. Let's assemble them in a new screen.

Comments screen

Create a new file `Comments.js` within the `screens` directory.

Within our new screen, we'll want to render first the `NavigationBar`, then the `CommentInput`, and finally the `CommentList`. We want this screen to take 4 props:

- `comments` - The array of comments to display.
- `onClose` - A function prop to call when the user presses the close button.
- `onSubmitComment` - A function prop to call when the user adds a new comment.
- `style` - The style to apply to the top-level `View` of this screen (just like we did with `Feed`)

Add the following to `Comments.js`:

image-feed/screens/Comments.js

```
import { SafeAreaView, ViewPropTypes } from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

import CommentInput from '../components/CommentInput';
import CommentList from '../components/CommentList';
import NavigationBar from '../components/NavigationBar';

export default function Comments({
  style,
  comments,
  onClose,
  onSubmitComment,
}) {
  return (
    <SafeAreaView style={style}>
      <NavigationBar
        title="Comments"
        leftText="Close"
        onPressLeftText={onClose}
      />
      <CommentInput
        placeholder="Leave a comment"
        onSubmit={onSubmitComment}
      />
      <CommentList items={comments} />
    </SafeAreaView>
```

```
  );
}

Comments.propTypes = {
  style: ViewPropTypes.style,
  comments: PropTypes.arrayOf(PropTypes.string).isRequired,
  onClose: PropTypes.func.isRequired,
  onSubmitComment: PropTypes.func.isRequired,
};

Comments.defaultProps = {
  style: null,
};
```

The code for our screen is fairly simple, since we already built the different parts of the UI as individual components.

Putting it all together

Now we need to allow navigation from the `Feed` screen we made earlier with this new `Comments` screen.

We want the `Comments` screen to slide up and cover the entire screen, so we'll use the built-in `Modal` component.

`Modal`

The `Modal` component lets us transition to an entirely different screen. This is most useful for simple apps, since for complex apps you'll likely be using a navigation library which will come with its own way of doing modals.

Common `props` include:

- **`animationType`** - This controls how the modal animates in and out. One of `'none'`, `'slide'`, or `'fade'` (defaults to `'none'`).

- **`onRequestClose`** - A function called when the user taps the Android back button.
- **`onShow`** - A function called after the modal is fully visible.
- **`transparent`** - A bool determining whether the background of the modal is transparent.
- **`visible`** - A bool determining whether the modal is visible or not.

The `visible` prop is the most important, since this lets us show and hide the `Modal`.

Adding `Modal` to `App`

We'll maintain the state of the `Modal` in the `state` of our `App` component. We'll use the `visible` prop of the `Modal` component to show and hide it, so we'll want to store a boolean `showModal` in `state`. We'll also want to store the `id` of the image we're viewing comments for, so we'll store `selectedItemId` in `state` too. And we'll want to store the actual text for the comments we type in, so let's create an object that maps from an image `id` to an array of comment strings. Let's update the `state` in `App.js` to look like this:

image-feed/App.js

```
  state = {
    commentsForItem: {},
    showModal: false,
    selectedItemId: null,
  };
```

Next, we'll make two function properties on our `App` component, for updating `state` in order to open and close the `Modal`.

image-feed/App.js

```
  openCommentScreen = id => {
    this.setState({
      showModal: true,
      selectedItemId: id,
    });
  };

  closeCommentScreen = () => {
    this.setState({
      showModal: false,
      selectedItemId: null,
    });
  };
```

Notice that our `openCommentScreen` function takes the `id` of the image we want to display comments for. We'll need to call this function from within the `CardList` in order pass that `id`. Then we'll propagate the value through `Feed` and up to `App`. Save `App.js` and let's head over to `CardList.js` to make this possible.

Updating `CardList` with comments

We want the "Comments" link on each card to open the `Modal` we just created:

To do this, let's tweak our `CardList` component, adding an `onPressComments` prop (which we can use to call `openCommentScreen`) and a `commentsForItem` prop (which we can use to display the number of comments per image).

image-feed/components/CardList.js

```
// ...

export default class CardList extends React.Component {
  static propTypes = {
    items: PropTypes.arrayOf(
      PropTypes.shape({
        id: PropTypes.number.isRequired,
        author: PropTypes.string.isRequired,
      }),
    ).isRequired,
    commentsForItem: PropTypes.objectOf(
      PropTypes.arrayOf(PropTypes.string),
    ).isRequired,
    onPressComments: PropTypes.func.isRequired,
  };

  // ...
}

// ...
```

Let's call `onPressComments` from within `renderItem`, passing the `id` of the item so that we know which image to display comments for.

image-feed/components/CardList.js

```
  renderItem = ({ item: { id, author } }) => {
    const { commentsForItem, onPressComments } = this.props;
    const comments = commentsForItem[id];

    return (
      <Card
        fullname={author}
        image={{
          uri: getImageFromId(id),
```

```
        }}
        linkText={`${comments ? comments.length : 0} Comments`}
        onPressLinkText={() => onPressComments(id)}
      />
    );
  };
```

There's one small problem with our `CardList` so far: the count of comments we use for the `linkText` won't immediately update when we add new comments. This is due to how the `FlatList` decides whether or not to re-render items; the `FlatList` will only re-render an item when the `data` prop changes or when scrolling. In this case, we pass the `items` prop of `CardList` into the `data` prop of `FlatList`, but our `commentsForItem` prop doesn't cause the `items` array to change, so the `FlatList` won't update when new comments are added. We can use the prop `extraData` of `FlatList` to inform the `FlatList` that it should monitor another source of input data for changes.

Let's update the `render` method within `CardList`, passing `commentsForItem` as the `extraData` prop of `FlatList`.

image-feed/components/CardList.js

```
// ...
  const { items, commentsForItem } = this.props;

  return (
    <FlatList
      data={items}
      renderItem={this.renderItem}
      keyExtractor={keyExtractor}
      extraData={commentsForItem}
    />
  );

// ...
```

Save `CardList.js`. This will put your app in an error state, since `CardList` isn't currently being passed a `commentsForItem` prop.

Let's fix that!

Updating `Feed` with comments

Open `Feed.js`. We need to accept `commentsForItem` and `onPressComments` here too, and pass them into `CardList`.

Update the `propTypes`:

image-feed/screens/Feed.js

```
  static propTypes = {
    style: ViewPropTypes.style,
    commentsForItem: PropTypes.objectOf(
      PropTypes.arrayOf(PropTypes.string),
    ).isRequired,
    onPressComments: PropTypes.func.isRequired,
  };
```

And update the `render` method:

image-feed/screens/Feed.js

```
render() {
  const { commentsForItem, onPressComments, style } = this.props;

  // ..

  return (
    <SafeAreaView style={style}>
      <CardList
        items={items}
        commentsForItem={commentsForItem}
        onPressComments={onPressComments}
      />
    </SafeAreaView>
  );
}

// ...
```

Save `Feed.js`. You should still see the same error message, since we're still not passing a value for `commentsForItem` into `Feed`.

Updating `App` with comments

Let's head back to `App.js` to connect these new `props` we've just added to `Feed` and to render the screen.

Import the `Modal` component and our `Comments` component:

image-feed/App.js

```
import { Modal, Platform, StyleSheet, View } from 'react-native';

// ...

import Comments from './screens/Comments';
```

Then update the `render` method to render `Comments` and update `Feed` with new props:

image-feed/App.js

```
// ...

export default class App extends React.Component {
  // ...

  render() {
    const { commentsForItem, showModal, selectedItemId } = this.state;

    return (
      <View style={styles.container}>
        <Feed
          style={styles.feed}
          commentsForItem={commentsForItem}
          onPressComments={this.openCommentScreen}
        />
        <Modal
          visible={showModal}
          animationType="slide"
          onRequestClose={this.closeCommentScreen}
```

```
        >
          <Comments
            style={styles.container}
            comments={commentsForItem[selectedItemId] || []}
            onClose={this.closeCommentScreen}
            // ...
          />
        </Modal>
      </View>
    );
  }
}

// ...
```

We'll also add one new style for the comments screen:

image-feed/App.js

```
// ...

const styles = StyleSheet.create({
  // ...
  comments: {
    flex: 1,
    marginTop:
      Platform.OS === 'ios' && platformVersion < 11
        ? Constants.statusBarHeight
        : 0,
  },
});
```

Like before, we need to handle iOS versions below 11 separately by adding a top margin. Modals naturally sit below the status bar on Android, so we only need a top margin on iOS in this case.

After saving `App.js`, you'll be able to open and close the `Comments` screen! Tap any `"Comments"` link to open it, and tap the `"Close"` button in the `NavigationBar` to close it.

There should still be a warning about a missing `onSubmitComment` prop. Let's add that next.

Adding new comments

Now that we can access our new `Comments` screen, we'll want to be able to type new comments.

Let's create a function property `onSubmitComment` on our `App` component for saving a new comment into the `commentsForItem` object in our state. Since our `commentsForItem` object should be immutable (it's part of state), we'll create a new object and copy over the existing keys and values using the `...` object spread syntax. For our `selectedItemId`, we'll either update the comments array within `commentsForItem`, copying over existing comments with the `...` array spread syntax, or we'll create a new array if this is the first comment.

image-feed/App.js

```
// ...

onSubmitComment = (text) => {
  const { selectedItemId, commentsForItem } = this.state;
  const comments = commentsForItem[selectedItemId] || [];

  const updated = {
    ...commentsForItem,
    [selectedItemId]: [...comments, text],
  };

  this.setState({ commentsForItem: updated });
};

// ...
```

Since we're creating a new `commentsForItem` object, when we end up passing it into `Feed`, the `Feed` will pass it to the `FlatList` as `extraData`, triggering a re-render (updating the `"0 Comments"` text).

Computed property names

When defining object literals, we can dynamically compute property names by putting array brackets around the property name. For example:

```
const name = 'foo';
const obj = { [name]: 'bar' };

console.log(obj.foo); // => 'bar'
```

This is roughly equivalent to:

```
const name = 'foo';
const obj = {};
obj[name] = 'bar';
```

Computed property names are convenient in cases like the above example, where we want the object literal to have property names based on dynamic values.

The last step for typing new comments is to pass the `onSubmitComment` function to the `Comments` component when rendering:

image-feed/App.js

```
// ...

return (
  <View style={styles.container}>
    <Feed
      style={styles.feed}
      commentsForItem={commentsForItem}
      onPressComments={this.openCommentScreen}
    />
```

```
    <Modal
      visible={showModal}
      animationType="slide"
      onRequestClose={this.closeCommentScreen}
    >
      <Comments
        style={styles.comments}
        comments={commentsForItem[selectedItemId] || []}
        onClose={this.closeCommentScreen}
        onSubmitComment={this.onSubmitComment}
      />
    </Modal>
  </View>
);

// ...
```

Save `App.js`, then go ahead and play around with the app for a bit! You should be able to tap the "0 Comments" text at the top right of each image to open up the `Modal` containing the `Comments` screen. You should be able to type new comments and see them appear in the list of comments. When you close the `Modal`, you should see the number of comments has increased for the image you chose.

Bonus: Persisting comments to device storage

You may have noticed that any comments you added will disappear if you reload the app. This is because we don't save them anywhere.

As an optional final step, we can persist the comments we write to the device via the `AsyncStorage` API. `AsyncStorage` is a simple key-value store provided by React Native for storing small quantities of string data (which we usually serialize as JSON). Like the name implies, saving and reading from this store both happen asynchronously. We can call `AsyncStorage.getItem(key)` and `AsyncStorage.setItem(key, value)` to store and retrieve a string `value` using a string `key`.

In `App.js`, we'll first need to import `AsyncStorage`:

image-feed/App.js

```
import {
  AsyncStorage,
  Modal,
  Platform,
  StyleSheet,
  View,
} from 'react-native';
```

Then we'll define an arbitrary key for persisting our comments object as JSON:

image-feed/App.js

```
const ASYNC_STORAGE_COMMENTS_KEY = 'ASYNC_STORAGE_COMMENTS_KEY';
```

Then we'll update our `componentDidMount` and `onSubmitComment` to save and read from `AsyncStorage`, respectively. Since we can only store string values using `AsyncStorage`, if we want to store a complex object, we'll have to serialize it to `JSON` first. To do this, we can call `JSON.stringify` before storing values and `JSON.parse` after retreiving them.

We'll load all comments into `state` when our `App` mounts:

image-feed/App.js

```
  async componentDidMount() {
    try {
      const commentsForItem = await AsyncStorage.getItem(
        ASYNC_STORAGE_COMMENTS_KEY,
      );

      this.setState({
        commentsForItem: commentsForItem
          ? JSON.parse(commentsForItem)
          : {},
      });
    } catch (e) {
```

```
      console.log('Failed to load comments');
    }
  }
```

Then we'll update the stored comments anytime we add a new comment by modifying `onSubmitComment`:

```
// ...

onSubmitComment = async text => {
  const { selectedItemId, commentsForItem } = this.state;
  const comments = commentsForItem[selectedItemId] || [];

  const updated = {
    ...commentsForItem,
    [selectedItemId]: [...comments, text],
  };

  this.setState({ commentsForItem: updated });

  try {
    await AsyncStorage.setItem(
      ASYNC_STORAGE_COMMENTS_KEY,
      JSON.stringify(updated),
    );
  } catch (e) {
    console.log(
      'Failed to save comment',
      text,
      'for',
      selectedItemId,
    );
  }
};
// ...
```

Note that `getItem` and `setItem` both return promises that can fail (e.g. when disk I/O fails), so we need to use `async/await` and wrap the calls in `try/catch`.

That's all we had to do to persist comments to disk! Now when you write comments and reload the app, they'll still be there. Give it a shot!

Wrapping up

Many of the built-in components we've covered in this chapter are highly generic and resusable: `View`, `Text`, `Image`, `ScrollView`, and `FlatList`. The bulk of the UI in most apps will be written with a combination of these components.

We covered a few other components which are for more specialized use cases, like `ActivityIndicator`, `TextInput`, and `Modal`. There are many more components like this which we didn't cover.

You don't need to memorize every built-in React Native component – in fact, there are some components you'll probably never need. The important thing is: you now have a strong foundation in *how* React Native works, so you'll be able to figure out how to use any built-in component just by reading the docs.

UI components are a huge part of what React Native has to offer. However, most apps need more than just UI components. There's another big part of React Native which we touched on in this chapter: imperative APIs. These are APIs (like `AsyncStorage`) which we can call from the component lifecycle to fetch data, access the camera roll, query our geolocation, etc. In the next chapter, we'll explore some of the most common React Native APIs.

Core APIs, Part 1

So far we've primarily used React components to interact with the underlying native APIs – we've used components like `View`, `Text`, and `Image` to create native UI elements on the screen.

React provides a simple, consistent interface for APIs which create visual components. Some APIs don't create UI components though: for example, accessing the Camera Roll, or querying the current network connectivity of the device.

React Native also comes with APIs for interacting with these non-visual native APIs. In contrast with components, these APIs are generally *imperative* functions: we must call them explicitly at the right time, rather than returning something from a component's `render` function and letting React call them later. React Native simply provides us a JavaScript wrapper, often cross-platform, for controlling the underlying native APIs.

Building a messaging app

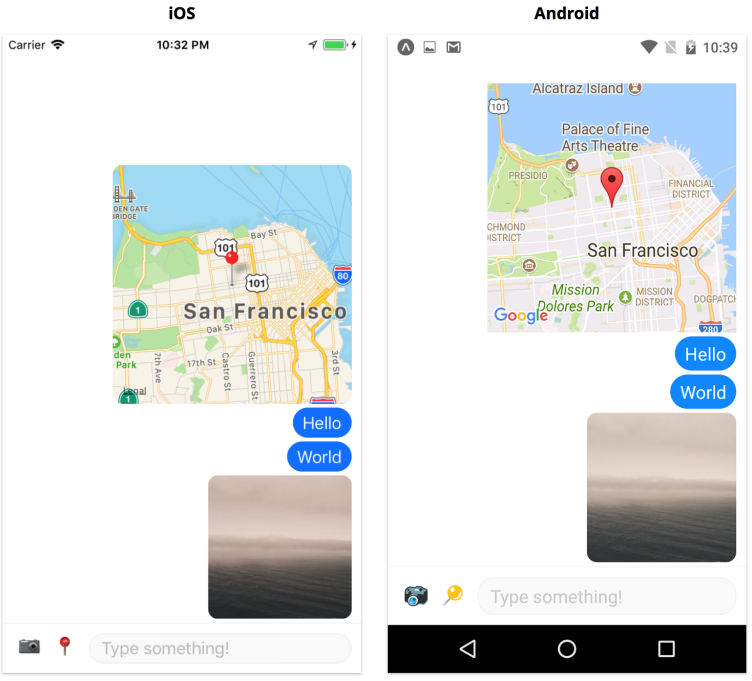
In this chapter, we'll build the start of a messaging app (similar to iMessage) that gives us a tour of some of the most common core APIs. Our app will let us send text, send photos from the camera roll, and share our location. It will let us know when we are disconnected from the network. It will handle keyboard interactions and the back button on Android.

To try the completed app:

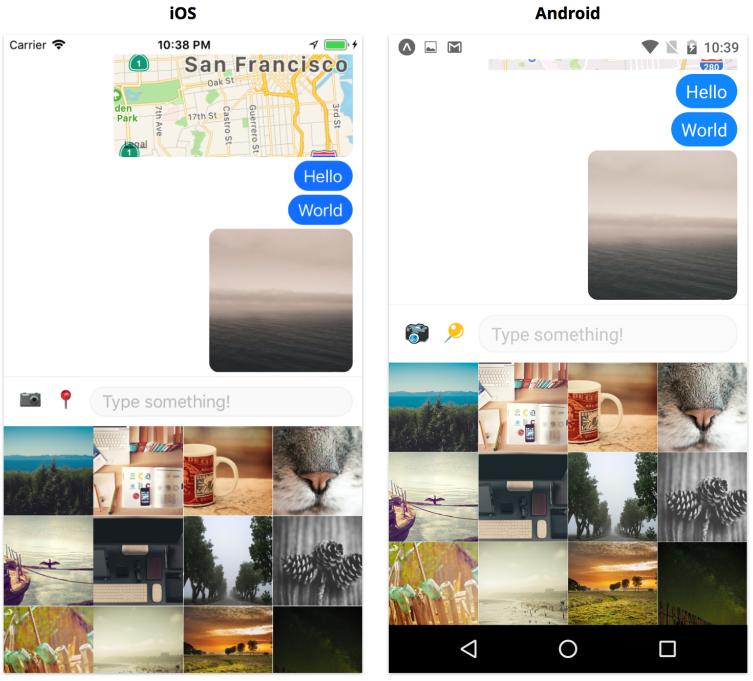
- On Android, you can scan the following QR code from within the Expo app:

- On iOS, you can navigate to the `messaging/` directory within our sample code folder and build the app. You can either preview it using the iOS simulator or send the link of the project URL to your device as we mentioned in the first chapter.

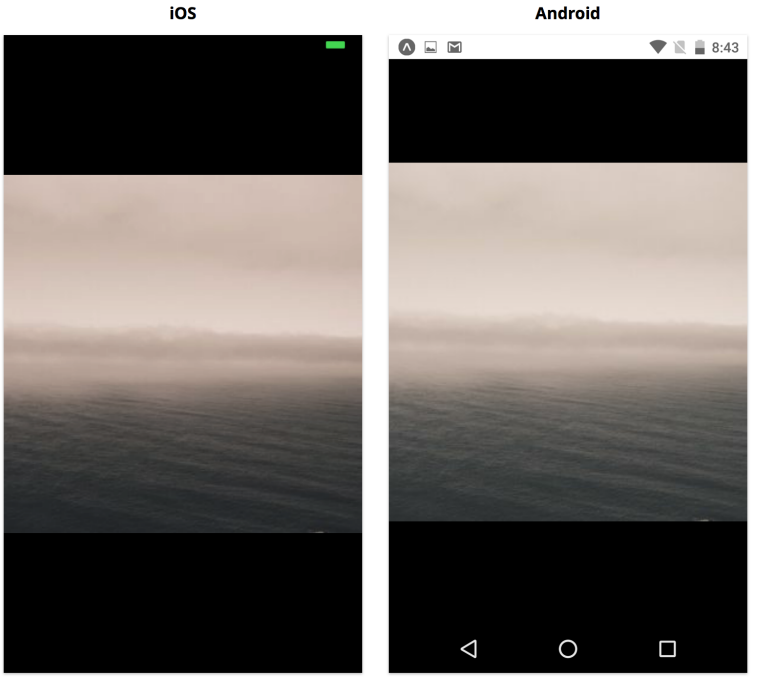
We can send text messages, images, and maps:



We can choose images from our device camera roll:



And we can view images fullscreen:



We'll use the following APIs:

- `Alert` - Displays modal dialog windows for simple user input
- `BackHandler` - Controls the back button on Android
- `CameraRoll` - Returns images and videos stored on the device
- `Dimensions` - Returns the dimensions of the screen
- `Geolocation` - Returns the location of the device, and emits events when the location changes
- `Keyboard` - Emits events when the keyboard appears or disappears
- `NetInfo` - Returns network connectivity information, and emits events when the connectivity changes
- `PixelRatio` - Translates from density-independent pixels to density-dependent pixels (more detail on this later)
- `StatusBar` - Controls the visibility and color of the status bar

We'll just be focusing on the UI, so we won't *actually* send messages, but we could connect the UI we build to a backend if we wanted to use it in a production app.

Initializing the project

Just as we did in the previous chapters, let's create a new app with the following command:

```
$ expo init messaging --template blank@sdk-33 --yarn
```

Once this finishes, navigate into the `messaging` directory.

In this chapter we'll create the `utils` directory ourselves, so there's no need to copy over the sample code. We do however want to install a few additional node modules. Install `expo-constants`, `expo-permissions`, and `react-native-maps` using the following command:

```
$ yarn add expo-constants expo-permissions react-native-maps
```

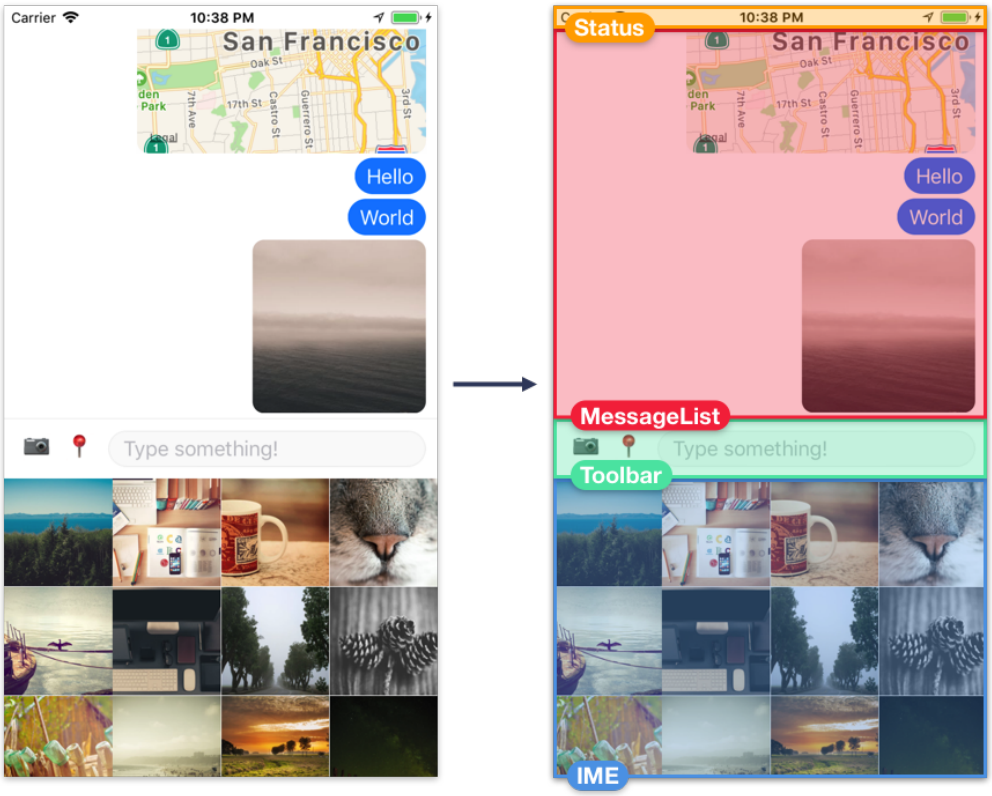
The app

Let's start by setting up the skeleton of the app. We'll do this in `App.js`. After that, we'll build out the different parts of the screen, one component at a time. We'll tackle keyboard handling last, since that's the most difficult and intricate.

We'll follow the same general process as in the previous chapters: we'll start by breaking down the screen into components, building a hardcoded version, adding state, and so on.

The app's skeleton

If we look at the app from top to bottom, these are the main sections of the UI:



- **`Status`** - The device generally renders a *status bar*, the horizontal strip at the top of the screen that shows time, battery life, etc – but in this case, we'll augment it to show network connectivity more prominently. We'll create our own component, `Status`, which renders beneath the device's status bar.
- **`MessageList`** - This is where we'll render text messages, images, and maps.
- **`Toolbar`** - This is where the user can switch between sending text, images, or location, and where the input field for typing messages lives.
- Input Method Editor (IME) - This is where we can render a custom input method, i.e. sending images. We'll build an image picker component, **`ImageGrid`**, and use it here. Note that the keyboard is rendered natively by the operating system, so we will trigger the keyboard to appear and disappear at the right times, but we won't render it ourselves.

In this chapter we'll be building top-down. We'll start by representing the message list, the toolbar, and the IME with a placeholder `View`. By starting with a rough layout, we can then create components for each section, putting each one in its respective `View`. Each section will be made up of a few different components.

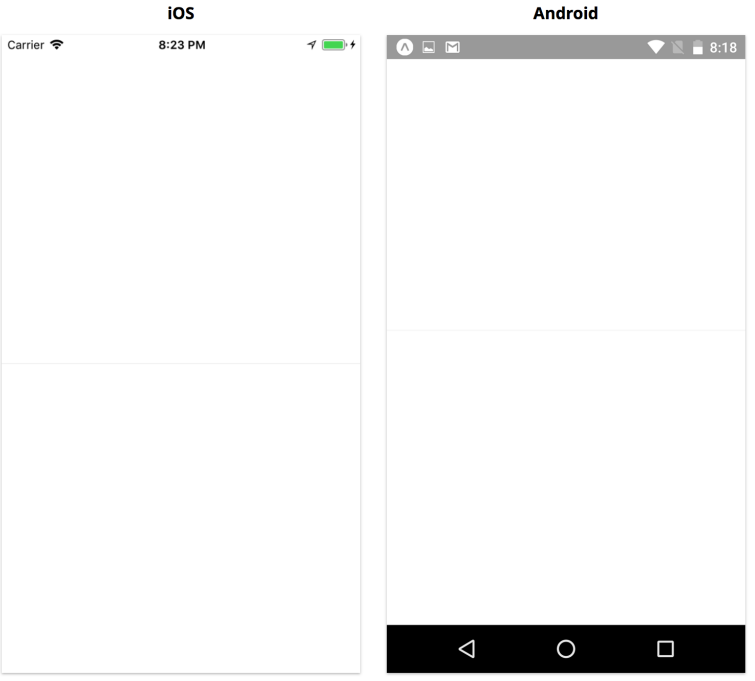
Open `App.js` and add the following skeleton:

messaging/App.js

```
import { StyleSheet, View } from 'react-native';
import React from 'react';

export default class App extends React.Component {
  renderMessageList() {
    return (
      <View style={styles.content}></View>
    );
  }

  renderInputMethodEditor() {
    return (
      <View style={styles.inputMethodEditor}></View>
    );
  }

  renderToolbar() {
    return (
      <View style={styles.toolbar}></View>
    );
  }

  render() {
    return (
      <View style={styles.container}>
        {this.renderMessageList()}
        {this.renderToolbar()}
        {this.renderInputMethodEditor()}
      </View>
```

```
    );
  }
}

const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: 'white',
  },
  content: {
    flex: 1,
    backgroundColor: 'white',
  },
  inputMethodEditor: {
    flex: 1,
    backgroundColor: 'white',
  },
  toolbar: {
    borderTopWidth: 1,
    borderTopColor: 'rgba(0,0,0,0.04)',
    backgroundColor: 'white',
  },
});
```

When you save `App.js`, the app should reload on your device and you'll see the following:

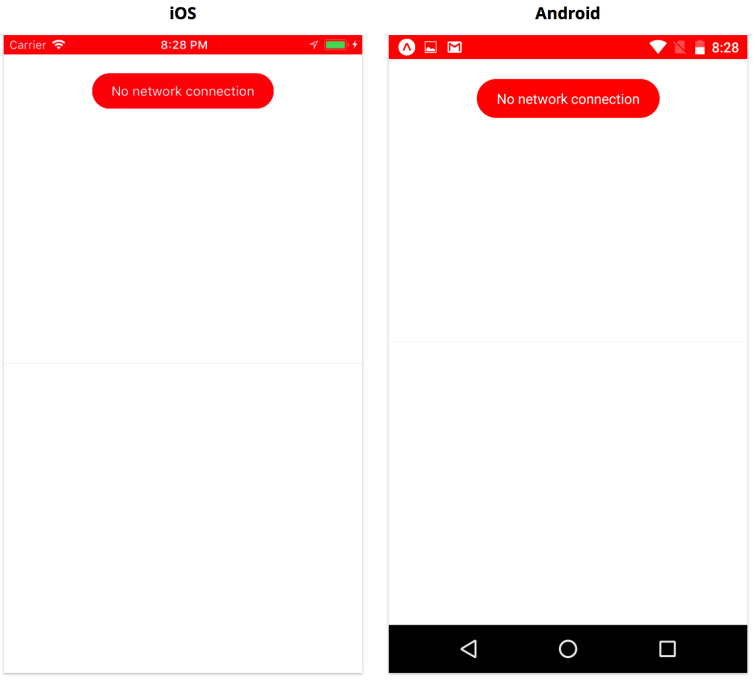


Awesome, a blank screen with a small gray line through the middle! Now we can start building out the different sections of the screen. The `App` component will orchestrate how data is populated, and when to hide or show the various input methods – but first, we need to start creating the different components in the UI.

Now's a good time to create a new directory, `components`, within our main `messaging` directory. We'll put the UI components we build in the `components` directory.

Network connectivity indicator

Since we're building a messaging app, network connectivity is relevant at all times. Let's let the user know when they've lost connectivity by turning the status bar red and displaying a short message.



`StatusBar`

Many apps display the default status bar, but sometimes we want to customize the style, e.g. turning the background red.

The status bar works a little differently on iOS and Android. On iOS the status bar background is always transparent, so we can render content behind the status bar text. On Android, we can set the status bar background to transparent, or to a specific solid color. If we use a transparent status bar, we can render content behind it just like on iOS – unlike on iOS, by default the status bar text is white and there's typically a semi-transparent black background. If we choose a solid color status bar, our app's content renders below the status bar, and the height of our UI will be a little smaller. In our app, we'll use a solid color status bar, since this will let us customize the color.

To use a solid color status bar, we need to open up `app.json` and add the following to the `expo` object (although you can skip this if you're not using an Android):

messaging/app.json

```
"expo": {
  // ...
  "androidStatusBar": {
    "barStyle": "dark-content",
    "backgroundColor": "#FFFFFF"
  }
}
```

Let's restart the packager with `npm run start` to make sure this change takes effect.

> If we had used `react-native init` instead of `expo init`, we wouldn't need to do this. Expo handles the status bar specially. You can check out the guide on configuring the status bar[56] for more detail.

On both platforms, we can set the status bar text color by using the built-in `StatusBar` component and passing a `barStyle` of either `light-content` (white text) or `dark-content` (black text).

There are two different ways we can use `StatusBar`: imperatively and as a component. In this example we'll use the component approach.

Create a new file `Status.js` in the `components` directory now.

`Status` styles

Let's first start with the background styles. We need to create a `View` that sits behind the text of the status bar – on iOS, rendering the background color of the status bar is our responsibility, since the operating system only renders the status bar text.

We'll have two visual states: one where the user is connected to the network, and one where the user is disconnected. We'll set the color for each state in `render`, so let's start with the base style for the status bar:

[56] https://docs.expo.io/versions/latest/guides/configuring-statusbar.html

messaging/components/Status.js

```
import Constants from 'expo-constants';
import { StyleSheet } from 'react-native';

// ...

const statusHeight =
  (Platform.OS === 'ios' ? Constants.statusBarHeight : 0);

const styles = StyleSheet.create({
  status: {
    zIndex: 1,
    height: statusHeight,
  },
  // ...
});
```

The base style `status` will give the `View` its height. The `View` will have the same height regardless of whether this component is in the connected or disconnected state. We use a `zIndex` of `1` to indicate that this `View` should be drawn on top of other content – this will be relevant later, since we're going to render a `ScrollView` beneath it.

Depending on the component's `state`, we'll then pass a style object containing a background color (in addition to passing the `status` style).

We'll store the network connectivity status in component `state` as `state.isConnected`. If `state.isConnected` is `true` then the device is connected to the internet, and if it's `false` then the device is disconnected. We'll set `isConnected` to true by default, since that's the most likely case, and since it would be a poor user experience to show a connectivity message when it's not needed.

Let's try rendering this background `View`.

messaging/components/Status.js

```
import Constants from 'expo-constants';
import {
  NetInfo,
  Platform,
  StatusBar,
  StyleSheet,
  Text,
  View,
} from 'react-native';
import React from 'react';

export default class Status extends React.Component {
  state = {
    isConnected: null,
  };

  // ...

  render() {
    const { isConnected } = this.state;

    const backgroundColor = isConnected ? 'white' : 'red';

    if (Platform.OS === 'ios') {
      return (
        <View style={[styles.status, { backgroundColor }]}></View>
      );
    }

    return null; // Temporary!
  }
}

// ...
```

Notice how we use an array for the `View` to apply two styles: the `status` style, and then a style object containing a different background color depending on whether we're connected to the network or not.

Let's save `Status.js` and import it from `App.js` so we can see what we have so far.

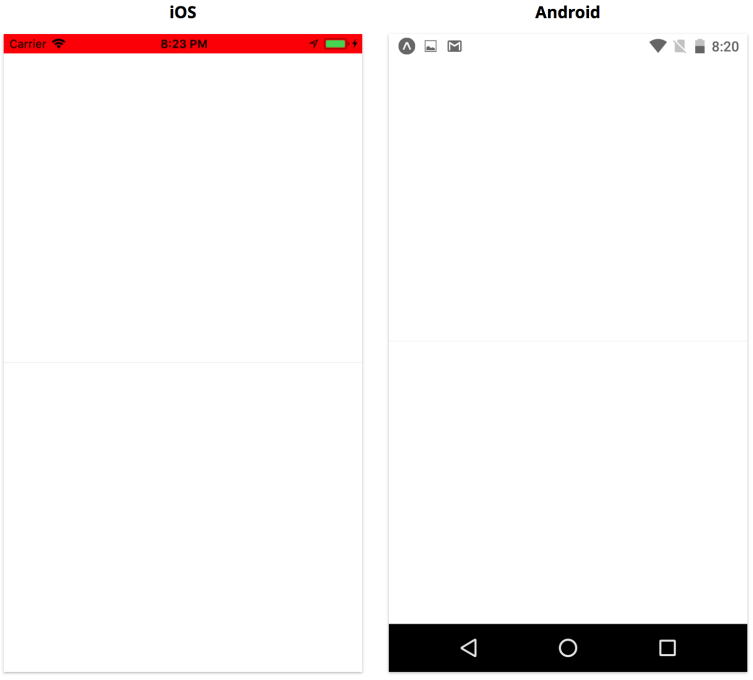
We can now go ahead and render our new `Status` component from `App`:

messaging/App.js

```
// ...

import Status from './components/Status';

export default class App extends React.Component {

  // ...

  render() {
    return (
      <View style={styles.container}>
        <Status />
        {this.renderMessageList()}
        {this.renderToolbar()}
        {this.renderInputMethodEditor()}
      </View>
    );
  }

  // ...

}

// ...
```

We shouldn't see anything yet... but to verify that everything is working, you can temporarily set `isConnected: 'false'` in the `state` of `Status`. This will show a red background behind the status bar text.

Doing this, we should see:



Using `StatusBar`

The black text on the red background doesn't look very good. This is where the `StatusBar` component comes in. Let's import it from `react-native` and render it within our `View`.

messaging/components/Status.js

```
import Constants from 'expo-constants';
import { StatusBar, StyleSheet, View } from 'react-native';
import React from 'react';

export default class Status extends React.Component {
  state = {
    isConnected: true,
  };

  // ...

  render() {
    const { isConnected } = this.state;

    const backgroundColor = isConnected ? 'white' : 'red';

    const statusBar = (
      <StatusBar
        backgroundColor={backgroundColor}
        barStyle={isConnected ? 'dark-content' : 'light-content'}
        animated={false}
      />
    );

    if (Platform.OS === 'ios') {
      return (
        <View style={[styles.status, { backgroundColor }]}>
          {messageContainer}
        </View>
      );
    }

    return null; // Temporary!
  }
}
```

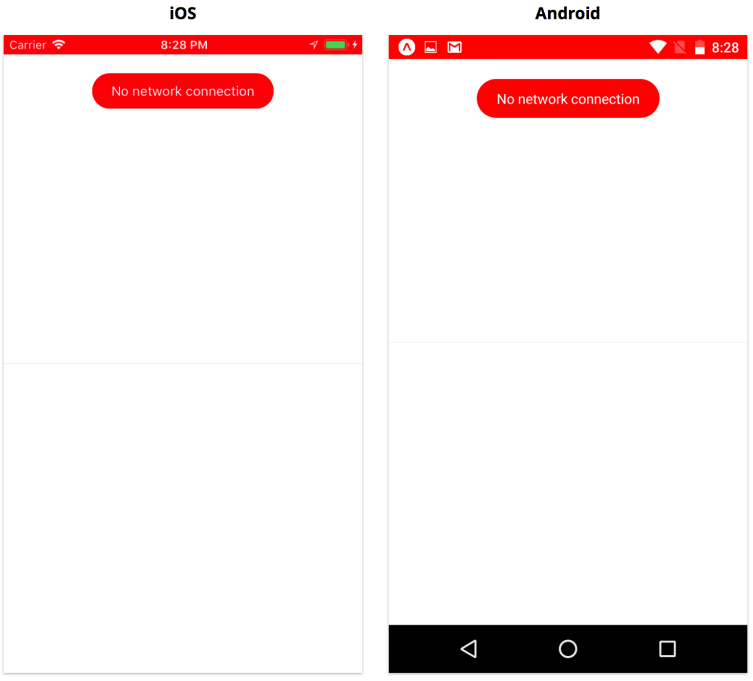
Here we set `barStyle` to `dark-content` if we're connected (black text on our white background) and `light-content` if we're disconnected (white text on our red background). We set `backgroundColor` to set the correct background color on Android. We also set `animated` to `false` – since we're not animating the background color on iOS, animating the text color won't look very good.

Note that the `StatusBar` component doesn't actually render the status bar text. We use this component to *configure* the status bar. We can render the `StatusBar` component anywhere in the component hierarchy of our app to configure it, since the status bar is configured globally.

We can even render `StatusBar` in multiple different components, e.g. we could render it from `App.js` in addition to `Status.js`. If we do this, the `props` we set as configuration are merged in the order the components mount. In practice it can be a bit hard to follow the mount order, so it may be easier to use the imperative API if you find yourself with many `StatusBar` components (more on this later).

Message bubble

Since the red status bar alone doesn't indicate anything about network connectivity, let's also add a short message in a floating bubble at the top of the screen.



If we're not connected to the network, we'll render a few more components. On Android, since we don't need to render the background behind the status bar, we can return just the message bubble components.

messaging/components/Status.js

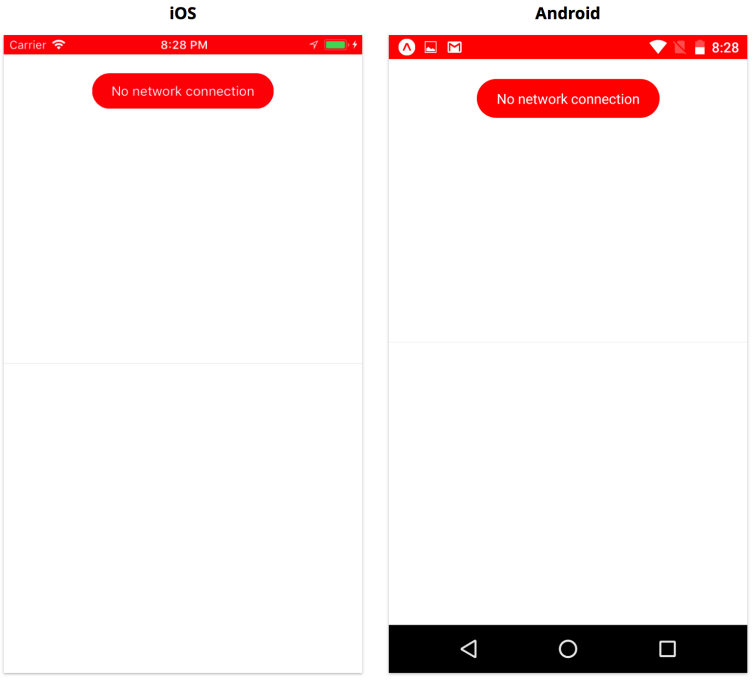
```
import Constants from 'expo-constants';
import {
  NetInfo,
  StatusBar,
  StyleSheet,
  Text,
  View
} from 'react-native';
import React from 'react';

export default class Status extends React.Component {
  // ...
```

```
  render() {
    const { isConnected } = this.state;

    const backgroundColor = isConnected ? 'white' : 'red';

    const statusBar = (
      <StatusBar
        backgroundColor={backgroundColor}
        barStyle={isConnected ? 'dark-content' : 'light-content'}
        animated={false}
      />
    );

    const messageContainer = (
      <View style={styles.messageContainer} pointerEvents={'none'}>
        {statusBar}
        {!isConnected && (
          <View style={styles.bubble}>
            <Text style={styles.text}>No network connection</Text>
          </View>
        )}
      </View>
    );

    if (Platform.OS === 'ios') {
      return (
        <View style={[styles.status, { backgroundColor }]}>
          {messageContainer}
        </View>
      );
    }

    return messageContainer;
  }
}
```

```
const styles = StyleSheet.create({
  // ...
  messageContainer: {
    zIndex: 1,
    position: 'absolute',
    top: statusHeight + 20,
    right: 0,
    left: 0,
    height: 80,
    alignItems: 'center',
  },
  bubble: {
    paddingHorizontal: 20,
    paddingVertical: 10,
    borderRadius: 20,
    backgroundColor: 'red',
  },
  text: {
    color: 'white',
  },
});
```

Here we use `absolute` position to precisely position the message bubble on top of the rest of the content we'll render, without pushing our other content out of the way. We use `pointerEvent={'none'}` so that this component doesn't prevent us from tapping the `ScrollView` we'll render underneath it. The `pointerEvents` prop allows us to control whether a component can respond to touch interactions, or whether they pass through to the components behind it.

Save `Status.js` and you should see the following.



Our connectivity indicator UI is looking good! Now it's time to hook it up to the device's real network connectivity state.

`NetInfo`

We have `isConnected` in `state`, and we have logic to switch between showing a connected and disconnected UI in our `render` method. Now we need to update this state whenever network connectivity changes. We can do this using the `NetInfo` APIs.

The `NetInfo` APIs are a good example of React Native core APIs: these provide a uniform interface to the lower level native APIs on iOS and Android. React Native is essentially providing JavaScript bindings and smoothing out platform differences for us.

We can call `NetInfo.isConnected.fetch()` to get the network connectivity status. `NetInfo.isConnected.fetch()` returns a promise which resolves to a boolean. If the

device is connected, the boolean value will be `true`. If the device isn't connected, the promise will still resolve, but with the value `false`.

If we wanted to update our UI when the network connection changes, we could continuously poll `NetInfo.isConnected.fetch()` to get the network status – but this would be inefficient. Instead, we can add an *event listener* to `NetInfo.isConnected`. `NetInfo.isConnected` provides the method `addEventListener`, which we can call with a *callback function*, which it will invoke each time the network status changes.

Here's an example of using `NetInfo.isConnected.addEventListener`:

```
const handler = (status) => {
  console.log('Network status changed', status);
};

NetInfo.isConnected.addEventListener('connectionChange', handler);
```

This example would log a new status each time the network connectivity changes. We can call `NetInfo.isConnected.removeEventListener('connectionChange', handler)` when we want to stop listening for changes – most of the time, we'll do this when our component unmounts.

For our app, we'll use both:

- `NetInfo.isConnected.fetch` and
- `NetInfo.isConnected.addEventListener`.

First we'll call `NetInfo.isConnected.fetch` when the `Status` component mounts to get the initial network connectivity.

Then we'll use `NetInfo.isConnected.addEventListener` to update our UI when a change occurs.

Let's add the following lines to our `Status` component in `Status.js`:

```
// ...

async componentWillMount() {
  NetInfo.isConnected.addEventListener(
    'connectionChange',
    this.handleChange,
  );

  const isConnected = await NetInfo.isConnected.fetch();

  this.setState({ isConnected });
}

componentWillUnmount() {
  NetInfo.isConnected.removeEventListener(
    'connectionChange',
    this.handleChange,
  );
}

handleChange = (isConnected) => {
  this.setState({ isConnected });
};

// ...
```

Now we receive both the initial status and handle connectivity changes.

Note that we declared `componentWillMount` as an `async` method so that we can use `await` when calling `NetInfo.isConnected.fetch()`. Most of the React lifecycle methods can be declared with `async`, since React doesn't use the return value from these.

> To test changes in network connectivity without setting the device to airplane mode, we can add: `setTimeout(() => this.handleChange(false), 3000);` to the end of `componentWillMount`. This way we can observe the transition from our initial state (probably `true`) to the disconnected state.

For reference, if we wanted to use the imperative approach to changing the status bar style, we would write our `handleChange` as:

```
handleChange = (isConnected) => {
  this.setState({ isConnected });
  StatusBar.setBarStyle(
    isConnected ? 'light-content' : 'dark-content'
  );
};
```

We would then remove the `<StatusBar ... />` component from our `render` function. The `StatusBar` component is a little unusual because it doesn't *actually render anything*. Under the hood, the `StatusBar` component just calls `StatusBar.setBarStyle` at the appropriate times. Calling the imperative APIs directly can be simpler than figuring out how and where to render `StatusBar` components in a complex app.

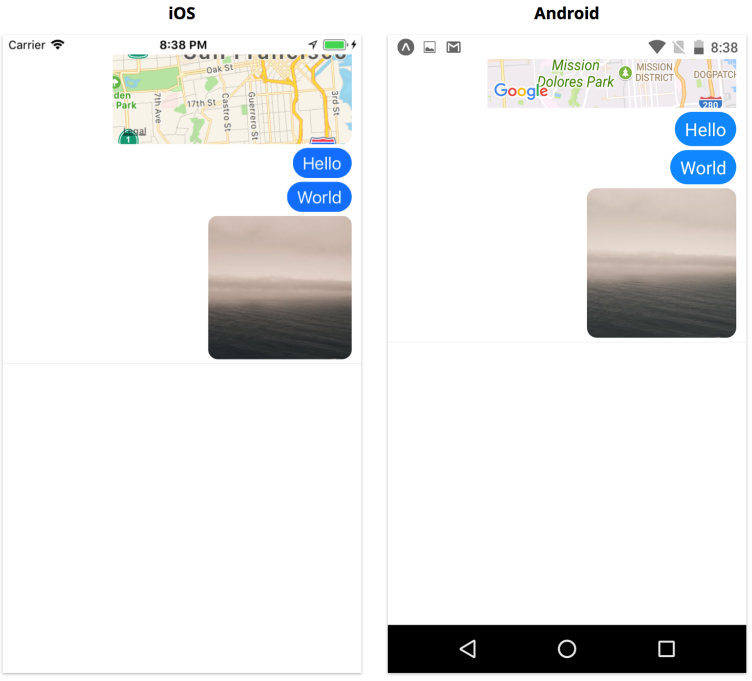
Wrapping up `StatusBar` and `NetInfo`

We're finished with the status bar and network connectivity indicator! We've just written a cross-platform UI that works on both iOS and Android, with only a little bit of platform-specific code.

For future improvements, we could consider animating the message bubble as it appears and disappears, and animating the status bar as it changes colors. We'll cover this kind of animation in more depth in a later chapter. For now, let's move on to the message list.

The message list

Let's create the message list. The message list will display a vertically scrolling list of text messages, image messages, and location messages. We should be able to tap the messages to potentially trigger other actions (e.g. view the image fullscreen).



We'll use the `FlatList` component we learned about in the previous chapter to handle rendering the list. In order to do that, we should first decide how we'll store our message objects.

`MessageUtils`

Let's first write a few utility functions for creating message objects so that we keep this logic separate from our rendering logic.

Create a new directory called `utils` in the `messaging` directory. Within `utils`, create a new file called `MessageUtils.js`.

Within `MessageUtils.js`, let's first define the shape of each message using `PropTypes.shape`. All of the messages we render will have a `type` and an `id`, and then some messages will have either a `text`, `uri`, or `coordinate` value, depending on the `type`.

Add the following to `MessageUtils.js`:

messaging/utils/MessageUtils.js

```
import PropTypes from 'prop-types';

export const MessageShape = PropTypes.shape({
  id: PropTypes.number.isRequired,
  type: PropTypes.oneOf(['text', 'image', 'location']),
  text: PropTypes.string,
  uri: PropTypes.string,
  coordinate: PropTypes.shape({
    latitude: PropTypes.number.isRequired,
    longitude: PropTypes.number.isRequired,
  }),
});
```

By using this `shape` in the `propTypes` of a component, React will automatically warn us if we accidentally pass invalid message data. Declaring our data models this way is also great for documentation purposes: if another developer reads our component, they'll know exactly what the input data should look like, without having to sprinkle `console.log` throughout the app and actually run it.

Declaring our data models this way is optional. For a model that will likely be used in many places throughout the app, it's probably worthwhile to spend the extra effort. It isn't as valuable for a model used within a single component, or a model that you're still iterating on during development. If you decide to use a strongly-typed variant of JavaScript, i.e. Flow or TypeScript, you'll likely declare your types elsewhere and won't need to also declare PropTypes.

Next, let's write a few utility functions for creating the different kinds of messages:

messaging/utils/MessageUtils.js

```
let messageId = 0;

function getNextId() {
  messageId += 1;
  return messageId;
}

export function createTextMessage(text) {
  return {
    type: 'text',
    id: getNextId(),
    text,
  };
}

export function createImageMessage(uri) {
  return {
    type: 'image',
    id: getNextId(),
    uri,
  };
}

export function createLocationMessage(coordinate) {
  return {
    type: 'location',
    id: getNextId(),
    coordinate,
  };
}
```

We created a utility `getNextId()` for getting a unique message `id`. It's important that we ensure uniqueness for each `id`, since we'll be using the `id` as the `key` when rendering these messages in a list.

> We would likely want to use a more sophisticated `id`, such as a UUID, if we were actually connecting with a backend. Incrementing a number works for our purposes, but once messages are persisted or coming from multiple devices, there would be `id` collisions.

By exporting `createTextMessage`, `createImageMessage`, and `createLocationMessage`, we can now easily create new messages of each type from elsewhere in our app. We'll use these messages to populate the `FlatList`.

`MessageList`

Our `MessageList` component will render an array of the message objects we defined in `MessageUtils`. We can determine how to render each message based on its `type`.

Let's start by determining the `propTypes` for this component. Here's a good opportunity to use the `MessageShape` we just defined. We'll also want to notify the parent component whenever a message in the list is pressed. We can do this using an `onPressMessage` function prop.

Create a new file, `MessageList.js`, in our `components` directory. Add the following to it:

messaging/components/MessageList.js

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

import { MessageShape } from '../utils/MessageUtils';

export default class MessageList extends React.Component {
  static propTypes = {
    messages: PropTypes.arrayOf(MessageShape).isRequired,
    onPressMessage: PropTypes.func,
  };

  static defaultProps = {
    onPressMessage: () => {},
  };
```

```
  // ...
}
```

By using our `MessageShape`, React will warn us if we're passed malformed data.

Now let's render our `messages` into a `FlatList`. Just as in the previous chapter, We need to use a `keyExtractor` to tell the `FlatList` how to find the unique `id` of our message objects.

Let's update `MessageList.js` to render a `FlatList`:

messaging/components/MessageList.js

```
import { FlatList, StyleSheet } from 'react-native';

// ...

const keyExtractor = item => item.id.toString();

export default class MessageList extends React.Component {
  // ...

  renderMessageItem = ({ item }) => {
    // ...
  };

  render() {
    const { messages } = this.props;

    return (
      <FlatList
        style={styles.container}
        inverted
        data={messages}
        renderItem={this.renderMessageItem}
        keyExtractor={keyExtractor}
        keyboardShouldPersistTaps={'handled'}
```

```
      />
    );
  }
}

const styles = StyleSheet.create({
  container: {
    flex: 1,
    overflow: 'visible', // Prevents clipping on resize!
  },
});
```

We looked at the `data`, `renderItem`, and `keyExtractor` props in the previous chapter. There are a few new props here that are worth looking at in more detail.

`inverted`

In a messaging app, we typically want new messages to appear at the bottom of the list. To accomplish this, we've added the `inverted` prop to our `FlatList`.

This "new-messages-at-the-bottom" behavior is difficult to achieve without using `inverted`. If we didn't use `inverted`, every time a new message is added, we would have to scroll to the bottom of the list by adding a `ref` to the list and calling the `scrollToEnd` method. While it may sound relatively simple, it quickly gets complicated when we start adding asynchronous animations, e.g. in response to the keyboard appearing. Since `ScrollView` doesn't support `inverted`, we almost always want to use a `FlatList` for this.

Behind-the-scenes, our `FlatList` is vertically inverted using a `transform` style, and then each row within the list is also vertically inverted. Since rows are *doubly* inverted, they appear right-side-up. Pretty clever!

`keyboardShouldPersistTaps`

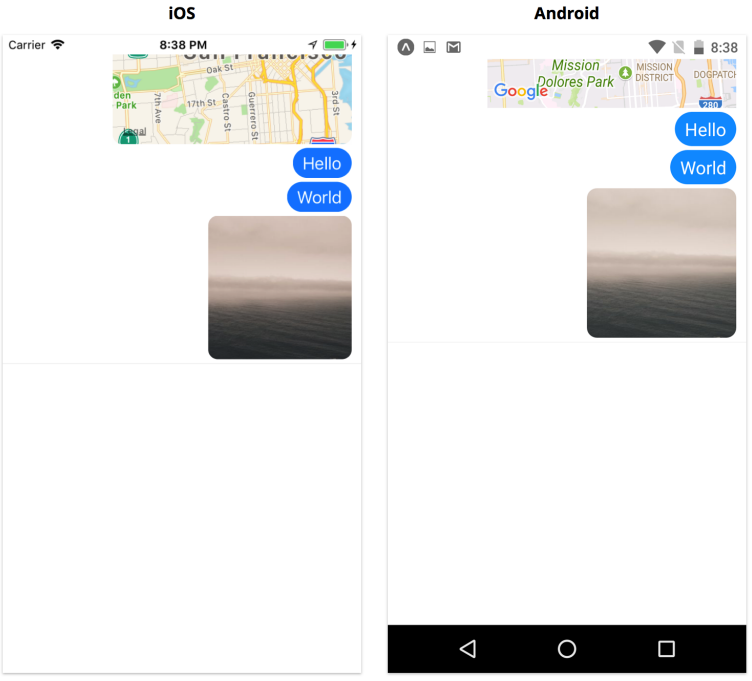
We use the `keyboardShouldPersistTaps` prop to configure what happens when we tap the `FlatList`. This prop has three possible options:

- `never` - Tapping the list will dismiss the keyboard and blur any focused elements. This is the default behavior.
- `always` - Tapping the list will have no effect on the keyboard or focus.
- `handled` - Tapping the list will dismiss the keyboard, *unless* the tap is handled by a child element first (e.g. tapping a message within the list). We want `handled`, so that we enable tapping messages without dismissing the keyboard.

We add `overflow: 'visible'` to the style of the `FlatList` to prevent content from getting clipped during animations. When an animation causes the list to resize to a smaller size, the content within it will be clipped to the smaller size instantly, while the list itself resizes gradually. If we don't include this line, some content will get clipped at the start of the animation that should actually be clipped at the end. It'll be easier to understand why this is necessary after we're a bit further along. You can comment out this property and observe the difference in behavior as the keyboard appears.

Rendering messages

We've successfully set up a scrolling list, so now we can populate it with messages. As a reminder, this is what we're aiming to build:



Let's start with the styles. Conceptually, each message is a row in the list, so let's call our top-level message style `messageRow` and give it `flexDirection: 'row'`. We want to align messages to the right using `justifyContent: 'flex-end'`, but leave a little space on the left with `marginLeft: 60` in case our message gets long. Text messages should appear in blue bubbles: this is what `messageBubble` is for.

messaging/components/MessageList.js

```
const styles = StyleSheet.create({
  container: {
    flex: 1,
    overflow: 'visible', // Prevents clipping on resize!
  },
  messageRow: {
    flexDirection: 'row',
    justifyContent: 'flex-end',
    marginBottom: 4,
    marginRight: 10,
```

```
    marginLeft: 60,
  },
  messageBubble: {
    paddingVertical: 5,
    paddingHorizontal: 10,
    backgroundColor: 'rgb(16,135,255)',
    borderRadius: 20,
  },
  text: {
    fontSize: 18,
    color: 'white',
  },
  image: {
    width: 150,
    height: 150,
    borderRadius: 10,
  },
  map: {
    width: 250,
    height: 250,
    borderRadius: 10,
  },
});
```

Feel free to experiment with other styles. There are a lot of ways to customize a messaging app to give it a unique look.

Let's move on to `renderMessageItem` and begin using the styles we just created. We can start by updating our imports to include all of the components we'll render from `MessageList`:

```
import { FlatList, Image, StyleSheet, Text, TouchableOpacity, View } fr\
om 'react-native';
import MapView from 'react-native-maps';
```

Here we'll use `MapView` for the first time. You'll notice we import this from `Expo`, rather than from React Native. `MapView` comes from the 3rd party module:

`react-native-maps`,

which `Expo` includes by default. If we had created our app via `react-native-cli` rather than `expo init`, we would have to remember to install and link `react-native-maps`.

If you're running an Android emulator, you'll need the Google Play Services installed to actually see a `MapView` (otherwise you'll see a placeholder label). You can create an emulator from Android Studio with this, but it can be difficult to connect it to Expo. If you don't know how to do this already, we recommend testing on a real Android device if possible.

React Native used to include a built-in `MapView`, but this has been removed in favor of `react-native-maps`. The `react-native-maps` module quickly became the de-facto standard for using maps in React Native, obsoleting the original built-in version.

Then let's add the following:

messaging/components/MessageList.js

```
// ...

renderMessageItem = ({ item }) => {
  const { onPressMessage } = this.props;

  return (
    <View key={item.id} style={styles.messageRow}>
      <TouchableOpacity onPress={() => onPressMessage(item)}>
        {this.renderMessageBody(item)}
```

```
      </TouchableOpacity>
    </View>
  );
};

renderMessageBody = ({ type, text, uri, coordinate }) => {
  // ...
}

// ...
```

Just as in the previous chapters, we use the `id` of the item as the `key` of the top-level element we return, so React can keep track of existing items. Without this, React would have to re-render all items when we add more, since it wouldn't know which items are old and which are new.

We want each message to be tappable, so we wrap the message body in a `TouchableOpacity`, and call `onPressItem` with the `item` object when tapped.

Finally, we call `this.renderMessageBody` with the `item` (our message), where we'll render the body of each message. We'll switch on the `type` of the message to decide what to render.

messaging/components/MessageList.js

```
export default class MessageList extends React.Component {
  // ...

  renderMessageBody = ({ type, text, uri, coordinate }) => {
    switch (type) {
      case 'text':
        return (
          <View style={styles.messageBubble}>
            <Text style={styles.text}>{text}</Text>
          </View>
        );
      case 'image':
        return <Image style={styles.image} source={{ uri }} />;
```

```
      case 'location':
        return (
          <MapView
            style={styles.map}
            initialRegion={{
              ...coordinate,
              latitudeDelta: 0.08,
              longitudeDelta: 0.04,
            }}
          >
            <MapView.Marker coordinate={coordinate} />
          </MapView>
        );
      default:
        return null;
    }
  };

  // ...
}
```

Each type of message, `text`, `image`, and `location` has a different kind of UI. Most of the components we used for `text` and `image` should look pretty familiar.

For `location` messages, we use a `MapView`. The `MapView` API is fairly advanced, allowing custom drawing and animations on top of maps. We'll use the `initialRegion` to supply a bounding box to display on the map, and we'll create a `MapView.Marker` to drop a pin at the `coordinate` in the message. You can read more about the `MapView` API in the official docs for react-native-maps[57].

We now have a scrollable, tappable list of messages that supports different kinds of content. Let's test it out.

Adding `MessageList` to `App`

To test our new `MessageList` component, we can render it from within the method:

[57] https://github.com/airbnb/react-native-maps

`renderMessageList` of `App.js`.

Heading back to `App.js` now, we'll need to import our new `MessageList` component and our utility functions for creating messages:

messaging/App.js

```
// ...

import MessageList from './components/MessageList';
import {
  createImageMessage,
  createLocationMessage,
  createTextMessage,
} from './utils/MessageUtils';

//...
```

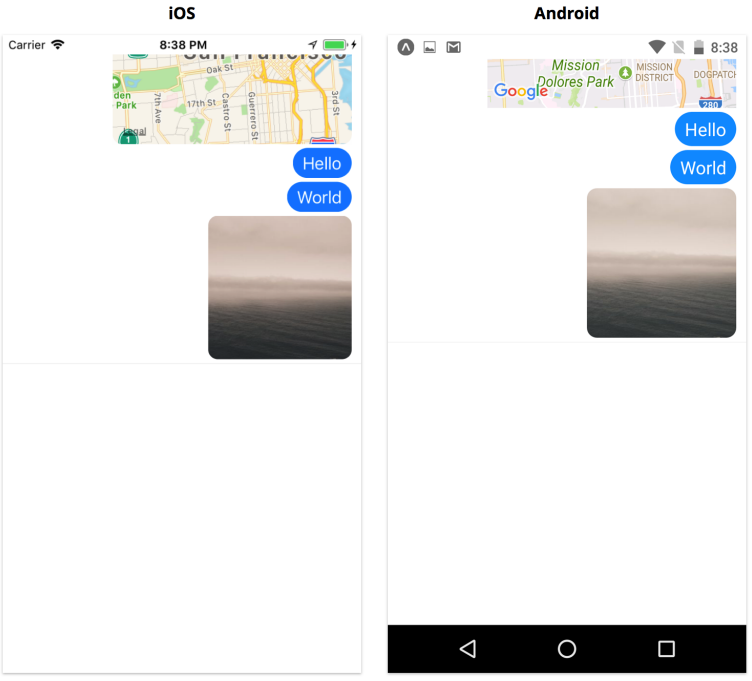
We can use these utility functions to create a few sample messages in the initial `state` of our app:

messaging/App.js

```
// ...

state = {
  messages: [
    createImageMessage('https://unsplash.it/300/300'),
    createTextMessage('World'),
    createTextMessage('Hello'),
    createLocationMessage({
      latitude: 37.78825,
      longitude: -122.4324,
    }),
  ],
};

handlePressMessage = () => {}
```

```
renderMessageList() {
  const { messages } = this.state;

  return (
    <View style={styles.content}>
      <MessageList
        messages={messages}
        onPressMessage={this.handlePressMessage}
      />
    </View>
  );
}

// ...
```

We've now hooked up the hardcoded message data with our `MessageList` component. We also added a placeholder `handlePressMessage` for handling tapping messages. When you save `App.js`, if everything is working correctly, here's what you should see:



We're successfully rendering our message list! We can display messages of different types and our new messages appear at the bottom, just like we'd expect from a messaging app.

At this point, we have the prop `onPressMessages` set to the empty function:

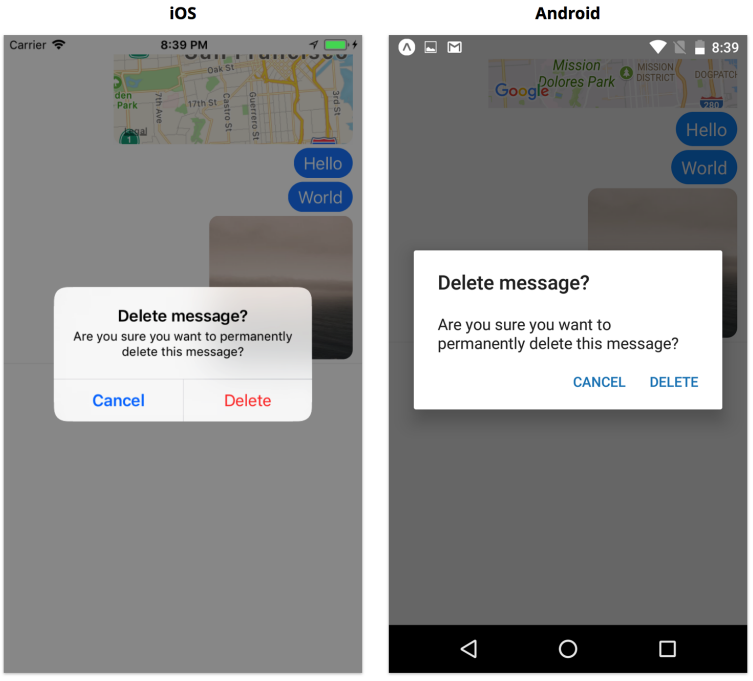
`handlePressMessage`.

Let's hook up a few different actions to `onPressMessages`.

`Alert`

The first action we'll add is to `text` messages. We'll add a "delete" feature: when the user taps a text message, we'll give the user the option to delete that message. We'll present a dialog with two choices: delete and cancel.

We can use the `Alert.alert` API to present the user with a native dialog window for making this choice.



Alert dialogs are commonly used for asking simple "yes or no" questions. The text and quantity of buttons are configurable.

Alert dialogs can also be used for debugging. Sometimes it can be easier to pop open an alert dialog than tracking down a `console.log` message.

The full method signature is `Alert.alert(title, message?, buttons?, options?, type?)`:

- `title` - A string, shown in a large bold font, at the top of the dialog
- `message` - A string, typically longer, shown in a normal weight font below the `title`
- `buttons` - An array of objects containing `text` (a string), `onPress` (a callback function), and optionally a `style` on iOS (styles can be one of `default`, `cancel`, or `destructive`).

- `options` - An object for controlling the dialog dismissal behavior on Android. Tapping outside the dialog will normally exit the dialog. This can be prevented by setting `{ cancelable: false }` or handled specially with `{ onDismiss: () => {} }`.
- `type` - Allows text entry on iOS using one of the following options: `default`, `plain-text`, `secure-text`, or `login-password`.

Let's trigger an alert from `App.js`. First we'll need to import `Alert`:

messaging/App.js

```
import {
  Alert,
  // ...
} from 'react-native';
```

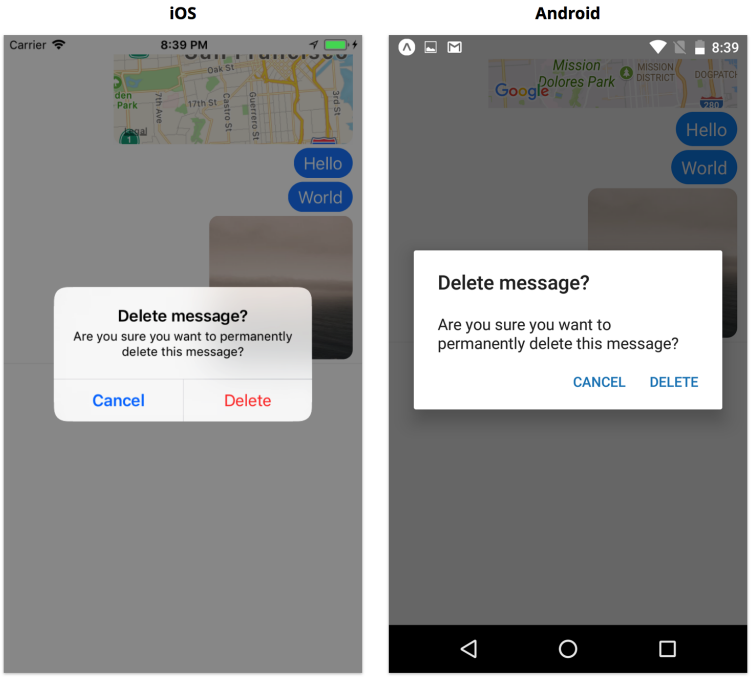
Then we can add the following to our `handlePressMessage` method:

messaging/App.js

```
// ...

handlePressMessage = ({ id, type }) => {
  switch (type) {
    case 'text':
      Alert.alert(
        'Delete message?',
        'Are you sure you want to permanently delete this message?',
        [
          {
            text: 'Cancel',
            style: 'cancel',
          },
          {
            text: 'Delete',
            style: 'destructive',
            onPress: () => {
```

```
              const { messages } = this.state;
              this.setState({
                messages: messages.filter(
                  message => message.id !== id,
                ),
              });
            },
          },
        ],
      );
      break;
    default:
      break;
  }
};

// ...
```

After adding these lines, save `App.js`. When we tap a text message, we should see something like this:



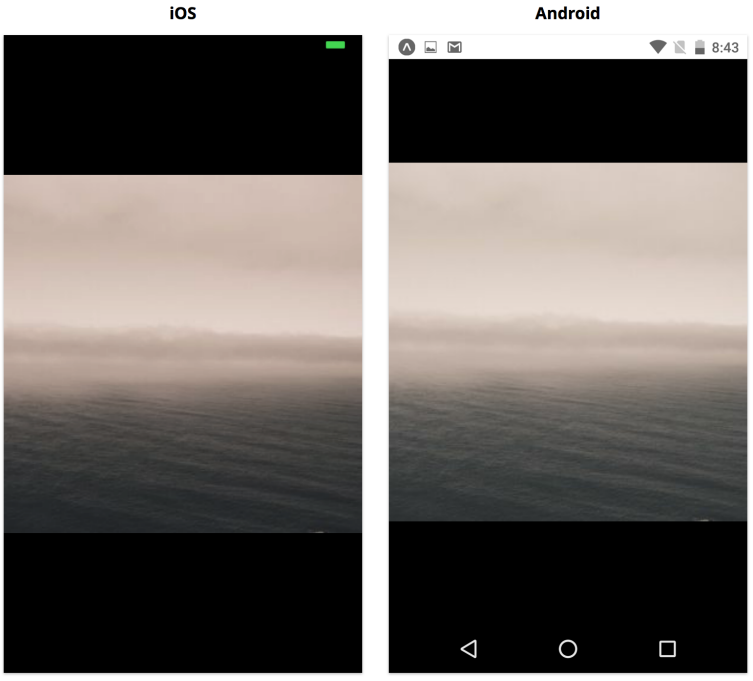
Pressing "Delete" will remove the message from the list. We do this by filtering the list of messages and removing the message with the `id` that we tapped. The removal currently isn't animated, but it will be when we're finished with this app!

It's fairly easy to call `Alert` incorrectly. If you're coming from the web, you might attempt to call `Alert()` rather than `Alert.alert`. You also might try to call `Alert.alert` with parameters that are numbers instead of strings, e.g. our message `id`. Both of these will crash the app with confusing error messages. It's also possible to get into a corrupted state, where you'll have to restart the app before `Alert.alert` will function properly again.

Deleting text messages is useful, but what should we do when the user taps other kinds of messages? For images, let's show the image fullscreen.

Fullscreen image

When the user presses an image, we'll show it fullscreen.



Transitioning to fullscreen might be accomplished using a navigation library (which we'll cover in a later chapter), but we can also do it manually. If we do, we'll want the Android back button to dismiss the fullscreen image – we can use the `BackHandler` API to accomplish this. Let's also dismiss the image when it's pressed again, so that we're not trapped in a fullscreen image state on iOS.

In `App.js`, we'll use `state` to keep track of which image was pressed. Let's add the following for state tracking:

messaging/App.js

```
// ...

state = {
  // ...
  fullscreenImageId: null,
};

dismissFullscreenImage = () => {
  this.setState({ fullscreenImageId: null });
};

// ...
```

We've initialized `fullscreenImageId` to `null` to indicate that we don't want to show any image. Then, when a message is pressed, we'll set it to the `id` of the message object. We can update `handlePressMessage` with the following:

messaging/App.js

```
// ...

handlePressMessage = ({ id, type }) => {
  switch (type) {
    case 'text':
      // ...
    case 'image':
      this.setState({ fullscreenImageId: id });
      break;
    default:
      break;
  }
};

// ...
```

Now we need to render the fullscreen image. We'll use a `TouchableHighlight` for the black overlay background so we can tap it to dismiss the image. Within that, we'll use an `Image`. We'll use the `fullscreenImageId` to look up which image we need to display as the `uri` of the `Image` component.

First, let's import `Image` and `TouchableHighlight`:

messaging/App.js

```
import {
  // ...
  Image,
  TouchableHighlight,
} from 'react-native';
```

Then we can set up the styles:

messaging/App.js

```
const styles = StyleSheet.create({
  // ...
  fullscreenOverlay: {
    ...StyleSheet.absoluteFillObject,
    backgroundColor: 'black',
    zIndex: 2,
  },
  fullscreenImage: {
    flex: 1,
    resizeMode: 'contain',
  },
});
```

We'll use the built-in `StyleSheet.absoluteFillObject` so that our overlay background is fullscreen, and then we'll add `zIndex: 2` so that it renders on top of the rest of our UI. Our image should fill the overlay, so we use `flex: 1`.

Next, let's create a helper method for rendering the fullscreen image called:

`renderFullscreenImage`.

We can also use this method to determine if we need to show an image. We'll call this from `render`.

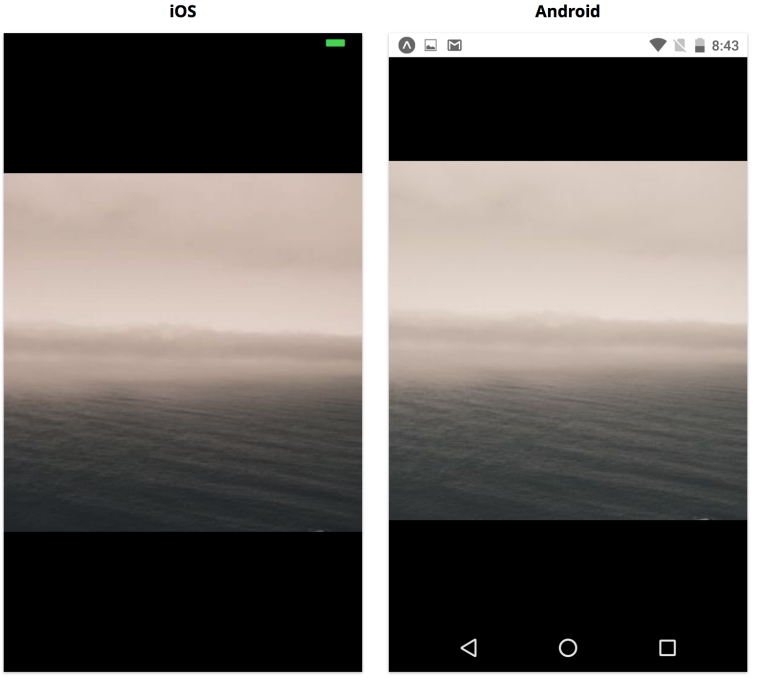
Add the following:

messaging/App.js

```
// ...

renderFullscreenImage = () => {
  const { messages, fullscreenImageId } = this.state;

  if (!fullscreenImageId) return null;

  const image = messages.find(
    message => message.id === fullscreenImageId,
  );

  if (!image) return null;

  const { uri } = image;

  return (
    <TouchableHighlight
      style={styles.fullscreenOverlay}
      onPress={this.dismissFullscreenImage}
    >
      <Image style={styles.fullscreenImage} source={{ uri }} />
    </TouchableHighlight>
  );
};

// ...

render() {
  return (
    <View style={styles.container}>
      <Status />
```

```
        {this.renderMessageList()}
        {this.renderToolbar()}
        {this.renderInputMethodEditor()}
        {this.renderFullscreenImage()}
      </View>
    );
}
```

Save `App.js`. Now when we tap an image, we should see it fullscreen, and we can tap it again to dismiss it:



On Android though, we'll also want the device's back button to dismiss the image. We do this using the `BackHandler` API.

BackHandler

If you're not using an Android, you can skip this section!

Like with `NetInfo`, we use the *event listener* pattern to handle back button press events:

```
BackHandler.addEventListener('hardwareBackPress', handlerFunction);
```

We can use this to get notified every time the user presses the back button on an Android device. We'll have our `handlerFunction` hide our fullscreen image.

We can return `true` from our `handlerFunction` to indicate that we've handled the back button. By returning `false`, we indicate that we didn't handle the event. Therefore, if any other functions have been registered, the next one registered should be called. These functions are called in the reverse of the order they were registered – the last handler registered will be called first. If no handler returns `true`, then the back button will exit to the home screen (the default back button behavior).

First, import the `BackHandler` API:

messaging/App.js

```
import {
  // ...
  BackHandler,
} from 'react-native';
```

Then we'll use `componentWillMount` and `componentWillUnmount` to listen to back button presses:

messaging/App.js

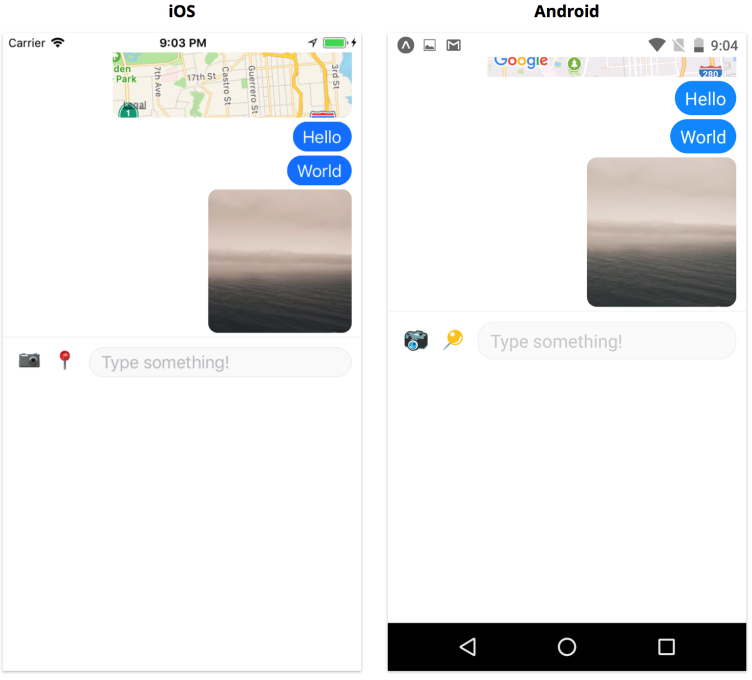
```
// ...

componentWillMount() {
  this.subscription = BackHandler.addEventListener(
    'hardwareBackPress',
    () => {
      const { fullscreenImageId } = this.state;

      if (fullscreenImageId) {
        this.dismissFullscreenImage();
        return true;
      }

      return false;
    },
  );
}

componentWillUnmount() {
  this.subscription.remove();
}

// ...
```

If `state.fullscreenImageId` exists, then we're currently showing a fullscreen image, so we'll want the back button to dismiss it. We return `true` to indicate that we shouldn't exit the app. If we're not showing a fullscreen image, we return `false`. Because no other handlers should be registered, this will allow for the default back button behavior (exiting the app).

Our message list is working pretty well now! We've used two core APIs, `Alert` and `BackHandler`, to create cross-platform interactions for deleting and enlarging messages. Now that we've finished with the message list, let's move on to the next section of the UI and create the toolbar.

`Toolbar`

The toolbar will sit above the keyboard and contain an input field for typing messages, along with buttons for switching to an image picker and sending a location.



Building the `Toolbar`

The toolbar is similar to the `CommentInput` from the Core Components chapter: it maintains the state of a `TextInput` field internally and uses an `onSubmit` function prop to tell the parent when the message is ready to send. We'll need a little more control over the focus state of the `TextInput` this time, so we'll use an `isFocused` prop to control the focus state and an `onChangeFocus` function prop to tell the parent when the state should changes.

Let's create a new file `Toolbar.js` in the `components` directory, and render the top level `View` which will contain all the elements in the toolbar. We'll add `propTypes` for the focus state and the various functions which the parent component can pass in:

messaging/components/Toolbar.js

```
import {
  StyleSheet,
  Text,
  TextInput,
  TouchableOpacity,
  View,
} from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

export default class Toolbar extends React.Component {
  static propTypes = {
    isFocused: PropTypes.bool.isRequired,
    onChangeFocus: PropTypes.func,
    onSubmit: PropTypes.func,
    onPressCamera: PropTypes.func,
    onPressLocation: PropTypes.func,
  };

  static defaultProps = {
    onChangeFocus: () => {},
    onSubmit: () => {},
    onPressCamera: () => {},
    onPressLocation: () => {},
  };

  render() {
    return (
      <View style={styles.toolbar}>
        {/* ... */}
      </View>
    );
  }
}
```

```
const styles = StyleSheet.create({
  toolbar: {
    flexDirection: 'row',
    alignItems: 'center',
    paddingVertical: 10,
    paddingHorizontal: 10,
    paddingLeft: 16,
    backgroundColor: 'white',
  },
  // ...
});
```

Let's add a camera button and a location button and use them to call the `onPressCamera` and `onPressLocation` props.

```
// ...

const ToolbarButton = ({ title, onPress }) => (
  <TouchableOpacity onPress={onPress}>
    <Text style={styles.button}>{title}</Text>
  </TouchableOpacity>
);

ToolbarButton.propTypes = {
  title: PropTypes.string.isRequired,
  onPress: PropTypes.func.isRequired,
};

export default class Toolbar extends React.Component {
  // ...

  render() {
    const { onPressCamera, onPressLocation } = this.props;

    return (
```

```
      <View style={styles.toolbar}>
        {/* Use emojis for icons instead! */}
        <ToolbarButton title={'C'} onPress={onPressCamera} />
        <ToolbarButton title={'L'} onPress={onPressLocation} />
        {/* ... */}
      </View>
    );
  }
}

const styles = StyleSheet.create({
  // ...
  button: {
    top: -2,
    marginRight: 12,
    fontSize: 20,
    color: 'grey',
  },
  // ...
});
```

We can use emojis here for button icons! They require some positioning tweaks in `styles.button`, but look decent on both platforms. Later we could swap these out for images or an icon font.

Unfortunately our PDF-creation software doesn't handle emojis very well, so we couldn't include them in the code snippet. You'll have to grab them from the sample code or choose emojis of your own!

We define a `ToolbarButton` component at the top of the file which we can use in the toolbar. This component is fairly small and styled specifically for use in the toolbar, so we leave it in the same file as `Toolbar`. In terms of coding style, it's common to define small utility components in the same file that they're used, and move them into separate files later if we want to reuse them.

Now let's render a `TextInput`. As a reminder from the Core Components chapter: when we style a `TextInput`, it's often easier to put styles like `border` and `padding` on

a wrapper `View`. Otherwise we tend to run into slight rendering inconsistencies, e.g. borders not rendering.

```
// ...

export default class Toolbar extends React.Component {
  // ...

  state = {
    text: '',
  };

  handleChangeText = (text) => {
    this.setState({ text });
  };

  handleSubmitEditing = () => {
    const { onSubmit } = this.props;
    const { text } = this.state;

    if (!text) return;

    onSubmit(text);
    this.setState({ text: '' });
  };

  render() {
    const { onPressCamera, onPressLocation } = this.props;
    const { text } = this.state;

    return (
      <View style={styles.toolbar}>
        {/* Use emojis for icons instead! */}
        <ToolbarButton title={'C'} onPress={onPressCamera} />
        <ToolbarButton title={'L'} onPress={onPressLocation} />
        <View style={styles.inputContainer}>
```

```
34            <TextInput
35              style={styles.input}
36              underlineColorAndroid={'transparent'}
37              placeholder={'Type something!'}
38              blurOnSubmit={false}
39              value={text}
40              onChangeText={this.handleChangeText}
41              onSubmitEditing={this.handleSubmitEditing}
42              // ...
43            />
44          </View>
45        </View>
46      );
47    }
48  }
49
50  const styles = StyleSheet.create({
51    // ...
52    inputContainer: {
53      flex: 1,
54      flexDirection: 'row',
55      borderWidth: 1,
56      borderColor: 'rgba(0,0,0,0.04)',
57      borderRadius: 16,
58      paddingVertical: 4,
59      paddingHorizontal: 12,
60      backgroundColor: 'rgba(0,0,0,0.02)',
61    },
62    input: {
63      flex: 1,
64      fontSize: 18,
65    },
66  });
```

Just like in the previous chapter, we store the value of the input field as `state.text`. When the user presses the return key on the keyboard, we call `onSubmit` with this

value and then reset `state.text`. Our messaging app doesn't allow sending multiline messages (we're using the return key to submit, so there's no way to insert a newline).

We use `blurOnSubmit={false}` so that the keyboard isn't dismissed when the user presses the return key. This is common in messaging apps, since it allows sending multiple messages in a row more easily.

We'll need more control over the input field's internal state than we did in the previous chapter. We'll need to focus and blur the input field at specific times. We need to do this because when the user presses the camera icon, we want to dismiss the keyboard. The built-in React Native APIs for this are imperative: we have to call `.focus()` and `.blur()` on an instance of `TextInput`. We'll contain this complexity in this component, so that `App` can use an `isFocused` prop to declare the focus state. In order to do this, we'll use a `ref` prop.

Refs

React let's us access the *instance* of any component we render using a `ref` prop. This is a special prop that we can supply a callback – the callback will be called with the instance as a parameter, after the component mounts (and before it unmounts). We can store a reference to the component instance.

You can think of a component instance as the "this" when we access `this.props` or any method that's part of our class. In this case, the `TextInput` component class has a `focus` and `blur` method that can be called from the component instance. We can call these from within the lifecycle of our custom component to control the focus state of the `TextInput`.

Storing a ref

Let's capture a reference to the `TextInput` element we render.

We'll store this reference as `this.input`. We can then use this reference to imperatively focus and blur the input field with `this.input.focus()` and `this.input.blur()` when the `isFocused` prop changes.

```
// ...

export default class Toolbar extends React.Component {
  // ...

  setInputRef = (ref) => {
    this.input = ref;
  };

  componentWillReceiveProps(nextProps) {
    if (nextProps.isFocused !== this.props.isFocused) {
      if (nextProps.isFocused) {
        this.input.focus();
      } else {
        this.input.blur();
      }
    }
  }

  handleFocus = () => {
    const { onChangeFocus } = this.props;

    onChangeFocus(true);
  };

  handleBlur = () => {
    const { onChangeFocus } = this.props;

    onChangeFocus(false);
  };

  // ...

  render() {
    const { onPressCamera, onPressLocation } = this.props;

```

```
    // Grab this from state!
    const { text } = this.state;

    return (
      <View style={styles.toolbar}>
        {/* Use emojis for icons instead! */}
        <ToolbarButton title={'C'} onPress={onPressCamera} />
        <ToolbarButton title={'L'} onPress={onPressLocation} />
        <View style={styles.inputContainer}>
          <TextInput
            style={styles.input}
            underlineColorAndroid={'transparent'}
            placeholder={'Type something!'}
            blurOnSubmit={false}
            value={text}
            onChangeText={this.handleChangeText}
            onSubmitEditing={this.handleSubmitEditing}

            // Additional props!
            ref={this.setInputRef}
            onFocus={this.handleFocus}
            onBlur={this.handleBlur}
          />
        </View>
      </View>
    );
  }
}
```

The `onFocus` prop of the `TextInput` will be called when the user taps within the input field, and the `onBlur` prop will be called when the user taps outside the input field. We use `handleFocus` and `handleBlur` to notify the parent of changes to the focus state.

Whenever the parent passes a different value for the `isFocused` prop, we update the focus state of the `TextInput` by calling `this.input.focus()` or `this.input.blur()` in `componentWillReceiveProps`.

Go ahead and save `Toolbar.js`. We can now control the focus state of the toolbar entirely from `App` using `isFocused` and `onChangeFocus`. We won't use this much in the next section, but it'll be very important when working with the keyboard near the end of the chapter.

Adding `Toolbar` to `App`

Let's now render our `Toolbar` component from `App.js`. We can handle the `onSubmit` event to populate our message list with real messages. When we type in the input field and submit the text (by pressing the return key on the keyboard), we can add a new message to the `messages` in `state` using our `createTextMessage` utility function. We'll also add a few callback functions as placeholders.

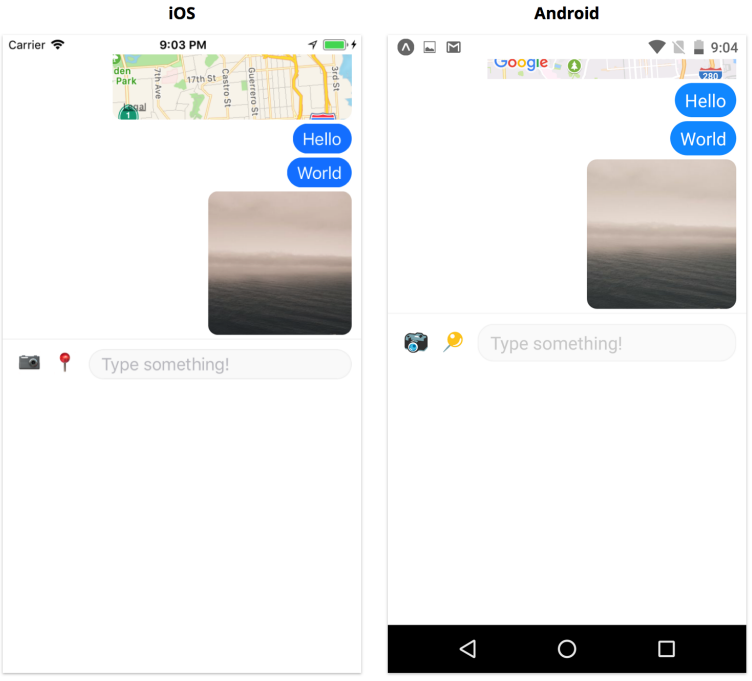
messaging/App.js

```
import Toolbar from './components/Toolbar';

// ...

export default class App extends React.Component {
  state = {
    // ...
    isInputFocused: false,
  }

  handlePressToolbarCamera = () => {
    // ...
  }

  handlePressToolbarLocation = () => {
    // ...
  }

  handleChangeFocus = (isFocused) => {
    this.setState({ isInputFocused: isFocused });
  };
```

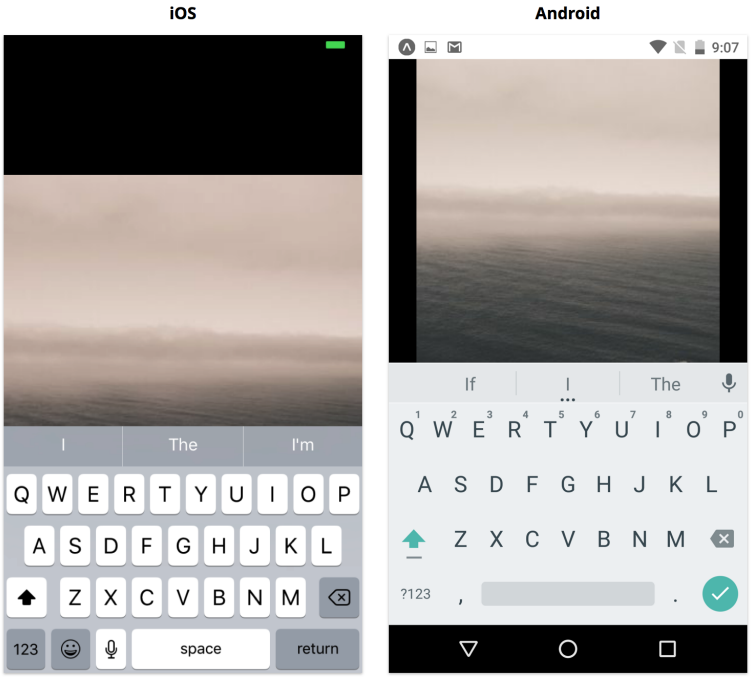
```
  handleSubmit = (text) => {
    const { messages } = this.state;

    this.setState({
      messages: [createTextMessage(text), ...messages],
    });
  };

  renderToolbar() {
    const { isInputFocused } = this.state;

    return (
      <View style={styles.toolbar}>
        <Toolbar
          isFocused={isInputFocused}
          onSubmit={this.handleSubmit}
          onChangeFocus={this.handleChangeFocus}
          onPressCamera={this.handlePressToolbarCamera}
          onPressLocation={this.handlePressToolbarLocation}
        />
      </View>
    );
  }

  // ...

}

// ...
```

We'll store `isInputFocused` in `this.state` to keep track of the focus state of the `TextInput` in toolbar.

After saving `App.js`, our toolbar should look like this:



There's an interesting edge case when we open a fullscreen image preview while the input field is focused – the keyboard stays up even though the input field is no longer visible!



We can address this by updating our `handlePressMessage` function to also set `isInputFocused: false` in the component's state.

messaging/App.js

```
// ...

handlePressMessage = ({ id, type }) => {
  switch (type) {
    // ...
    case 'image':
      this.setState({
        fullscreenImageId: id,
        isInputFocused: false,
      });
      break;
    default:
      break;
```

```
  }
};

// ...
```

Now the keyboard should be dismissed when we tap an image to preview it fullscreen.

Next, let's connect the location button so we can send messages containing a map with a pin at our location.

Geolocation

The React Native `geolocation` API is slightly different than other APIs: we can access it directly from the global `navigator` object, rather than importing it at the top of the file.

> The `geolocation` API in React Native is the same as the one found in modern web browsers. This means better compatibility between libraries and a lower learning curve if you're coming from web development. On the web, the `navigator` object contains a lot of useful metadata about your web browser. In React Native, it's really just a container for `geolocation` and potentially a handful of other browser APIs. Accessing a global variable feels a bit unusual in React Native, but is necessary to provide the exact same API on web and mobile.

We'll use `navigator.geolocation.getCurrentPosition` to get our current position. This API takes a callback parameter which is called with an object containing our coordinates, `coords`, in `latitude` and `longitude`.

There's currently a bug in Expo/React Native. This method never calls its callback parameter on Android. We'll update this chapter as soon as it's fixed!

Let's try it out. We can get our current position and use it to create a location message in the `MessageList`. Add the following to `handlePressToolbarLocation` in `App.js`:

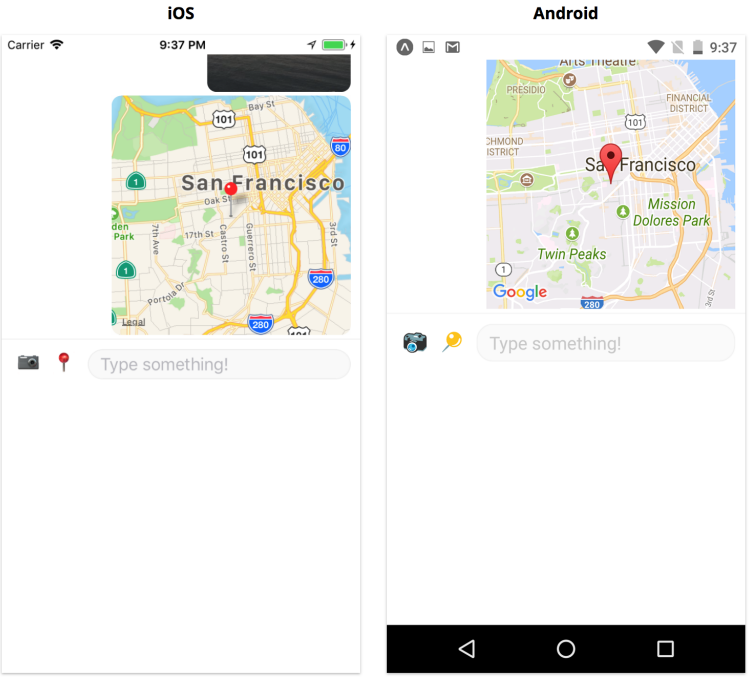
```
// ...

handlePressToolbarLocation = () => {
  const { messages } = this.state;

  navigator.geolocation.getCurrentPosition((position) => {
    const { coords: { latitude, longitude } } = position;

    this.setState({
      messages: [
        createLocationMessage({
          latitude,
          longitude,
        }),
        ...messages,
      ],
    });
  });
};

// ...
```

Pretty simple!

If you try it out, you may be prompted to give Expo permission to access your location. Expo is already set up to allow the location permission.

If you're building an app using `react-native-cli`, you'll also need to modify your `Info.plist` on iOS and `AndroidManifest.xml` on Android to enable location permissions.

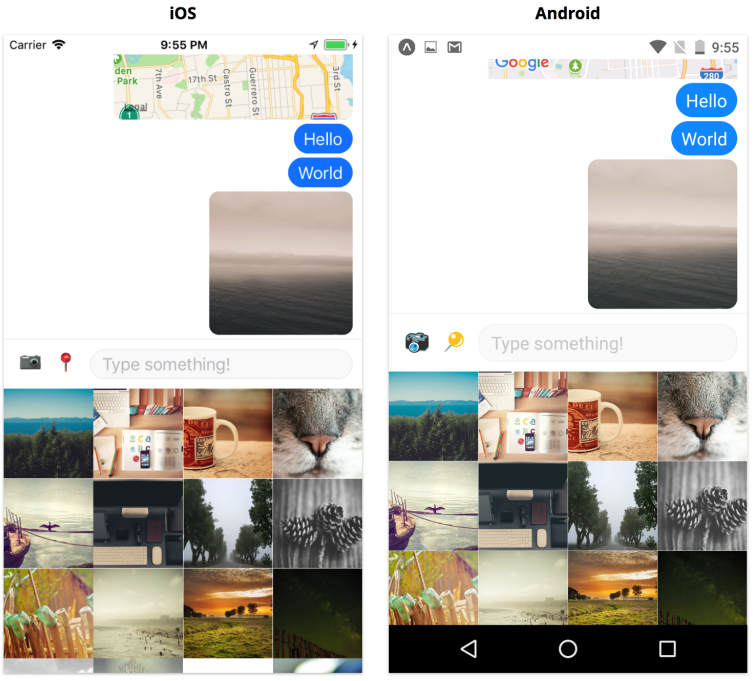
Tapping the location button should now add a location message:



Depending on how we're using `geolocation`, there are a few other APIs that might be useful: - `watchPosition(success, error?, options?)` and `clearWatch(watchID)` can be used to receive notifications when location changes. We can also pass the options `timeout` (number in ms), `maximumAge` (number in ms), and `enableHighAccuracy` (bool) for more granular control. - `requestAuthorization()` can be used to request access to device location. This can be a better experience than presenting an alert when a map is shown for the first time. - `getCurrentPosition(geo_success, geo_error?, geo_options?)` is the full function signature of the `getCurrentPosition` API we use above. Although we didn't do it in our example, we would generally want to handle errors and present them to the user in some way. We might also want to pass options for more granular control (the same options as `watchPosition`).

Input Method Editor (IME)

We've finished creating the message list and toolbar. Let's move on to one of the more interesting features of our app: the custom input method editor for sending images.



We'll build the image grid flexibly so we could easily use it in other apps with just a few modifications.

Image picker

Let's populate our image grid with photos from the camera roll. To do this, we'll need to access the images saved on the device and display them in an infinitely scrolling grid. We can do this with a combination of the Core APIs `CameraRoll`, `Dimensions`, and `PixelRatio`.

Building a grid

Let's make a new `Grid` component which we'll use to display `Image` components from the camera roll.

Here we'll use a `FlatList` to make our image grid. If you recall from the previous chapter, the `FlatList` component is a feature-packed `ScrollView` that we can use for

infinite scrolling out-of-the-box. The `FlatList` can be configured to display multiple columns, instead of the normal single column, by passing the `numColumns` prop.

Let's make a new file `Grid.js` within the `components` directory. In this, we can create a `Grid` component which renders a `FlatList`. Our `Grid` will be a wrapper around `FlatList` that configures it specifically for our use case: displaying multiple columns of square-shaped components.

Our `Grid` will pass along all of its props to `FlatList`, since it's mostly acting as a more specific case of the very general `FlatList` component. Our `Grid` component will handle three `props` (two of which are also `FlatList` props):

- `renderItem` - A function called with each item. Should return a React element. We want to intercept this function before passing it to `FlatList`. We're going to call it with the same arguments that `FlatList` would call it with, but we're going to add some extra information about the style of the item to render.
- `numColumns` - The number of columns per row. We'll use this to calculate item dimensions. We'll pass this to `FlatList` directly.
- `itemMargin` - The vertical and horizontal spacing between each item in the grid. This prop doesn't need to be passed into `FlatList`.

Here's a skeleton for the `Grid` component code:

messaging/components/Grid.js

```
import { Dimensions, FlatList, PixelRatio, StyleSheet } from 'react-nat\
ive';
import PropTypes from 'prop-types';
import React from 'react';

export default class Grid extends React.Component {
  static propTypes = {
    renderItem: PropTypes.func.isRequired,
    numColumns: PropTypes.number,
    itemMargin: PropTypes.number,
  };

  static defaultProps = {
```

```
    numColumns: 4,
    itemMargin: StyleSheet.hairlineWidth,
  };

  renderGridItem = (info) => {
    // ... The interesting stuff happens here!
  };

  render() {
    return (
      <FlatList {...this.props} renderItem={this.renderGridItem} />
    );
  }
}
```

Note that we pass all `props` into `FlatList`. We're building a wrapper around `FlatList` that adds some extra rendering info to each item, but we're going to let `FlatList` do the hard work of rendering rows of content in an infinitely scrolling list. We'll focus on rendering square `Image` components of equal size in the `renderGridItem` function.

We'll need to get the dimensions of the device using the `Dimensions` API.

messaging/components/Grid.js

```
renderGridItem = (info) => {
  // ...

  const { width } = Dimensions.get('window');

  // ...
};
```

At first glance, it might look like we should call `Dimensions.get('window')` outside of the `render` path, so we only have to retrieve it once. However, `width` can change sizes depending on device orientation, multitasking mode, etc, so it's best to do this within the `render` path.

Next, let's calculate the dimensions of each item we'll render. Here we'll want to use the `PixelRatio.roundToNearestPixel` API. This API helps us ensure we align content to *physical pixels* when we're dealing with non-integer dimensions.

> In React Native, we specify dimensions in terms of *logical pixels* rather than *physical pixels*. There may be multiple physical pixels per logical pixels in a device with a high pixel density, e.g. retina display. When we make calculations that can result in non-integer dimensions, we should use `PixelRatio` to help us align to the nearest physical pixel - otherwise, there may be visual inconsistencies (e.g. some elements or margins appear larger than others).

messaging/components/Grid.js

```
renderGridItem = (info) => {
  // ...

  const { numColumns, itemMargin } = this.props;

  const { width } = Dimensions.get('window');

  const size = PixelRatio.roundToNearestPixel(
    (width - itemMargin * (numColumns - 1)) / numColumns,
  );

  // ...
};
```

We now have a pixel-aligned size for each item in the grid. Let's also calculate the margins between elements. We can use the index of the item, which is passed to us automatically by the `FlatList`.

messaging/components/Grid.js

```
renderGridItem = (info) => {
  const { index } = info;
  const { numColumns, itemMargin } = this.props;

  const { width } = Dimensions.get('window');

  const size = PixelRatio.roundToNearestPixel(
    (width - itemMargin * (numColumns - 1)) / numColumns,
  );

  // We don't want to include a `marginLeft` on the first item of a
  // row
  const marginLeft = index % numColumns === 0 ? 0 : itemMargin;

  // We don't want to include a `marginTop` on the first row of the
  // grid
  const marginTop = index < numColumns ? 0 : itemMargin;

  // ...
};
```

Great! We've done all the calculations necessary to start rendering `Image` elements of the appropriate size. Let's call the `renderItem` prop with this information.

messaging/components/Grid.js

```
renderGridItem = (info) => {
  const { renderItem, numColumns, itemMargin } = this.props;

  // ...

  return renderItem({ ...info, size, marginLeft, marginTop });
};
```

We augment the `info` passed by `FlatList` with `size`, `marginLeft`, and `marginTop`, so that we can render items at the correct size from within the `renderItem` function.

On generic vs. specific components

What we just did was a little complicated: we created a `Grid` component which accepts a `renderItem` function prop, then we passed a different function, `renderGridItem`, into the `FlatList`.

Our goal here is to take the very powerful and generic `FlatList` and create a more specific version called `Grid`. We want to expose nearly all the customizability of `FlatList` (we propagate all the props from `Grid` into `FlatList`), while tweaking a few parts to make rendering in a grid format more straightforward. By keeping the API as similar as possible to `FlatList`, our `Grid` can be used as an almost drop-in replacement. Additionally, the learning curve for using our `Grid` is much lower than a completely custom component, since if we know the API of `FlatList` we also know the API of `Grid`.

Adding images to the grid

Our grid is ready to go! We wrote the `Grid` component so that we could add an infinitely scrolling grid of images for the user to send as messages.

Ultimately we want to fill this grid with photos from the camera roll. But first, let's try using it with some placeholder images to test it out.

Create a new file in `components` called `ImageGrid.js`. We'll use our `Grid` component by adding the following code:

messaging/components/ImageGrid.js

```
import {
  CameraRoll,
  Image,
  StyleSheet,
  TouchableOpacity,
} from 'react-native';
import * as Permissions from 'expo-permissions';
import PropTypes from 'prop-types';
import React from 'react';
```

```
import Grid from './Grid';

const keyExtractor = ({ uri }) => uri;

export default class ImageGrid extends React.Component {
  static propTypes = {
    onPressImage: PropTypes.func,
  };

  static defaultProps = {
    onPressImage: () => {},
  };

  state = {
    images: [
      { uri: 'https://picsum.photos/600/600?image=10' },
      { uri: 'https://picsum.photos/600/600?image=20' },
      { uri: 'https://picsum.photos/600/600?image=30' },
      { uri: 'https://picsum.photos/600/600?image=40' },
    ],
  };

  renderItem = ({ item: { uri }, size, marginTop, marginLeft }) => {
    const style = {
      width: size,
      height: size,
      marginLeft,
      marginTop,
    };

    return (
      <Image source={{ uri }} style={style} />
    );
  };

  render() {
```

```
    const { images } = this.state;

    return (
      <Grid
        data={images}
        renderItem={this.renderItem}
        keyExtractor={keyExtractor}
        // ...
      />
    );
  }
}

const styles = StyleSheet.create({
  image: {
    flex: 1,
  },
});
```

You can see that we use `Grid` in almost the same way as we would use a `FlatList`. The difference is that `renderItem` has a few additional values we can use for layout: `size`, `marginTop`, and `marginLeft`.

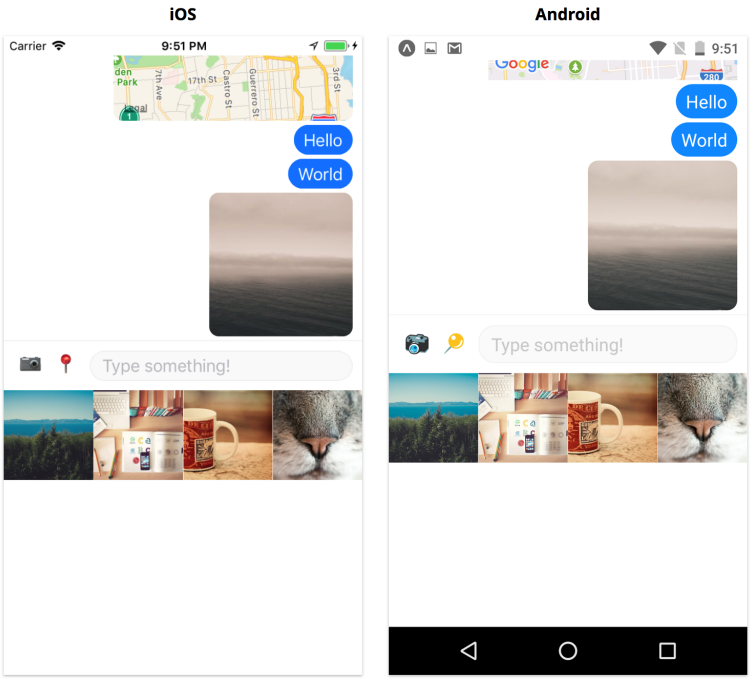
Save `ImageGrid.js`. Let's render `ImageGrid` from `App.js` to see what we have so far. Update `App.js` with the following:

messaging/App.js

```
// ...

import ImageGrid from './components/ImageGrid';

export default class App extends React.Component {

  // ...

  renderInputMethodEditor = () => (
```

```
      <View style={styles.inputMethodEditor}>
        <ImageGrid />
      </View>
    );

    // ...

}

// ...
```

When we save `App.js`, we should see something similar to this:



On separating components

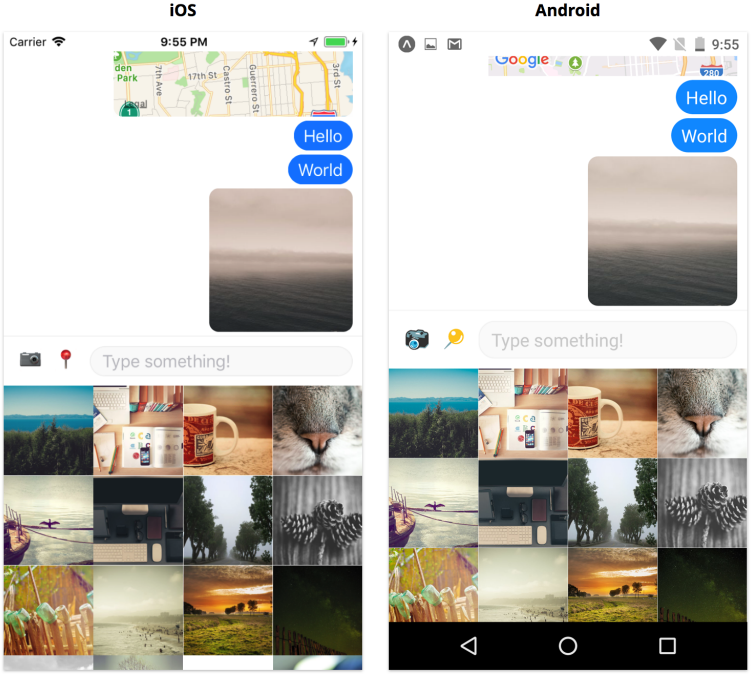
Notice how by making a separate `Grid` component, we've cleanly separated the grid rendering logic from the content we render. We could have written the grid rendering

logic, and the image loading from the camera roll in the same `ImageGrid` component, but then the component would've had two reasonably complex and distinct tasks.

As a general guideline for React Native, it's useful to separate complex concerns (e.g. rendering calculations, data fetching) into separate components, so that our components remain focused on a single task. This makes them easier understand when reading them later, and easier to reuse. Our `Grid` can easily be reused in other apps with other kinds of content. Our `ImageGrid` could render images into a `FlatList` instead of a `Grid` with very few changes.

Loading images from the camera roll

Let's replace the placeholder images we've added to `state.images` with real images from the camera roll.



We can use `CameraRoll.getPhotos(options)` to request an array of images from the device. We can specify the number of images we want to get with the `first` option. We can use a cursor to iterate through the list of images by passing an

`after` option (more on this soon). We also need to specify which `assetType` we want (`Photos`, `Videos`, or `All`), and we can optinally specify a `groupName` to choose a specific category of photos on iOS (the default is `SavedPhotos`). This API is asynchronous and returns a promise containing the image metadata, along with pagination info.

Since this API is asynchronous, it may take some time for the first images to be returned. The more images we request, the longer it will take. It's best to request just enough images to fill the entire screen: we want the API response as soon as we can, but we also want the screen to load all at once, rather than piecemeal.

Calling `CameraRoll.getPhotos(options)` returns a promise, which resolves to an object containing:

- `edges` - An array of items, each containing a `node` object. The `node` object contains metadata about the image, such as `timestamp` and `location`. The `node` object also contains an `image` object with the `filename`, `width`, `height`, and `uri` of the image.
- `page_info` - An object containing a boolean `has_next_page`, a string `end_cursor`, and a string `before_cursor`.

We can pass `end_cursor` to the `after` option of `CameraRoll.getPhotos(options)` in order to iterate through the list.

> If you're not familiar with using cursors, they're a common way to iterate through lists of data stored on servers or in databases. A cursor points to a specific item in a list. By passing the cursor along with a request for more items, the server or database will know which items it's already returned to you and which it should return next. The details aren't too relevant for our uses, but if you're curious about cursors, you can read more here[58].

Before we can access the camera roll on Android, we'll need to request the user's permission to do so. We can use the Expo `Permissions` API to do this. We can await a call to `Permissions.askAsync` containing the permission we want access to, and check the returned object for whether request was granted.

[58] https://en.wikipedia.org/wiki/Cursor_(databases)

```
await Permissions.askAsync(Permissions.CAMERA_ROLL);

if (status !== 'granted') {
  // Denied
} else {
  // Good to go!
}
```

More info about permissions is available in the Expo docs[59].

In `componentDidMount`, let's get camera roll permissions, load an initial set of images, and store the images in `state.images`.

messaging/components/ImageGrid.js

```
// ...

export default class ImageGrid extends React.Component {
  state = {
    images: [],
  };

  componentDidMount() {
    this.getImages();
  }

  getImages = async () => {
    const { status } = await Permissions.askAsync(
      Permissions.CAMERA_ROLL,
    );

    if (status !== 'granted') {
      console.log('Camera roll permission denied');
```

[59] https://docs.expo.io/versions/latest/sdk/permissions.html

```
      return;
    }

    const results = await CameraRoll.getPhotos({
      first: 20,
      assetType: 'Photos',
    });

    const { edges } = results;

    const loadedImages = edges.map(item => item.node.image);

    this.setState({ images: loadedImages });
  };

  // ...
}
```

This should give us at most 20 images. If there are fewer than 20 images saved on the device, then we may see fewer.

We make our `getImages` method `async` so that we can use `await` with `CameraRoll.getPhotos`.

This works well for 20 images, but now we need to load more when the user scrolls to the bottom of the `Grid`. We can use the `onEndReached` function prop of `FlatList` (which is also a prop of `Grid`) to notify us that we need to load more images. This is trickier than it sounds: the `onEndReached` function we pass may be called multiple times before we have finished loading a new set of images. We need to be careful not to load the same set of images twice. Let's start by calling `getNextImages` when we reach the end of the list:

messaging/components/ImageGrid.js

```
// ...

export default class ImageGrid extends React.Component {

  // ...

  getNextImages = () => {
    // ...
  };

  // ...

  render() {
    const { images } = this.state;

    return (
      <Grid
        data={images}
        renderItem={this.renderItem}
        keyExtractor={keyExtractor}
        onEndReached={this.getNextImages}
      />
    );
  }
}
```

We can use the `page_info` object in the response of `CameraRoll.getPhotos` to determine if we need to load another page. We'll use:

- `has_next_page` - Are there more images to load?
- `end_cursor` - The cursor we can use to load more images after the current set we've just retrieved.

Let's keep track of the internal state of the pagination with two member variables, `this.loading` and `this.cursor`. We don't need to put these in `this.state` since they

don't directly affect component rendering. We can also update them synchronously which will make our implementation simpler. Anytime we use `this.setState` we have to keep in mind that it occurs asynchronously.

messaging/components/ImageGrid.js

```
// ...

export default class ImageGrid extends React.Component {
  loading = false;
  cursor = null;

  // ...

  getNextImages = () => {
    if (!this.cursor) return;

    this.getImages(this.cursor);
  };

  getImages = async (after) => {
    if (this.loading) return;

    this.loading = true;

    const results = await CameraRoll.getPhotos({
      first: 20,
      after,
      assetType: 'Photos',
    });

    const {
      edges,
      page_info: { has_next_page, end_cursor },
    } = results;

    const loadedImages = edges.map(item => item.node.image);
```

```
    this.setState(
      {
        images: this.state.images.concat(loadedImages),
      },
      () => {
        this.loading = false;
        this.cursor = has_next_page ? end_cursor : null;
      },
    );
  };
}
```

By keeping track of `loading`, we can be certain that we'll only ever load one set of images at a time. We set `this.loading = true` before making the asynchronous call to `getPhotos`, and we wait till the asynchronous call to `this.setState()` has completed before setting `this.loading = false`.

The second parameter of `this.setState` is a completion callback. We can use this to avoid race conditions between the time we call `this.setState` and the time `this.state` is actually updated. If we didn't use the completion callback and instead set `this.loading = false` after calling `this.setState`, we would potentially access `this.state.images` before it had been updated, thus one set of the images we loaded would fail to be added to the list.

We abort `getNextImages` if `this.cursor` doesn't have a value. This stops us from loading the initial set of images again once we reach the end of the camera roll. If we preferred, we could instead record a boolean `this.hasNextPage` to help us track when we've reached the end.

The last thing we'll do in this file is call the `onPressImage` prop whenever we tap an image. We'll pass the `uri` of the image so that we can use it within messages.

We'll wrap the `Image` in a `TouchableOpacity` in order to handle press events. Update `renderItem` with the following:

messaging/components/ImageGrid.js

```
// ...

renderItem = ({ item: { uri }, size, marginTop, marginLeft }) => {
  const { onPressImage } = this.props;

  const style = {
    width: size,
    height: size,
    marginLeft,
    marginTop,
  };

  return (
    <TouchableOpacity
      key={uri}
      activeOpacity={0.75}
      onPress={() => onPressImage(uri)}
      style={style}
    >
      <Image source={{ uri }} style={styles.image} />
    </TouchableOpacity>
  );
};

// ...
```

Save `ImageGrid.js` and let's start using it to add messages to the message list!

Sending images from `ImageGrid`

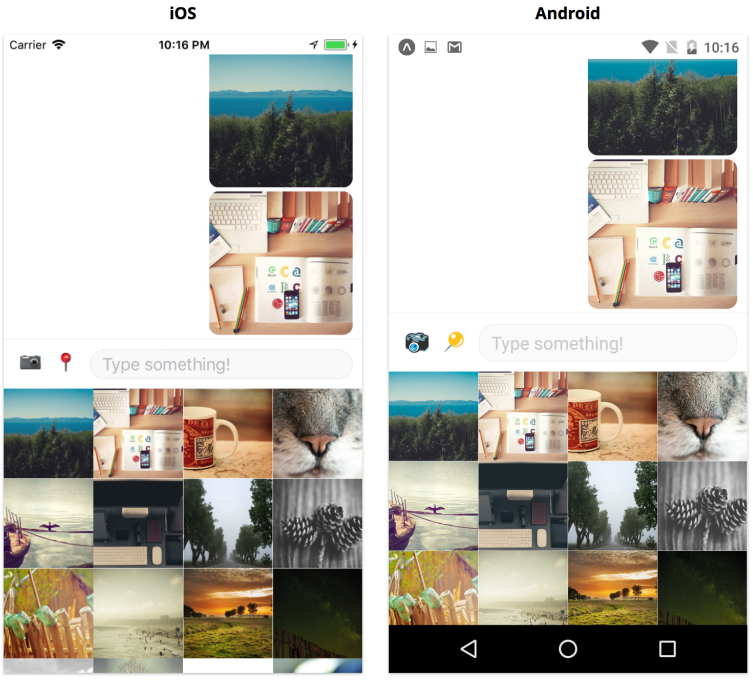
We can now load images from the camera roll and display them in a pixel-perfect grid. When we tap an image, let's add a new image message to the list of `messages` in state using our `createImageMessage` utility function.

We'll use `handlePressImage` to add a new image to the message list:

messaging/App.js

```
// ...

export default class App extends React.Component {

  // ...

  handlePressImage = (uri) => {
    const { messages } = this.state;

    this.setState({
      messages: [createImageMessage(uri), ...messages],
    });
  };

  renderInputMethodEditor = () => (
    <View style={styles.inputMethodEditor}>
      <ImageGrid onPressImage={this.handlePressImage} />
    </View>
  );

  // ...

}
```

Great! We can now tap images and they'll appear in the `MessageList` we wrote earlier. Here's what it should look like:



What we've built

At this point, we have the bulk of the UI components written. In order to access device information, we've used a variety of APIs including `Alert`, `CameraRoll`, `Dimensions`, `Geolocation`, `NetInfo`,`PixelRatio`, and `StatusBar`.

Using React Native APIs tends to follow a pattern:

1. Figure out which API we need to call.
2. Figure out which lifecycle/helper method is the most appropriate place to call it.
3. Call the API (either synchronously or asynchronously).
4. Store the results in component state.
5. Re-render the UI based on the new state.

We can use this approach with nearly any API. We'll continue covering other APIs in the second part of this chapter, and in the rest of the book.

Core APIs, Part 2

In the first part of this section, we covered a variety of React Native APIs for accessing device information. In this part, we'll focus on one fundamental feature of mobile devices: the keyboard.

This is a **code checkpoint**. If you haven't been coding along with us but would like to start now, we've included a snapshot of our current progress in the sample code for this book.

If you haven't created a project yet, you'll need to do so with:

```
$ expo init messaging --template blank@sdk-33 --yarn
```

Then, copy the contents of the directory `messaging/1` from the sample code into your new `messaging` project directory.

The keyboard

Keyboard handling in React Native can be very complex. We're going to learn how to manage the complexity, but it's a challenging problem with a lot of nuanced details.

Our UI is currently a bit flawed: on iOS, when we focus the message input field, the keyboard opens up and covers the toolbar. We have no way of switching between the image picker and the keyboard. We'll focus on fixing these issues.

We're about to embark on a deep dive into keyboard handling. We'll cover some extremely useful APIs and patterns – however, you shouldn't feel like you have to complete the entire chapter now. Feel free to stop here and return again when you're actively building a React Native app that involves the keyboard.

Why it's difficult

Keyboard handling can be challenging for many reasons:

- The keyboard is enabled, rendered, and animated natively, so we have much less control over its behavior than if it were a component (where we control the lifecycle).
- We have to handle a variety of asynchronous events when the keyboard is shown, hidden, or resized, and update our UI accordingly. These events are somewhat different on iOS and Android, and even slightly different in the simulator compared to a real device.
- The keyboard works differently on iOS and Android at a fundamental level. On iOS, the keyboard appears *on top* of the existing UI; the existing UI doesn't resize to avoid the keyboard. On Android, the keyboard *resizes* the UI above it; the existing UI will shrink to fit in the available space. We generally want interactions to feel similar on both platforms, despite this fundamental difference.
- Keyboards interact specially with certain native elements e.g. `ScrollView`. On iOS, dragging downward on a `ScrollView` can dismiss the keyboard at the same rate of the pan gesture.
- Keyboards are user-customizable on both platforms, meaning there's an almost unlimited number of shapes and sizes our UI has to handle.

In this app, we'll attempt to achieve a native-quality messaging experience. Ultimately though, there will be a few aspects that don't quite feel native. It's extremely difficult to get an app with complex keyboard interactions to feel *perfect* without dropping down to the native level. If you can't achieve the right experience in React Native, consider writing a native module for the screen that interacts heavily with the keyboard. This is part of the beauty of React Native – you can start with a JavaScript version in your initial implementation of a screen or feature, then seamlessly swap it out for a native implementation when you're certain it's worth the time and effort.

If you're lucky, you'll be able to find an existing open source native component that does exactly that!

`KeyboardAvoidingView`

In the first chapter, we demonstrated how to use the `KeyboardAvoidingView` component to move the UI of the app out from under the keyboard. This component is great for simple use cases, e.g. focusing the UI on an input field in a form.

When we need more precise control, it's often better to write something custom. That's what we'll do here, since we need to coordinate the keyboard with our custom image input method.

Our goal here is for our image picker to have the same height as the native keyboard, in essence acting as a custom keyboard created by our app. We'll want to smoothly animate the transition between these two input methods.

For a demo of the desired behavior, you can try playing around with the completed app (it's the same app as the previous section):

- On Android, you can scan this QR code from within the Expo app:

- On iOS, you can build the app and preview it on the iOS simulator or send the link of the project URL to your device like we've done in previous chapters.

On managing complexity

Since this problem is fairly complicated, we're going to break it down into 3 parts, each with its own component:

- `MeasureLayout` - This component will measure the available space for our messaging UI
- `KeyboardState` - This component will keep track of the keyboard's visibility, height, etc
- `MessagingContainer` - This component will displaying the correct IME (text, images) at the correct size

We'll connect them so that `MeasureLayout` renders `KeyboardState`, which in turn renders `MessagingContainer`.

We *could* build one massive component that handles everything, but this would get very complicated and be difficult to modify or reuse elsewhere.

`Keyboard`

We'll need to measure the available space on the screen and the keyboard height ourselves, and adjust our UI accordingly. We'll keep track of whether the keyboard is currently transitioning. And we'll animate our UI to transition between the different keyboard states.

To do this, we'll use the `Keyboard` API. The `Keyboard` API is the lower-level API that `KeyboardAvoidingView` uses under the hood.

On iOS, the keyboard uses an animation with a special easing curve that's hard to replicate in JavaScript, so we'll hook into the native animation directly using the `LayoutAnimation` API. `LayoutAnimation` is one of the two main ways to animate our UI (the other being `Animated`). We'll cover animation more in a later chapter.

Measuring the available space

Let's start by measuring the space we have to work with. We want to measure the space that our `MessageList` can use, so we'll measure from below the status bar (anything above our `MessageList`) to the bottom of the screen. We need to do this to get a numeric value for height, so we can transition between the height when the keyboard isn't visible to the height when the keyboard is visible. Since the keyboard doesn't actually take up any space in our UI, we can't rely on `flex: 1` to take care of this for us.

Measuring in React Native is always asynchronous. In other words, the first time we render our UI, we have no general-purpose way of knowing the height. If the content above our `MessageList` has a fixed height, we can calculate the initial height by taking `Dimensions.get('window').width` and subtracting the height of the content above our `MessageList` – however, this is not very flexible. Instead, let's create a container `View` with a flexible height `flex: 1` and measure it on first render. After that, we'll always have a numeric value for height.

We can measure this `View` with the `onLayout` prop. By passing a callback to `onLayout`, we can get the `layout` of the `View`. This `layout` contains values for `x`, `y`, `width`, and `height`.

messaging/components/MeasureLayout.js

```
import Constants from 'expo-constants';
import { Platform, StyleSheet, View } from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

export default class MeasureLayout extends React.Component {
  static propTypes = {
    children: PropTypes.func.isRequired,
  };

  state = {
    layout: null,
  };

  handleLayout = event => {
    const { nativeEvent: { layout } } = event;

    this.setState({
      layout: {
        ...layout,
        y:
          layout.y +
          (Platform.OS === 'android' ? Constants.statusBarHeight : 0),
      },
```

```
    });
  };

  render() {
    const { children } = this.props;
    const { layout } = this.state;

    // Measure the available space with a placeholder view set to
    // flex 1
    if (!layout) {
      return (
        <View onLayout={this.handleLayout} style={styles.container} />
      );
    }

    return children(layout);
  }
}

const styles = StyleSheet.create({
  container: {
    flex: 1,
  },
});
```

Here we render a placeholder `View` with an `onLayout` prop. When called, we update `state` with the new `layout`.

Most React Native components accept an `onLayout` function prop. This is conceptually similar to a React lifecycle method: the function we pass is called every time the component updates its dimensions. We need to be careful when calling `setState` within this function, since `setState` may cause the component to re-render, in which case `onLayout` will get called again… and now we're stuck in an infinite loop!

We have to compensate for the solid color status bar we use on Android by adjusting

the `y` value, since the status bar height isn't included in the layout data. We can do this by merging the existing properties of layout, `...layout`, and an updated `y` value that includes the status bar height.

We use a new pattern here for propagating the `layout` into the children of this component: we require the `children` prop to be a function. When we use our `MeasureLayout` component, it will look something like this:

```
<MeasureLayout>
  {layout => <View ... />}
</MeasureLayout>
```

> This pattern is similar to having a `renderX` prop, where `X` indicates what will be rendered, e.g. `renderMessages`. However, using `children` makes the hierarchy of the component tree more clear. Using the `children` prop implies that these children components are the main thing the parent renders. As an analogy, this pattern is similar to choosing between `export default` and `export X`. If there's only one variable to export from a file, it's generally more clear to go with `export default`. If there's a variable with the same name as the file, or a variable that seems like the primary purpose of the file, you would also likely export it with `export default` and export other variables with `export X`. Similarly, you should consider using `children` if this prop is the "default" or "primary" thing a component renders. Ultimately this is an API style preference. Even if you choose not to use it, it's useful to be aware of the pattern since you may encounter it when using open source libraries.

We're now be able to get a precise height which we can use to resize our UI when the keyboard appears and disappears.

Keyboard events

We have the initial height for our messaging UI, but we need to update the height when the keyboard appears and disappears. The `Keyboard` object emits events to let us know when it appears and disappears. These events contain layout information, and on iOS, information about the animation that will/did occur.

KeyboardState

Let's create a new component called `KeyboardState` to encapsulate the keyboard event handling logic. For this component, we're going to use the same pattern as we did for `MeasureLayout`: we'll take a `children` function prop and call it with information about the keyboard layout.

We can start by figuring out the `propTypes` for this component. We know we're going to have a `children` function prop. We're also going to consume the `layout` from the `MeasureLayout` component, and use it in our keyboard height calculations.

messaging/components/KeyboardState.js

```
import { Keyboard, Platform } from "react-native";
import PropTypes from 'prop-types';
import React from 'react';

export default class KeyboardState extends React.Component {
  static propTypes = {
    layout: PropTypes.shape({
      x: PropTypes.number.isRequired,
      y: PropTypes.number.isRequired,
      width: PropTypes.number.isRequired,
      height: PropTypes.number.isRequired,
    }).isRequired,
    children: PropTypes.func.isRequired,
  };

  // ...
}
```

Now let's think about the `state`. We want to keep track of 6 different values, which we'll pass into the `children` of this component:

- `contentHeight`: The height available for our messaging content.
- `keyboardHeight`: The height of the keyboard. We keep track of this so we set our image picker to the same size as the keyboard.

- `keyboardVisible`: Is the keyboard fully visible or fully hidden?
- `keyboardWillShow`: Is the keyboard animating into view currently? This is only relevant on iOS.
- `keyboardWillHide`: Is the keyboard animating out of view currently? This is only relevant on iOS, and we'll only use it for fixing visual issues on the iPhone X.
- `keyboardAnimationDuration`: When we animate our UI to avoid the keyboard, we'll want to use the same animation duration as the keyboard. Let's initialize this with the value `250` (in milliseconds) as an approximation.

messaging/components/KeyboardState.js

```
// ...

const INITIAL_ANIMATION_DURATION = 250;

export default class KeyboardState extends React.Component {
  // ...

  constructor(props) {
    super(props);

    const { layout: { height } } = props;

    this.state = {
      contentHeight: height,
      keyboardHeight: 0,
      keyboardVisible: false,
      keyboardWillShow: false,
      keyboardWillHide: false,
      keyboardAnimationDuration: INITIAL_ANIMATION_DURATION,
    };
  }

  // ...
}
```

Now that we've determined which properties to keep track of, let's update them based on keyboard events.

There are 4 `Keyboard` events we should listen for:

- `keyboardWillShow` (iOS only) - The keyboard is going to appear
- `keyboardWillHide` (iOS only) - The keyboard is going to disappear
- `keyboardDidShow` - The keyboard is now fully visible
- `keyboardDidHide` - The keyboard is now fully hidden

In `componentWillMount` we can add listeners to each keyboard event;

And in `componentWillUnmount` we can remove them:

```
// ...

  componentWillMount() {
    if (Platform.OS === 'ios') {
      this.subscriptions = [
        Keyboard.addListener(
          'keyboardWillShow',
          this.keyboardWillShow,
        ),
        Keyboard.addListener(
          'keyboardWillHide',
          this.keyboardWillHide,
        ),
        Keyboard.addListener('keyboardDidShow', this.keyboardDidShow),
        Keyboard.addListener('keyboardDidHide', this.keyboardDidHide),
      ];
    } else {
      this.subscriptions = [
        Keyboard.addListener('keyboardDidHide', this.keyboardDidHide),
        Keyboard.addListener('keyboardDidShow', this.keyboardDidShow),
      ];
    }
```

```
23    }
24
25    componentWillUnmount() {
26      this.subscriptions.forEach(subscription => subscription.remove());
27    }
28
29  // ...
```

We'll add the listeners slightly differently for each platform: on Android, we don't get events for `keyboardWillHide` or `keyboardWillShow`.

Storing subscription handles in an array is a common practice in React Native. We don't know exactly how many subscriptions we'll have until runtime, since it's different on each platform, so removing all subscriptions from an array is easier than storing and removing a reference to each listener callback.

Let's use these events to update `keyboardVisible`, `keyboardWillShow`, and `keyboardWillHide` in our `state`:

messaging/components/KeyboardState.js

```
// ...

keyboardWillShow = (event) => {
  this.setState({ keyboardWillShow: true });

  // ...
};

keyboardDidShow = () => {
  this.setState({
    keyboardWillShow: false,
    keyboardVisible: true,
  });

  // ...
};
```

```
keyboardWillHide = (event) => {
  this.setState({ keyboardWillHide: true });

  // ...
};

keyboardDidHide = () => {
  this.setState({
    keyboardWillHide: false,
    keyboardVisible: false
  });
};

// ...
```

The listeners `keyboardWillShow`, `keyboardDidShow`, and `keyboardWillHide` will each be called with an `event` object, which we can use to measure the `contentHeight` and `keyboardHeight`. Let's do that now, using `this.measure(event)` as a placeholder for the function which will perform measurements.

messaging/components/KeyboardState.js

```
// ...

keyboardWillShow = (event) => {
  this.setState({ keyboardWillShow: true });
  this.measure(event);
};

keyboardDidShow = (event) => {
  this.setState({
    keyboardWillShow: false,
    keyboardVisible: true,
  });
  this.measure(event);
};
```

```
keyboardWillHide = (event) => {
  this.setState({ keyboardWillHide: true });
  this.measure(event);
};

// ...
```

For iOS it would be sufficient to calculate measurements in the `keyboardWill*` events, since the `keyboardDid*` events should receive the same `event` parameter. However, since Android only supports the `keyboardDid*` events, we also need to use `keyboardDidShow`. Calculating measurements in `keyboardDidShow` on iOS shouldn't affect the app's behavior, but we could do this conditionally by checking `Platform.OS === 'android'` if we preferred.

We can use these events to keep track of the keyboard's current state. Each `event` object will have the following properties:

- `duration` - Duration of the keyboard animation. In practice, this is typically constant across all keyboard animations. This property only exists on iOS, so we'll use a constant to approximate it on Android.
- `easing` - Easing curve used by the keyboard animation. This will be the special easing curve called `'keyboard'`, which we can use to sync our own animations with the keyboard's. This property only exists on iOS, since there isn't a specific keyboard animation on Android. We'll use `'easeInEaseOut'` as a pleasant-looking default to approximate the keyboard animation on Android.
- `startCoordinates`, `endCoordinates` - An object containing keys `height`, `width`, `screenX`, and `screenY`. These refer to the start and end coordinates of the keyboard. Normally `height`, `width`, and `screenX` will stay the same. We can use `height` to determine the height of the keyboard. The `screenY` value refers to the top of the keyboard, which we can use to determine the remaining height available to render content.

To calculate the `contentHeight`, we can take the `screenY` (top coordinate of the keyboard) and subtract `layout.y` (top coordinate of our messaging component).

```
measure = (event) => {
  const { layout } = this.props;

  const {
    endCoordinates: { height, screenY },
    duration = INITIAL_ANIMATION_DURATION,
  } = event;

  this.setState({
    contentHeight: screenY - layout.y,
    keyboardHeight: height,
    keyboardAnimationDuration: duration,
  });
};

// ...
```

> Remember, `y` coordinates lower down on the screen are larger than those higher on the screen, so this calculation will resulting in a positive value.

Note that if a hardware keyboard is connected, the `height` of the keyboard will be `0` – we'll have to handle this specially later.

Let's propagate all of these values into the `children` of this component. We'll also propagate the height of the entire component as `containerHeight`.

messaging/components/KeyboardState.js

```
// ...

render() {
  const { children, layout } = this.props;
  const {
    contentHeight,
    keyboardHeight,
    keyboardVisible,
    keyboardWillShow,
```

```
    keyboardWillHide,
    keyboardAnimationDuration,
  } = this.state;

  return children({
    containerHeight: layout.height,
    contentHeight,
    keyboardHeight,
    keyboardVisible,
    keyboardWillShow,
    keyboardWillHide,
    keyboardAnimationDuration,
  });
}

// ...
```

When we use this component, it'll look roughly like this: we'll first wrap it in our `MeasureLayout` component, and pass the `layout` in as a prop. We can then render our content using the `keyboardInfo` object.

```
<MeasureLayout>
  {layout => (
    <KeyboardState layout={layout}>
      {keyboardInfo => /* ... */}
    </KeyboardState>
  )}
</MeasureLayout>
```

Alright, we're almost there! We have `MeasureLayout` and `KeyboardState`. The last component we need is `MessagingContainer` to render the content using the sizes we've calculated.

`MessagingContainer`

Let's create a new component `MessagingContainer` to render the correct Input Method Editor (IME) at the correct size.

Once again, let's figure out the `propTypes` first. This component is going to have a lot of `props`, since it's consuming data from the previous components we wrote, in addition to more `props` which we'll pass in from `App`.

The main job of this component is to display the correct IME at any given time. Let's define constants for each potential state:

- `NONE` - Don't show any IME.
- `KEYBOARD` - The text input is focused, so the keyboard should be visible.
- `CUSTOM` - Show our custom IME. In this case, we'll show our image picker, but we could show other kinds of input here if we wanted to.

Let's create an object to hold these. We'll also export it so that other components can easily use the correct string values.

messaging/components/MessagingContainer.js

```
import {
  BackHandler,
  LayoutAnimation,
  Platform,
  UIManager,
  View,
} from 'react-native';
import PropTypes from 'prop-types';
import React from 'react';

export const INPUT_METHOD = {
  NONE: 'NONE',
  KEYBOARD: 'KEYBOARD',
  CUSTOM: 'CUSTOM',
};
```

```
// ...
```

Now for the `propTypes`. We'll begin by declaring each of the values that will be passed from `KeyboardState`. We'll define `inputMethod` and `onChangeInputMethod` to handle switching between IMEs and notifying the parent of changes. We'll also support rendering content in both the keyboard area with `renderInputMethodEditor` and the main content area with `children`. In this case, `children` should be a normal React element rather than a function like in the two components we wrote previously.

messaging/components/MessagingContainer.js

```
// ...

export default class MessagingContainer extends React.Component {
  static propTypes = {
    // From `KeyboardState`
    containerHeight: PropTypes.number.isRequired,
    contentHeight: PropTypes.number.isRequired,
    keyboardHeight: PropTypes.number.isRequired,
    keyboardVisible: PropTypes.bool.isRequired,
    keyboardWillShow: PropTypes.bool.isRequired,
    keyboardWillHide: PropTypes.bool.isRequired,
    keyboardAnimationDuration: PropTypes.number.isRequired,

    // Managing the IME type
    inputMethod: PropTypes.oneOf(Object.values(INPUT_METHOD))
      .isRequired,
    onChangeInputMethod: PropTypes.func,

    // Rendering content
    children: PropTypes.node,
    renderInputMethodEditor: PropTypes.func.isRequired,
  };

  static defaultProps = {
    children: null,
```

```
    onChangeInputMethod: () => {},
  };

  // ...

}
```

Now let's use `componentWillReceiveProps` to handle switching the `inputMethod`. When the keyboard transitions from hidden to visible, we want to set the `inputMethod` to `INPUT_METHOD.KEYBOARD`. When the keyboard transitions from visible to hidden, we want to set the `inputMethod` to `INPUT_METHOD.NONE`... unless we're currently displaying the image picker (the keyboard should always be hidden when we display the image picker, so we can ignore this transition).

messaging/components/MessagingContainer.js

```
// ...

componentWillReceiveProps(nextProps) {
  const { onChangeInputMethod } = this.props;

  if (!this.props.keyboardVisible && nextProps.keyboardVisible) {
    // Keyboard shown
    onChangeInputMethod(INPUT_METHOD.KEYBOARD);
  } else if (
    // Keyboard hidden
    this.props.keyboardVisible &&
    !nextProps.keyboardVisible &&
    this.props.inputMethod !== INPUT_METHOD.CUSTOM
  ) {
    onChangeInputMethod(INPUT_METHOD.NONE);
  }

  // ... more to come!

}
```

```
// ...
```

Since `inputMethod` will be stored in the `state` of the parent, we'll call `onChangeInputMethod` and let the parent pass this prop back down. We *could* store `inputMethod` in the `state` of `MessagingContainer`, but since the parent needs to access this value, it's best that the parent stores it.

`LayoutAnimation`

We're going to use `LayoutAnimation` to handle automatically transitioning between the various states of this component. `LayoutAnimation` is still considered experimental, and it's more common to use the other animated API, `Animated`. However, `LayoutAnimation` is the only way we can match the exact animation of the keyboard. It's used internally by the built-in `KeyboardAvoidingView` component, so it's safe for us to use despite being considered experimental.

Currently `LayoutAnimation` is disabled by default on Android, so we need to enable it by calling `UIManager.setLayoutAnimationEnabledExperimental(true)`. We can enable it anywhere in the app, but let's do it at the top of `MessagingContainer.js`, since that's the file we use it in:

messaging/components/MessagingContainer.js

```
if (
  Platform.OS === 'android' &&
  UIManager.setLayoutAnimationEnabledExperimental
) {
  UIManager.setLayoutAnimationEnabledExperimental(true);
}
```

> The `UIManager` object contains a variety of APIs for getting access to native UI elements for measuring, but we won't use it for anything else here.

`LayoutAnimation` automatically handles animating elements that should change size or appear/disappear between calls to `render`. We call `LayoutAnimation.create` to

define an animation configuration, and then `LayoutAnimation.configureNext` to enqueue the animation to run the next time `render` is called.

The `LayoutAnimation.create` API takes three parameters:

- `duration` - The duration of the animation
- `easing` - The curve of the animation. We choose from a predefined set of curves: `spring`, `linear`, `easeInEaseOut`, `easeIn`, `easeOut`, `keyboard`. The `keyboard` curve is the key to matching the keyboard's animation curve – although it only exists on iOS.
- `creationProp` - The style to animate when a new element is added: `opacity` or `scaleXY`.

In our case, we want to call this every time the component will re-render, so `componentWillReceiveProps` is the best place.

messaging/components/MessagingContainer.js

```
// ...

componentWillReceiveProps(nextProps) {

  // ... from before!

  const { keyboardAnimationDuration } = nextProps;

  const animation = LayoutAnimation.create(
    keyboardAnimationDuration,
    Platform.OS === 'android'
      ? LayoutAnimation.Types.easeInEaseOut
      : LayoutAnimation.Types.keyboard,
    LayoutAnimation.Properties.opacity,
  );
  LayoutAnimation.configureNext(animation);
}

// ...
```

`LayoutAnimation` applies to the entire component hierarchy, not just the component we call it from, so this will actually animate every component in our app. It may be a better idea to selectively choose when to animate based on the exact props which have changed, but for simplicity, let's assume we always want to animate.

Handling the back button

We should add one last bit of logic in `MessagingContainer.js` to handle the hardware back button on Android. When the `CUSTOM` IME is active, we want the back button to dismiss the IME, just like it would for the device keyboard. We'll use `BackHandler` for this. When the back button is pressed, if the `CUSTOM` IME is active, we'll call `onChangeInputMethod(INPUT_METHOD.NONE)` to notify the parent.

messaging/components/MessagingContainer.js

```
// ...

componentDidMount() {
  this.subscription = BackHandler.addEventListener(
    'hardwareBackPress',
    () => {
      const { onChangeInputMethod, inputMethod } = this.props;

      if (inputMethod === INPUT_METHOD.CUSTOM) {
        onChangeInputMethod(INPUT_METHOD.NONE);
        return true;
      }

      return false;
    },
  );
}

componentWillUnmount() {
  this.subscription.remove();
}
```

```
// ...
```

Rendering the `MessagingContainer`

Now let's render this thing! We'll render an outer `View` which contains the message list and the toolbar (via `children`), and an inner `View` which renders the image picker (via `renderInputMethodEditor`).

The conditional logic is pretty complex, so let's take a look at it in-line with the code.

messaging/components/MessagingContainer.js

```
// ...

render() {
  const {
    children,
    renderInputMethodEditor,
    inputMethod,
    containerHeight,
    contentHeight,
    keyboardHeight,
    keyboardWillShow,
    keyboardWillHide,
  } = this.props;

  // For our outer `View`, we want to choose between rendering at
  // full height (`containerHeight`) or only the height above the
  // keyboard (`contentHeight`). If the keyboard is currently
  // appearing (`keyboardWillShow` is `true`) or if it's fully
  // visible (`inputMethod === INPUT_METHOD.KEYBOARD`), we should
  // use `contentHeight`.
  const useContentHeight =
    keyboardWillShow || inputMethod === INPUT_METHOD.KEYBOARD;
```

```
  const containerStyle = {
    height: useContentHeight ? contentHeight : containerHeight,
  };

  // We want to render our custom input when the user has pressed
  // the camera button (`inputMethod === INPUT_METHOD.CUSTOM`), so
  // long as the keyboard isn't currently appearing (which would
  // mean the input field has received focus, but we haven't updated
  // the `inputMethod` yet).
  const showCustomInput =
    inputMethod === INPUT_METHOD.CUSTOM && !keyboardWillShow;

  // If `keyboardHeight` is `0`, this means a hardware keyboard is
  // connected to the device. We still want to show our custom image
  // picker when a hardware keyboard is connected, so let's set
  // `keyboardHeight` to `250` in this case.
  const inputStyle = {
    height: showCustomInput ? keyboardHeight || 250 : 0,
  };

  return (
    <View style={containerStyle}>
      {children}
      <View style={inputStyle}>{renderInputMethodEditor()}</View>
    </View>
  );
}

// ...
```

In order for the toolbar to sit above the home indicator on the iPhone X, we'll need to adjust the space below the toolbar as the keyboard transitions up and down.

Supporting the iPhone X

You may skip this section if you're not testing with an iPhone X.

In the "Core Components" chapter, we used the `SafeAreaView` to support the iPhone X. This won't work here, since we want to *animate* the space below the toolbar (to avoid a jerk when the space changes).

We'll install the npm library `react-native-iphone-x-helper`[60] to help us determine if the device is an iPhone X.

In your terminal, install the library with:

```
yarn add react-native-iphone-x-helper@1.2.1
```

React Native doesn't currently provide a way to determine if the device is an iPhone X. This library simply checks the device's dimensions. Hopefully in the future something better will be provided out-of-the-box for accessing the safe area insets directly.

After this finishes, import the `isIphoneX` utility function at the top of the file:

messaging/components/MessagingContainer.js

```
import { isIphoneX } from 'react-native-iphone-x-helper';
```

Now we can update the `render` method above to include extra space below the toolbar:

[60] https://www.npmjs.com/package/react-native-iphone-x-helper

messaging/components/MessagingContainer.js

```
// ...

render() {
  // ...

  // The keyboard is hidden and not transitioning up
  const keyboardIsHidden =
    inputMethod === INPUT_METHOD.NONE && !keyboardWillShow;

  // The keyboard is visible and transitioning down
  const keyboardIsHiding =
    inputMethod === INPUT_METHOD.KEYBOARD && keyboardWillHide;

  const inputStyle = {
    height: showCustomInput ? keyboardHeight || 250 : 0,

    // Show extra space if the device is an iPhone X the keyboard is
    // not visible
    marginTop:
      isIphoneX() && (keyboardIsHidden || keyboardIsHiding)
        ? 24
        : 0,
  };

  // ...
}

// ...
```

Whew, we made it. Save `MessagingContainer.js`. Now we just need to render `MessagingContainer` from `App`.

Rendering `MessagingContainer` in `App`

Head back to `App.js` and import the components we've just created:

messaging/App.js

```
// ...

import KeyboardState from './components/KeyboardState';
import MeasureLayout from './components/MeasureLayout';
import MessagingContainer, {
  INPUT_METHOD,
} from './components/MessagingContainer';

// ...
```

Let's include the `inputMethod` in the `state` of `App`, and handle changes to it.

messaging/App.js

```
// ...

export default class App extends React.Component {
  state = {
    // ...
    inputMethod: INPUT_METHOD.NONE,
  };

  // ...

  handleChangeInputMethod = (inputMethod) => {
    this.setState({ inputMethod });
  };

  handlePressToolbarCamera = () => {
    this.setState({
      isInputFocused: false,
      inputMethod: INPUT_METHOD.CUSTOM,
    });
  };
```

```
  // ...

}

// ...
```

Lastly, let's use `MeasureLayout`, `KeyboardState`, and `MessagingContainer` to render the UI components we've already written.

We'll rearrange:

- `this.renderMessageList`,
- `this.renderToolbar`, and
- `this.renderInputMethodEditor`

so that they render within `MessagingContainer`.

We can update the render method of `App` to look like this:

```
// ...

render() {
  const { inputMethod } = this.state;

  return (
    <View style={styles.container}>
      <Status />
      <MeasureLayout>
        {layout => (
          <KeyboardState layout={layout}>
            {keyboardInfo => (
              <MessagingContainer
                {...keyboardInfo}
                inputMethod={inputMethod}
                onChangeInputMethod={this.handleChangeInputMethod}
                renderInputMethodEditor={
```

```
                this.renderInputMethodEditor
              }
            >
              {this.renderMessageList()}
              {this.renderToolbar()}
            </MessagingContainer>
          )}
        </KeyboardState>
      )}
    </MeasureLayout>
    {this.renderFullscreenImage()}
  </View>
);
}

// ...
```

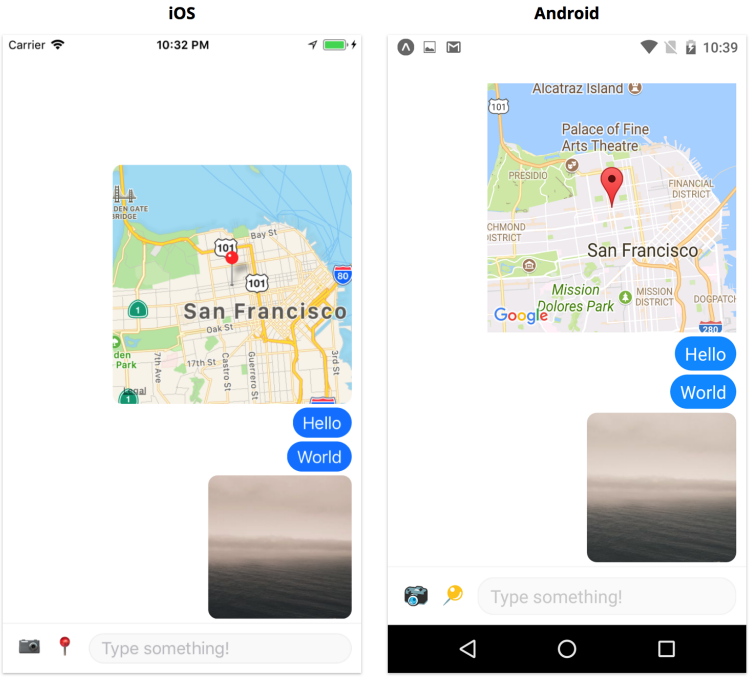
Using the `children` function prop pattern, we can pretty clearly visualize the flow of data downward into `MessagingContainer`.

Note that since `keyboardInfo` contains many properties, it's easiest to pass them all into `MessagingContainer` at once with the object spread syntax `...keyboardInfo`. If we prefer, we could also assign each property individually, e.g.

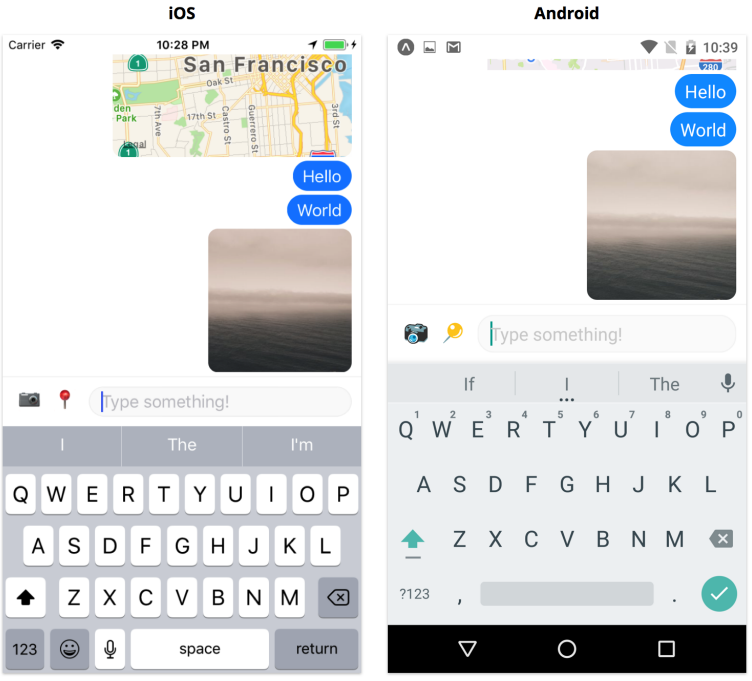
`keyboardHeight={keyboardInfo.keyboardHeight}`.

Save `App.js` and test it out! You should see the same components as before, but now they animate smoothly to avoid the keyboard as it appears and disappears.

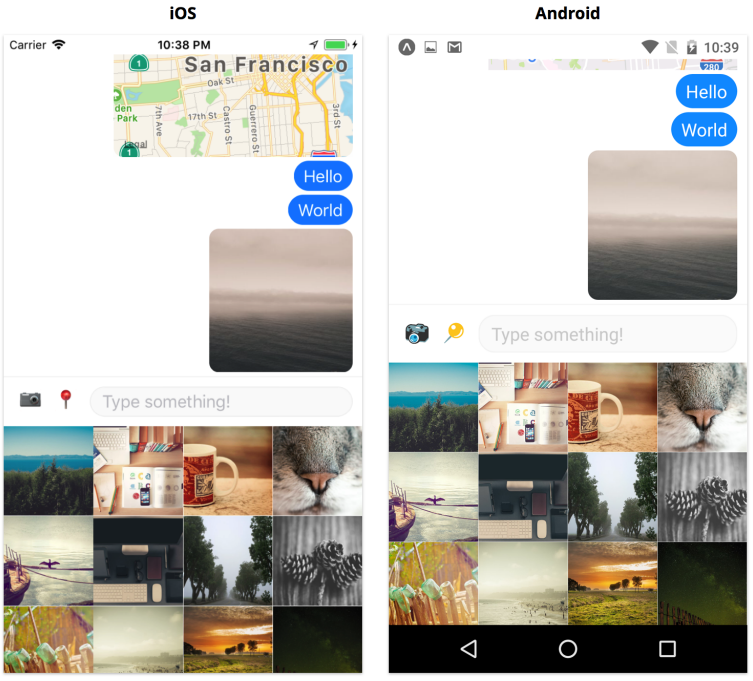
In the default state, our app should look like this:



Tapping the input field should pop open the keyboard, and smoothly transition the rest of the UI:



Tapping the camera icon should transition to the image picker:



We're Done!

We've built a messaging app UI complete with text messages, images, and maps. We notify the user of connectivity issues. We display a pixel-perfect infinite scrolling grid of photos. We smoothly animate the UI as new messages are added and removed (try it if you haven't! the `LayoutAnimation` takes care of this automatically). We handle the keyboard gracefully on both platforms.

Navigation

In the "Core Components" chapter, we explored how different parts of the app (the image feed and user comments) can be represented as separate *screens* - components that take up the entire device screen. When building screens, handling how the user navigates between them is a primary concern. **Navigation** is a major piece of any mobile application with multiple screens. With a navigation system in place, a user can access any part of an application. It also allows us to structure and separate how data is handled in the app.

Handling navigation in a mobile application is fundamentally different from a website. For a website, the state of a user's location is usually kept in the browser's URL. Although the browser maintains a history of pages visited in order to allow the user to move back and forth, the browser only stores page URLs and is otherwise stateless. On mobile, the entire history stack is maintained and can be accessed.

On mobile, we have more control and flexibility over history management. We can keep a *history stack* that includes details of each route including parameters and part of the application state.

Further, mobile navigation presents its own set of challenges. One of the biggest is the reduced real estate of the user's device screen compared to a desktop or laptop computer. We need to make sure there are easily visible and identifiable navigation components that will allow the user to move to another part of the application when pressed. Including a complex navigation flow comes with the cost of a larger number of navigation components (such as menu options). For this reason, most mobile apps tend to have a small and focused number of screens that a user can easily navigate to and understand.

Navigation in React Native

This section will explore the landscape of navigation in React Native in some detail. If you would like to jump straight to building our sample application, feel free to skip this section and return to it later.

One of the primary navigation patterns in a mobile app is a *stack-based* pattern. In this pattern, only one screen can be seen by the user at any given time. Navigating involves *pushing* the new screen onto the navigation stack. We'll explore stack-based navigation in more detail later in the chapter. For now, it is important to realize that this pattern, among others, uses different native components for iOS and Android. For example, building a stack-based navigation flow between screens can be done using `UINavigationController`[61] for iOS and connecting `Activities`[62] for Android.

There are two primary approaches to navigation in React. We can either include actual native iOS/Android navigational elements or use JavaScript to create the required animations and components that we need.

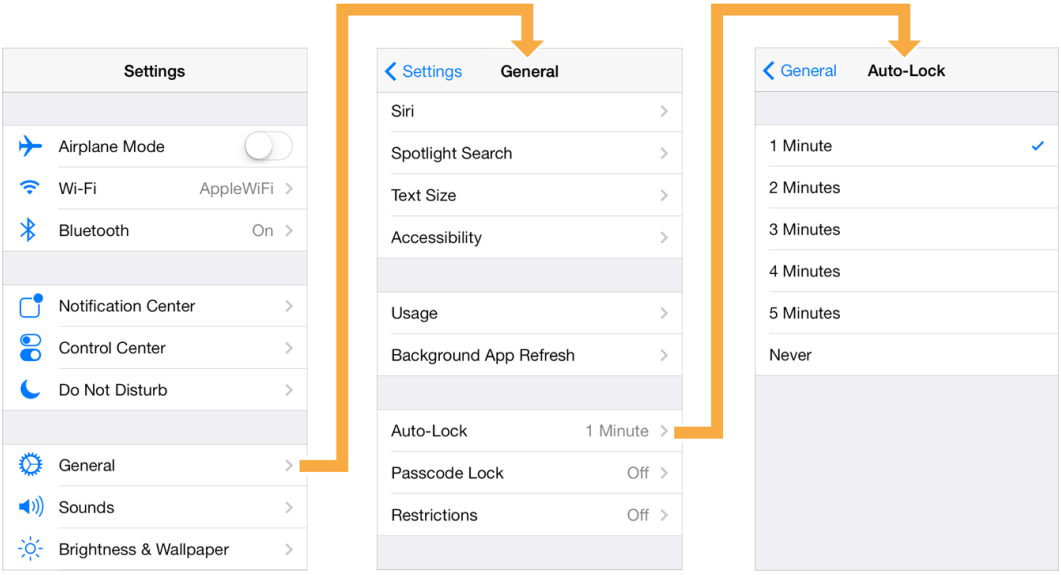
Native navigation

The first way we can add navigation is to use native iOS/Android navigational components.

In an iOS application, *views* are used to build the UI and display content to the user. A *view controller* (or the `UIViewController` class) is used to control a *set* of views and allows us to connect our UI with our application data. By including multiple view controllers in our app, we can build different screens as well as transition between them.

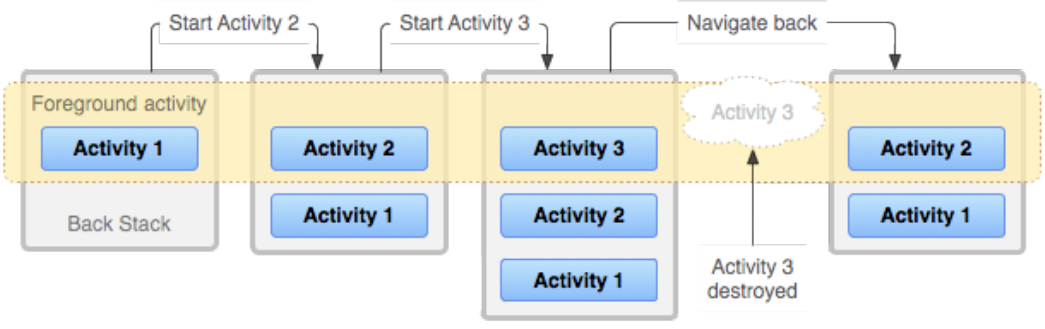
A *navigation controller* (`UINavigationController`) simplifies the process of navigating between screens by allowing us to pass in a *stack* of `UIViewControllers`. It will take care of including a header navigation bar at the top of our device with a back button that allows us to pop the current view controller off of the current stack. With this, it maintains the hierarchy of all the screens within the stack.

[61] https://developer.apple.com/documentation/uikit/uinavigationcontroller
[62] https://developer.android.com/guide/components/activities/index.html



Example of a navigation controller (from Apple Developer Documentation - UINavigationController)

In Android, *activities* are used to create single screens to define our UI. We can use *tasks* in order to define a stack of activities known as the *back stack*. The `startActivity` method can be used to start a new activity. When this happens, the activity is pushed onto the activity stack. In order to return to the previous screen, the physical back button on every Android device can be pressed in order to run the `finish` method on the activity. This closes the current activity, pops it off the stack and returns the user back to the previous activity.



Android Back Stack (from Android Developers Documentation - Tasks and Back Stack)

In React Native, all of our component code executes on a *JavaScript thread*. These components then **bridge** to a separate *main thread* responsible for rendering native iOS and Android views.

In the first chapter, we briefly mentioned how we can eject from Expo if we need to include any native dependencies ourselves. This includes any native iOS or Android code we wish to write ourselves or third-party libraries that provide a React Native API which bridges to a specific native module. We can use this to include native navigation in our application. We can create native modules around platform-specific navigation components (such as `UINavigationController` and `Activity`) and bridge them ourselves in a React Native app.

We'll explore bridging native APIs in much more detail in the "Native Modules" chapter.

Pros

The primary benefit of this approach is a smoother navigation experience for the user. This is because purely native iOS/Android navigation APIs can be used with all of our navigation happening within the native thread. This approach works well when including React Native in an existing native iOS or Android application. Using the same navigation components and transitions throughout the app means that different screens in the app will feel consistent regardless of whether they're written natively or with React Native.

Additionally, if an operating system update modifies the style or functionality of navigation components, you won't have to wait for the same modifications to be made in your JavaScript-based navigation library.

Cons

One of the issues with this navigation approach is that it usually involves more work. This is because we need to ensure navigation works for both iOS and Android, using their respective native navigational components.

Moreover, we will also have to eject from Expo and take care of linking and bridging any native modules ourselves. This means we cannot build an application with native iOS navigation components if we do not own a Mac computer.

Another potential problem with this solution is that it can be significantly harder to modify or create new navigation patterns. In order to customize how navigation is performed, we would have to dive in to the native code and understand how the underlying navigation APIs work before being able to change them.

Navigation with JavaScript

The second approach to adding navigation to a React Native app is to use JavaScript to create components and navigation patterns that *look* and *feel* like their native counterparts. This is done solely using React Native built-in components and the `Animated` API for animations.

We can explain how this works by using stack navigation as an example again. As we mentioned earlier, this pattern allows us to move between screens by pushing a second screen on top of the previous one. We usually see this happen by seeing the second screen *slide* in from either the right or bottom edge of the device screen or fading in from the bottom. When we attempt to navigate backwards, the current screen slides back out in the opposite direction or fades out from the top.

With the `Animated` API, we can use animated versions of some built-in components such as `View` as well as create our own. We can create stack based navigation (as well as other navigation patterns) by nesting our screen components within an `Animated` component. We can then have our screens slide (or fade) in and out of our device when we need to allow the user to navigate throughout our application. We'll have to maintain the hierarchy of screens entirely in JavaScript ourselves.

Pros

One of the advantages of using JavaScript-based navigation is that it can be simpler to build the components and animation mechanisms that can be used in both platforms instead of trying to create a bridge to all of the core native iOS/Android APIs that we would need. This also gives us more control and flexibility to customize specific navigation features instead of relying on what's available in the native platforms. We

can debug any issues we experience with navigation that is purely JavaScript-based without diving in to native code.

Most of the work during an animation using the React Native `Animated` API is on the JavaScript thread. This means that every frame needs to go over the bridge to the native thread to update the views during a transition. Fortunately, we have the option to use the API's *native driver* option to render natively driven animations. These animations are performed with animation calculations happening on the native thread. By building navigation with this, navigation animations will perform smoothly.

We'll explore the built-in `Animated` API in greater detail in the next chapter.

Another benefit of keeping all of our navigation elements within the JavaScript thread means that we can take advantage of services such as CodePush[63] to allow us to dynamically update the application's JavaScript code (which includes our navigation) without rolling out a new build to our users.

Cons

There are also disadvantages with this approach. Firstly, the app can never *feel* exactly like a native application in terms of navigation. As much as we can try to mimic how navigation components and animations look like in the native layer, there may always be slight discrepancies. This can be a bigger problem if we happen to be including React Native components into an existing native iOS or Android application. Building transitions between screens built natively and screens built with React Native can be a challenge if we're using only JavaScript for our navigation.

Another potential concern with JavaScript-based navigation is slower updates in relation to the underlying platform's operating system. Updates to the iOS or Android version may bring changes to the native navigational views and components. We'll need to make sure the views and components built with JavaScript are also updated in order to better match how they are represented natively.

[63] https://github.com/Microsoft/react-native-code-push

Third-party libraries

In React Native, we have the option of setting up navigation by creating our own native modules or by building our own JavaScript-based implementation. There are also a number of community-supported libraries that we can use for either of these approaches:

- React Native Navigation[64] by Wix engineering and Native Navigation[65] by Airbnb are both navigation libraries that provide access to native iOS/Android navigation components using a React Native API.
- React Navigation[66] and React Router[67] are two popular third-party JavaScript navigation libraries.

Using one of these libraries can make things significantly easier than building a navigation pattern entirely from scratch. Moreover, all of these community-built libraries are continuously maintained with updates included in each new release.

Navigation alternatives

Not all mobile applications need to have a complete navigation architecture. Examples include an app that only has a few screens or does not even need any navigation in the first place (such as a single-screen game). However, most applications with more than a few screens will usually need some form of navigation to allow the user to move between them.

There is no single correct solution for applications that require navigation. Different mobile apps will always have different features and complexities. For example, it may be easier to use a JavaScript implementation in a brand new and relatively simple application without complex navigation requirements. However, we might find it easier to use a native solution if we plan on rolling React Native components into a native application. We should always weigh the benefits and challenges of each solution before deciding which approach to take.

[64] https://wix.github.io/react-native-navigation/#/
[65] http://airbnb.io/native-navigation/
[66] https://facebook.github.io/react-native/docs/navigation.html#react-navigation
[67] https://reacttraining.com/react-router/native/guides/philosophy

Deprecated solutions

Navigation is a core tenet of any native application. Just like other built-in components (such as `View` and `Text`), React Native also used to provide a number of different built-in navigation APIs. Here are a few examples:

- NavigatorIOS[a] provides an API to access the `UINavigationController` component for iOS to build a screen navigation stack. It is not currently maintained and cannot be used for Android.
- `Navigator` is a JavaScript navigation implementation that was included into React Native when it first launched. Expo built `ExNavigator` on top of this API with the aim of providing more. features. However, it did not provide a complete navigation solution and was deprecated soon after.
- `NavigationExperimental` is another JavaScript implementation and aimed to solve the problems noticed in `Navigator`. `ExNavigation` was built by the Expo team to act as a wrapper around `NavigationExperimental`. It is also now deprecated.

It is important to note that all of these APIs are either not maintained or are deprecated. It is recommended to use one of the newer community-built navigation libraries instead.

Since navigation is an important part of many mobile applications, all of these efforts were done in order to provide a simple React Native API that can be imported and used directly in a component. However, navigation is a lot more complex than many other built-in components. It is not easy to provide a simple navigation API that can solve all navigation concerns in any application. For this reason, a number of different open-source alternatives were created by the community. The efforts from `Navigator`, `NavigationExperimental`, and the community-built `ex-navigation` were combined to form the community-built `React Navigation` library.

[a] https://facebook.github.io/react-native/docs/navigatorios.html

In this chapter

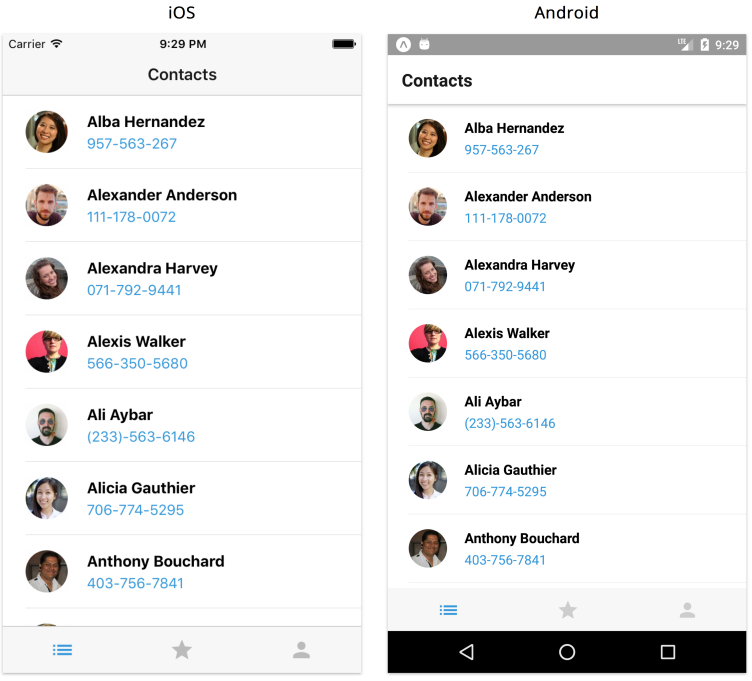
We covered the differences between native and JavaScript navigation implementations as well as some of their advantages and disadvantages. For each approach, we also discussed how using an open-source library that is continuously maintained can make things easier than building a navigation architecture from scratch.

Co-authored by the Facebook team and the open-source community, React Navigation[68] is the recommended option in the React Native documentation. For this reason, we'll use React Navigation, a JavaScript-based implementation, in this chapter to handle navigation in our sample application.

Contact List

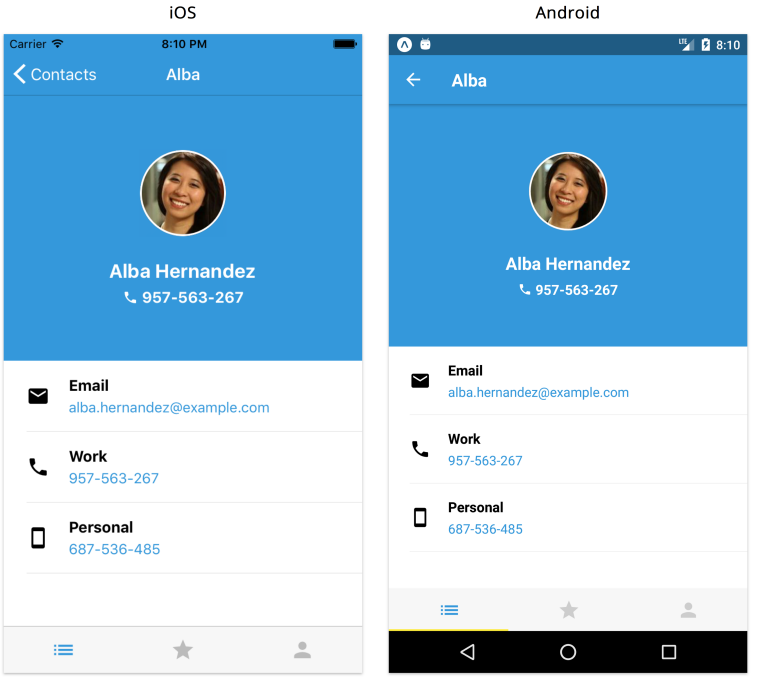
In this chapter, we're going to build a contact list application that allows a user to view contact information across several screens. We'll begin by building our first screen, `Contacts`, that shows a list of contact information fetched from a mock API.

[68] https://facebook.github.io/react-native/docs/navigation.html#react-navigation



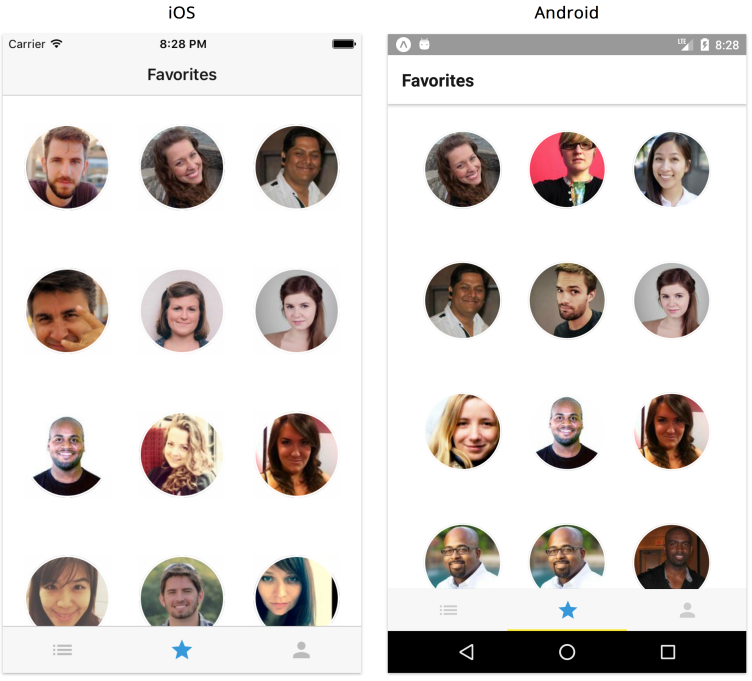
Contacts

Then we'll explore how we can allow the user to navigate to a separate `Profile` screen for each specific contact.



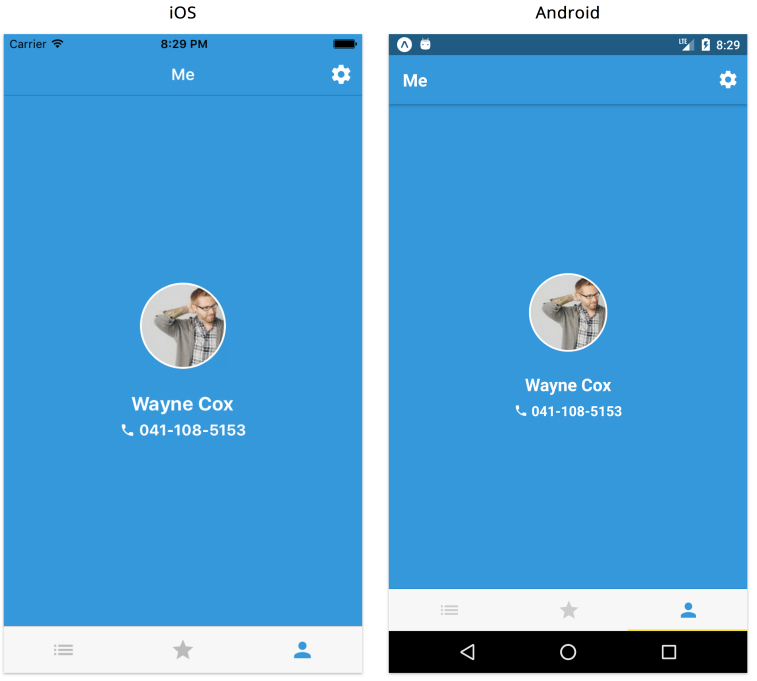
Profile

We'll then include another top level screen, `Favorites`, to show favorited contacts.



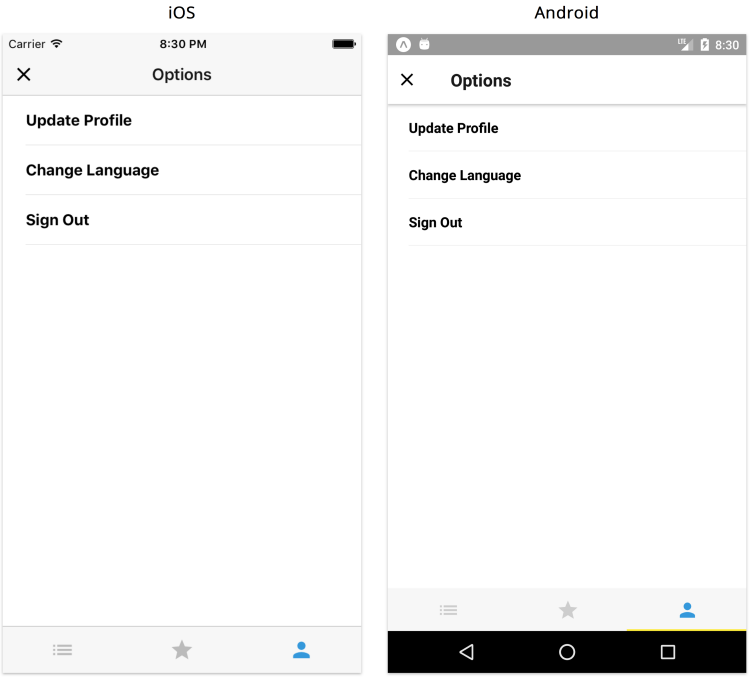
Favorites

Then we'll build a `User` screen and tie together our top level screens using a tab navigation component.



User

The last screen we'll create will be an options screen that the user can navigate to through the user screen.



Options

By building out each screen and connecting them, we'll get a better understanding of how a navigation pattern such as tabs can be coupled with stack navigation. While doing so, we'll also look into creating a small state container that controls the entire state of our app and can be accessed in any of our screens.

By the time we're finished with this chapter, we will have covered a number of different navigation patterns and show how they can fit together. We'll also be touching on a number of core concepts we've already covered in the previous chapters.

Previewing the app

Before we begin, to try the completed app on your device:

- On Android, you can scan this QR code with the Expo app:

QR Code

- On iOS, you can navigate to the `contact-list/` directory within the sample code folder and either preview it on the iOS simulator or send the link of the project URL to your device as we explained in the first chapter.

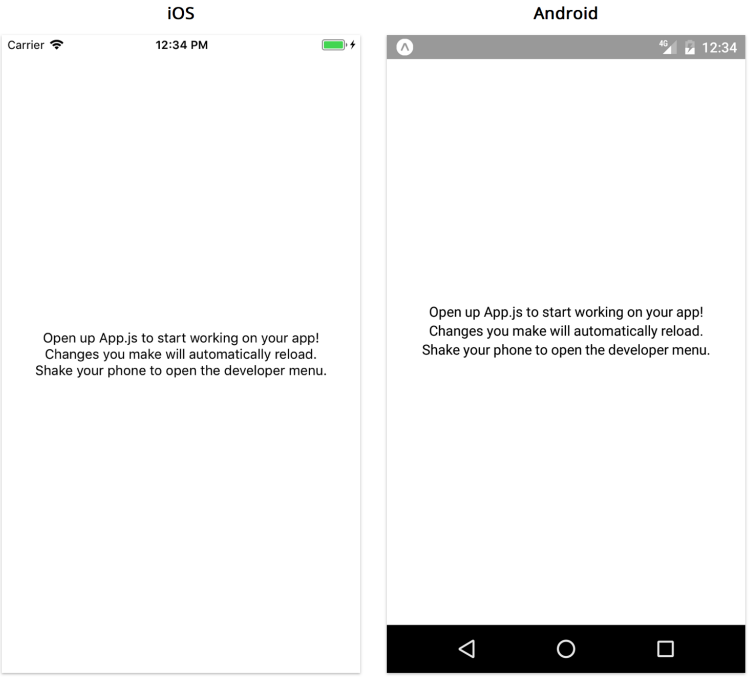
Spend a little time navigating between the different screens to get a feel for all the functionality.

Starting the project

Just as we did in the previous chapters, let's create a new app with the following command:

```
expo init contact-list --template blank@sdk-33 --yarn
```

Once this finishes, navigate into the `contact-list` directory and start the app.



Like you did in previous chapters, copy over the `contact-list/utils` directory from the sample code into your own project. The `utils/` directory contains the following:

- A few utility methods
- Methods that return results from a mock API. These are results copied from the Random User Generator[69] API and saved locally. A little delay is also included with each method.
- A colors object with a number of different colors

Copy over the `contact-list/components` directory as well. These components are the low level presentational components that don't manage any state of their own. They are used in the app to display UI elements in all of our screens. Here's a brief overview of each of the components:

- `ContactListItem` will be used for each contact's list item in the `Contacts` screen.

[69] https://randomuser.me/

- `ContactThumbnail` renders a thumbnail for the contact avatar that can fire an action when pressed. It can also show the user's name and phone number underneath based on optional props. This component will be used to render a list of user avatars in the `Favorites` screen as well as show the user thumbnail in the `Profile` and `User` screens.
- `DetailListItem` shows a list item with a title, subtitle, and an optional icon. This component will be used to show contact details in the `Profile` screen as well as mocked links in the `Options` screen.

Feel free to dive in and take a closer look at any of the files within `utils/` and `components/` to get a better idea of how they work.

Container and Presentational components

Before we dive in to building our application, let's take a little time to further understand how we separate our screen and component logic. In all of our previous chapters, we explored building custom components to create higher-level abstractions over built-in components (such as `View`, `Text`, etc...). We can think of *screens* in the same way. Just like any other component, screens wrap over lower level components. The difference here is that we can build our screen components to take up the entire device screen and allow the user to navigate between them.

We briefly explored this pattern in the "Core Components" chapter where we built a `Feed` and `Comments` screen for our Instagram clone app. While doing so, we managed all of our remote data fetching within the `Feed` screen and the rest of our lower level components only received this information via `props`. This further ties in to the pattern we've seen in each of the applications we've built in this book so far: the concept of *container* components that take care of data fetching and state management and *presentational* components that take in data and provide the markup and styling in our application. We can closely follow this logic by separating how we build screens and components in an application.

Although the `Feed` screen was responsible for data fetching in our Instagram clone app, we still had some state managed in our root `App` component. For a relatively large application with a significant number of screens, managing data in a single component like `App` may not be the most maintainable way to handle state. For this

reason, third-party state container libraries are commonly used. Instead of using a specific library and trying to understand its APIs, we'll handle data in our application by writing a small custom state container. The same pattern will apply to any complex application with a central state container regardless of which library is used.

Contacts

The first screen we'll build is the main contacts screen which will also serve as the starting point of our application. Create a `screens/` directory and add a `Contacts.js` file. As we mentioned in the "Core Components" chapter, a more complex application might be structured with directories nested within `screens/` for better categorizing of files. Since this application only consists of five screens, we'll add them all to the `screens/` directory.

We'll begin by defining our imports in the file:

contact-list/1/screens/Contacts.js

```
import React from 'react';
import {
  StyleSheet,
  Text,
  View,
  FlatList,
  ActivityIndicator,
} from 'react-native';

import ContactListItem from '../components/ContactListItem';

import { fetchContacts } from '../utils/api';
```

We've imported a few necessary built-in components including `FlatList` and `ActivityIndicator` as well as our custom `ContactListItem` component responsible for displaying each of our contacts items in the list. Aside from components, we also import the `fetchContacts` method in order to retrieve our list of contacts and our colors object from `utils`.

Now let's begin creating our class component:

contact-list/1/screens/Contacts.js

```
export default class Contacts extends React.Component {
  state = {
    contacts: [],
    loading: true,
    error: false,
  };

  async componentDidMount() {
    try {
      const contacts = await fetchContacts();

      this.setState({
        contacts,
        loading: false,
        error: false,
      });
    } catch (e) {
      this.setState({
        loading: false,
        error: true,
      });
    }
  }
```

We've set up local component state that includes a `contacts` array and `loading`/`error` attributes. In here, we've set our initial `loading` property to `true` because we fire our API call as soon as our component mounts. We then update this to `false` as soon as our request finishes successfully.

Let's now build the UI that gets rendered on the screen:

contact-list/1/screens/Contacts.js

```
  renderContact = ({ item }) => {
    const { name, avatar, phone } = item;

    return (
      <ContactListItem name={name} avatar={avatar} phone={phone} />
    );
  };

  render() {
    const { loading, contacts, error } = this.state;

    const contactsSorted = contacts.sort((a, b) =>
      a.name.localeCompare(b.name),
    );

    return (
      <View style={styles.container}>
        {loading && <ActivityIndicator size="large" />}
        {error && <Text>Error...</Text>}
        {!loading &&
          !error && (
            <FlatList
              data={contactsSorted}
              keyExtractor={keyExtractor}
              renderItem={this.renderContact}
            />
          )}
      </View>
    );
  }
```

In the component `render` method, we sort our contacts alphabetically and show a loading indicator if `state.loading` is true, an error message if `state.error` is true, or a list of our contacts using `FlatList`. For each item in the list, we use a `renderContact`

helper method that passes down the contact `name`, `avatar` and `phone` as props to `ContactListItem`.

We'll also need to create our list's `keyExtractor` method which we can write under our imports at the top of the file:

contact-list/1/screens/Contacts.js

```
import { fetchContacts } from '../utils/api';

const keyExtractor = ({ phone }) => phone;

export default class Contacts extends React.Component {
```

The last thing we'll need to do is set up the styles for this component. Since our existing presentational component `ContactListItem` takes care of most of our styling, we'll just set up styles for the container `View` component:

contact-list/1/screens/Contacts.js

```
const styles = StyleSheet.create({
  container: {
    backgroundColor: 'white',
    justifyContent: 'center',
    flex: 1,
  },
});
```

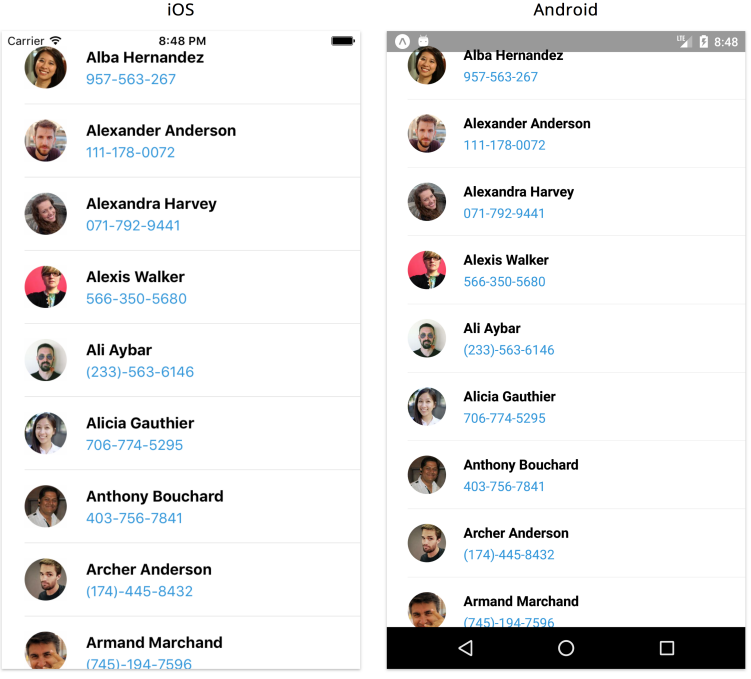
Try it out

To quickly take a look at how this screen renders, we can temporarily place this component within `App`:

contact-list/App.js

```
import React from 'react';

import Contacts from './screens/Contacts';

export default function App() {
  return <Contacts />;
}
```

Now we can see our `Contacts` screen if we run the app:



Contacts

You may notice the top and bottom of our list touches the edges of our device screen. This will be fixed once we introduce our header and tab navigation components to the app. Pressing any of the contacts does not do anything just yet. We'll explore how we can navigate to a specific contact's profile screen in a bit.

You may also see a warning about a missing `onPress` prop which is required in the `ContactListItem` component. We'll include it once we begin adding navigation to our application.

Profile

Let's move on to building our second screen, `Profile`, which shows details about a specific contact. Create a `Profile.js` file within the same screens directory. Again, we'll begin with our imports:

contact-list/1/screens/Profile.js

```
import React from 'react';
import { StyleSheet, View } from 'react-native';

import ContactThumbnail from '../components/ContactThumbnail';
import DetailListItem from '../components/DetailListItem';

import { fetchRandomContact } from '../utils/api';

import colors from '../utils/colors';
```

We've included the `ContactThumbnail` and `DetailListItem` presentational components that we'll need for this screen as well as the `colors` object we'll use for some styling.

We've also included `fetchRandomContact` to obtain a random contact's information. This is temporary in order to render this screen for the first time, but will be removed once we have navigation in place and the contact ID is passed from the previous screen to the `Profile` screen.

We can build our class component as follows:

contact-list/1/screens/Profile.js

```
export default class Profile extends React.Component {
  state = {
    contact: {},
  };

  async componentDidMount() {
    const contact = await fetchRandomContact();

    this.setState({
      contact,
    });
  }

  render() {
    const { avatar, name, email, phone, cell } = this.state.contact;

    return (
      <View style={styles.container}>
        <View style={styles.avatarSection}>
          <ContactThumbnail
            avatar={avatar}
            name={name}
            phone={phone}
          />
        </View>
        <View style={styles.detailsSection}>
          <DetailListItem
            icon="mail"
            title="Email"
            subtitle={email}
          />
          <DetailListItem
            icon="phone"
            title="Work"
            subtitle={phone}
```

```
            />
            <DetailListItem
              icon="smartphone"
              title="Personal"
              subtitle={cell}
            />
          </View>
        </View>
      );
    }
}
```

We've defined a `contact` object as our only attribute in our component state. Our `componentDidMount` method fires an API call to get a random contact. Again, this is temporary until we've included our navigation library. This is because we'll eventually pass the contact's information from the `Contacts` screen.

We have not included any `loading` or `error` attributes for this same reason. This is because once navigation is in place, this screen will only be accessible through another screen by pressing on a contact list item or thumbnail. This means there will be no loading or potential errors from data fetching happening at this point.

Although this might usually be the case when building screens that are only accessible through other screens in a stack, there are scenarios where we may need to fetch data in nested screens. A good example is *deep linking* which allows a user to navigate to a certain part of the app through another app or a web browser using a specific link. We'll explore this topic later in this chapter.

The `render` method is relatively straightforward. We show the user thumbnail for the top half of the screen using `ContactThumbnail` as our component (which accepts the user's avatar, name, and phone as props). For the bottom half of the screen, we're displaying a few `DetailListItem` components to show the user's email, work, and cell numbers.

We can now create styling for the `View` container components we're using for layout at the end of the file:

contact-list/1/screens/Profile.js

```
const styles = StyleSheet.create({
  container: {
    flex: 1,
  },
  avatarSection: {
    flex: 1,
    alignItems: 'center',
    justifyContent: 'center',
    backgroundColor: colors.blue,
  },
  detailsSection: {
    flex: 1,
    backgroundColor: 'white',
  },
});
```

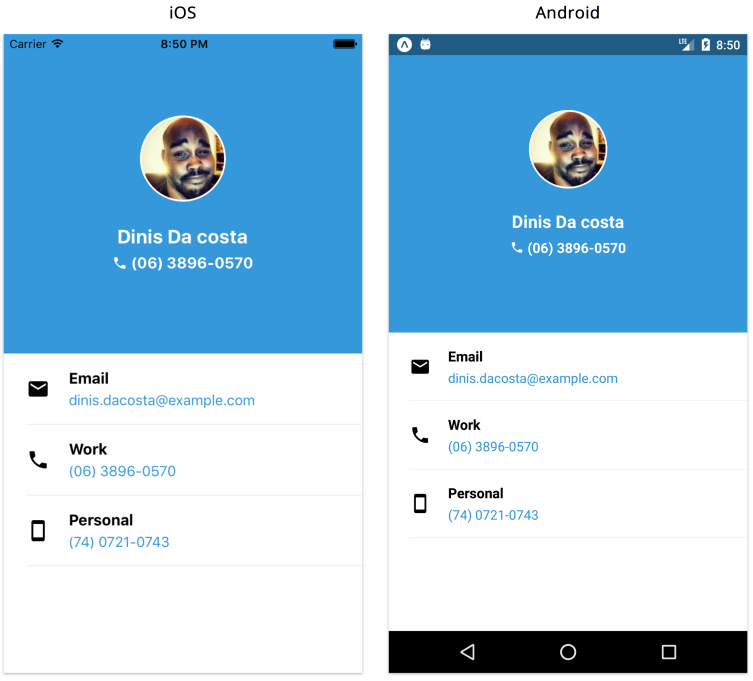
Try it out

Once again, let's render our screen to see if everything is working well:

contact-list/App.js

```
import React from 'react';

import Profile from './screens/Profile';

export default function App() {
  return <Profile />;
}
```

Running the app should show the `Profile` screen for a random contact:



Profile

React Navigation

Now that we have our first two screens in place, let's start adding navigation to our app! As we mentioned earlier in the chapter, there are a number of different open-source navigation libraries available. We'll be using React Navigation[70] for this application. Since it's purely a JavaScript implementation, we don't have to worry about linking iOS and Android dependencies. We can install it to our app by using `yarn`:

```
yarn add react-navigation@3.6.0
```

Specify version `3.6.0` as above so that the version in your application matches the version we use here.

[70] https://facebook.github.io/react-native/docs/navigation.html#react-navigation

`react-navigation` uses a separate library, `react-native-gesture-handler`[a], under the hood to leverage the native touch handling system to handle user gestures instead of the built-in "responder system" that React Native uses by default.

This library exposes the native platform's predefined gesture handlers (rotate, pan, long press, pinch, etc), and supports relationships between these gesture handlers, e.g. a tap gesture within a ScrollView should slightly delay any highlight states. In the next chapter we'll cover React Native's built-in gesture handling, which is a good choice for simple gestures and gestures that require custom JavaScript logic, but it's good to keep `react-native-gesture-handler` in mind for when you need the common native gestures.

With Expo, the library is already included automatically. If you need to use `react-navigation` without using an Expo managed workflow, you will need to install and link this library separately. The instructions[b] in the `react-navigation` documentation show you how.

[a] https://github.com/kmagiera/react-native-gesture-handler
[b] https://reactnavigation.org/docs/en/getting-started.html#installation

Stack navigation

We briefly described how a stack navigator works earlier in this chapter. This pattern allows a user to navigate from one screen to another by *pushing* the new screen to the top of the stack. The user can also *pop* the current screen off the stack in order to return to the previous screen.

In both iOS and Android, a back button at the top of the navigation bar is how a user usually navigates back to a previous screen by removing the current screen off the stack. On Android devices, there is also a physical or soft key back button at the bottom of the device screen that also allows you to go back on any application.

With this navigation flow, only one screen is visible at any given time. We can think of the entire navigation stack as an ordered array of screens, with the last element being the screen that is currently visible and the first element being the root screen (or the screen that is visible when loading the app for the first time).

Let's begin by connecting our first two screens as a single stack. We'll define all of our navigation logic in a separate `routes.js` file at the root of our entire app.

Create the file and add the following code:

contact-list/2/routes.js

```
import { createStackNavigator, createAppContainer } from 'react-navigat\
ion';

import Contacts from './screens/Contacts';
import Profile from './screens/Profile';

const StackNavigator = createStackNavigator({
  Contacts: {
    screen: Contacts,
  },
  Profile: {
    screen: Profile,
  },
});

export default createAppContainer(StackNavigator);
```

We pass in our *route configuration* as an argument to `createStackNavigator`. The object maps route names to their configuration. We have two routes defined above, `Contacts` and `Profile`.

For each route, we define a configuration object with just one property: `screen`. This is the component we wish to render at that specific route. We'll explore more configuration options in a bit.

We can also pass a second argument to `createStackNavigator`, our *stack navigator configurations*. We'll also explore this a little later in this section.

In React Navigation, every navigator including `createStackNavigator` creates a higher-order component that wraps over each of the screen components defined within its route configurations. It *enhances* each of its components by creating a new component with a **`navigation`** prop.

Finally, we export `createAppContainer` which defines a **navigation container**. This allows you to manage app state and define top-level navigations in your application.

Higher-Order Components

In short, **higher-order components** are functions that take in an existing component and return a new component with added functionality. They're useful for minimizing code duplication by containing common logic in a single component that can be shared among multiple components. They're also useful for libraries like React Navigation.

Internally, `createStackNavigator()` generates a higher-order component that provides each of our screens with a `navigation` prop. This prop serves as the interface between our screen components and the React Navigation library.

For more information on higher-order components, refer to its section in the Appendix.

The `navigation` prop provides us with the following:

- `navigate`: Method to allow us to navigate between screens. With a stack navigator, this method pushes the new screen on top of the current stack.
- `state`: Object that returns the name and identifier of the current route as well as its parameters.
- `setParams`: Method to change the current screen's parameters.
- `goBack`: Method that allows us to navigate to a previous screen. For stack navigation, this pops the current screen (or number of screens) until the specified screen is reached within the stack.

The React Navigation documentation[71] contains more detail about the navigation prop.

Let's now modify our `App.js` file to render our container instead of a single component:

[71] https://reactnavigation.org/docs/navigation-prop.html

contact-list/2/App.js

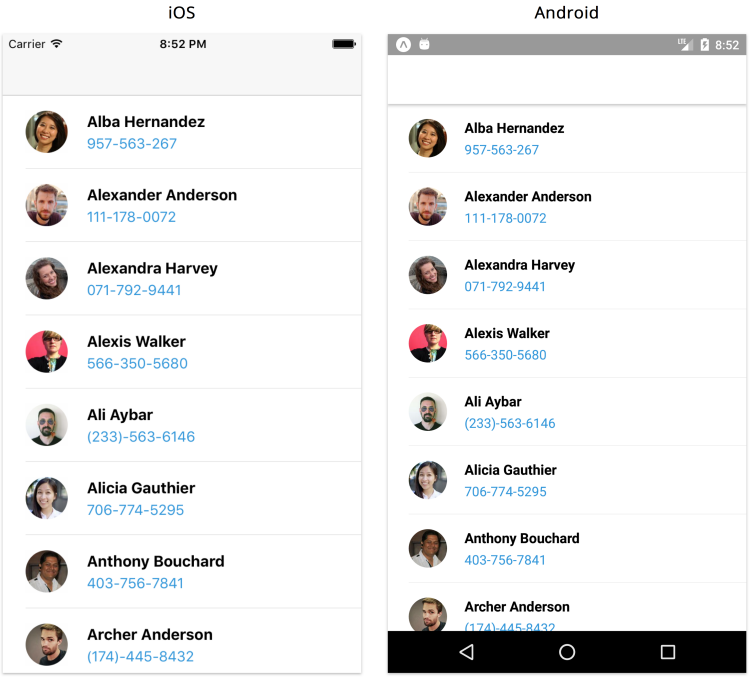
```
import React from 'react';

import AppContainer from './routes';

export default function App() {
  return <AppContainer />;
}
```

Now that we've set up the first stack navigator of our application, we'll need to use our navigation prop to allow the user to navigate from the `Contacts` screen to the `Profile` screen. We know that the `ContactListItem` component contains an `onPress` prop that fires the action passed to it. Let's modify how we render this component within our `Contacts` screen:

contact-list/2/screens/Contacts.js

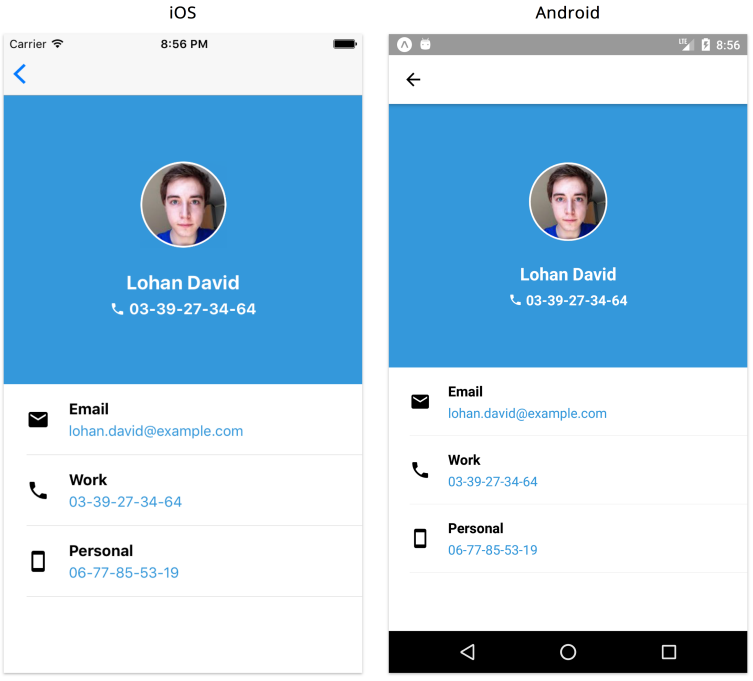
```
  renderContact = ({ item }) => {
    const { navigation: { navigate } } = this.props;
    const { name, avatar, phone } = item;

    return (
      <ContactListItem
        name={name}
        avatar={avatar}
        phone={phone}
        onPress={() => navigate('Profile')}
      />
    );
  };
```

Try running the app and you'll notice a header navigation bar at the top of the screen. In addition to supplying the `navigation` prop, the `createStackNavigator` HOC also renders a header above the screen components it wraps.



Contacts

Pressing any contact will navigate to the profile screen. The default behaviour for iOS is an animation that slides the new screen from the right. For Android, the newer screen fades in from the bottom.



Profile

Pressing the back button also pops the profile screen of the stack and returns us to the contacts screen.

Although our stack navigation pattern works, we have two problems:

- Recall that we're using the `fetchRandomContact()` method to obtain a random contact. This means that pressing a specific contact doesn't actually load their information in the `Profile` screen.
- The header navigation bar doesn't currently show anything. We should attempt to show the current screen name so the user knows which screen they're on.

Navigation parameters

When building multiple screens in a mobile application, it is common to have screens that depend on some particular data in order to display the correct information. A good example is the `Profile` screen in this application. Everytime a user presses a

contact on the `Contacts` screen, we expect to see that specific contact's information on the next screen.

The secondary screen here is *not* a child of the previous screen, but it still relies on a piece of data. In these scenarios, we need to be able to pass this data as part of the transition in our navigation flow. React Navigation lets us attach *navigation parameters* using the `navigate` method.

We previously mentioned that the `navigation` prop allows us to change parameters for a screen using its `setParams` method. We can similarly pass parameters to another screen. Let's take a look at how we set this up for navigating from the `Contacts` screen to `Profile`:

contact-list/3/screens/Contacts.js

```
  renderContact = ({ item }) => {
    const { navigation: { navigate } } = this.props;
    const { id, name, avatar, phone } = item;

    return (
      <ContactListItem
        name={name}
        avatar={avatar}
        phone={phone}
        onPress={() => navigate('Profile', { contact: item })}
      />
    );
  };
```

In the second argument of the `navigate` method, we pass a single object for our parameters that contains a `contact` key with the value being the actual contact item. This means that every time we press a contact on the `Contacts` screen, the user is navigated to the `Profile` screen with the actual contact being passed as a parameter.

With this, we can simplify our `Profile` screen component and not load a specific contact every time the screen is mounted:

Since we are now receiving a contact object through navigation props, we no longer need to fetch a random contact using `fetchRandomContact()`. We can simplify our `Profile` screen and not fire any API calls when our screen mounts:

contact-list/3/screens/Profile.js

```
export default class Profile extends React.Component {
  render() {
    const { navigation: { state: { params } } } = this.props;
    const { contact } = params;
    const { avatar, name, email, phone, cell } = contact;

    return (
      <View style={styles.container}>
        <View style={styles.avatarSection}>
          <ContactThumbnail
            avatar={avatar}
            name={name}
            phone={phone}
          />
        </View>
        <View style={styles.detailsSection}>
          <DetailListItem
            icon="mail"
            title="Email"
            subtitle={email}
          />
          <DetailListItem
            icon="phone"
            title="Work"
            subtitle={phone}
          />
          <DetailListItem
            icon="smartphone"
            title="Personal"
            subtitle={cell}
          />
        </View>
      </View>
    );
  }
```

```
}
```

We've removed all local state from `Profile` and the component is now driven by props. We extract the `contact` object from the `navigation` prop and use that to render the contact's information. If you try running the app now, navigating to a specific contact will show the correct information.

Although passing in the contact object as a navigation parameter works, we generally want to avoid this pattern.

So far, we've explored how parents and children use props to communicate. If a parent performs a state update, that update propagates through props down to its children. When the child receives the updated props, the child re-renders.

What's different here is that `Profile` is *not* a direct child of the `Contacts` screen. Instead `Profile` is receiving this data through navigation parameters. Navigation parameters are set once, at the time of navigation. So if the state for a contact changes, that state update will *not* be propagated through navigation parameters.

Put another way, we've pushed a copy of a part of our state into navigation parameters. But we have no means in place to *update* that copy when the state changes.

So, we should instead pass the `id` of a contact as a parameter. Then, `Profile` can look up the contact in the list of all contacts. We'll explore this improvement once we introduce a centralized location for all our state later in this chapter.

We've built the first two screens that make up our first navigator. We covered how to transition between them by using the API supplied by the `navigation` prop.

Each screen will usually have its own unique set of features, and we'll sometimes need to be able to modify how our navigation-specific components are displayed. Next, we'll explore how to configure our navigation screen options before moving on to expanding the number of screens and navigation patterns in our application.

Navigation screen options

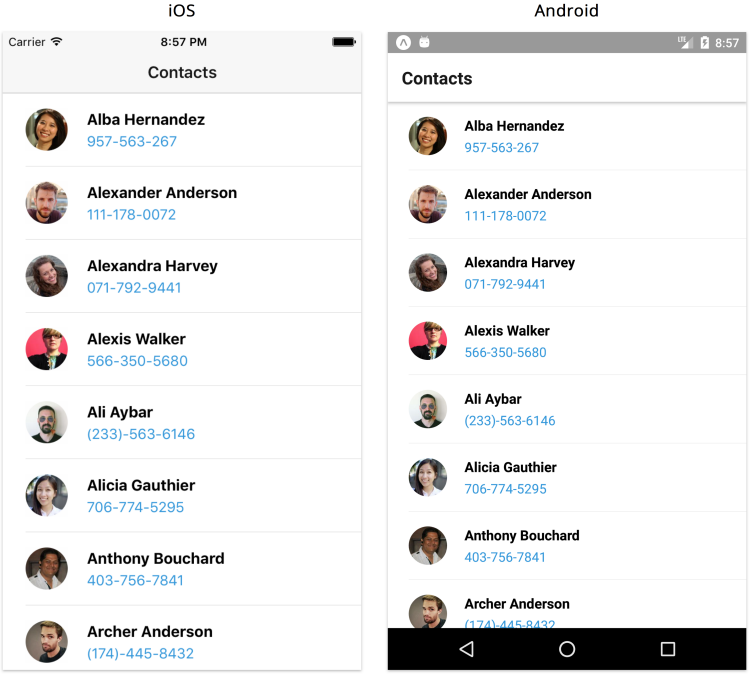
With React Navigation, we can use the `navigationOptions` property to modify navigation settings for a particular screen *or* to modify settings for every screen within a navigator (such as `createStackNavigator`).

We'll use this property to add a title to the navigation header at the top of both screens. Let's add it to each of our screens in `route.js`:

contact-list/3/routes.js

```
const StackNavigator = createStackNavigator({
  Contacts: {
    screen: Contacts,
    navigationOptions: {
      title: 'Contacts',
    },
  },
```

We add our options using a `navigationOptions` object. We specify the `title` attribute to be `Contacts`. We can run the application to confirm that this works.



Contacts

Now let's do the same for the `Profile` screen along with adding a few more details:

contact-list/3/routes.js

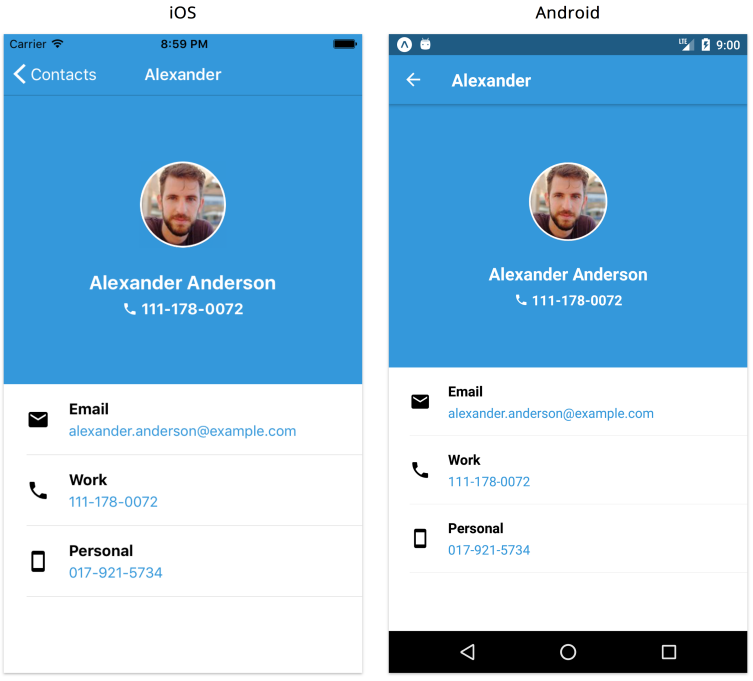
```
  Profile: {
    screen: Profile,
    navigationOptions: ({ navigation: { state: { params } } }) => {
      const { contact: { name } } = params;
      return {
        title: name.split(' ')[0],
        headerTintColor: 'white',
        headerStyle: {
          backgroundColor: colors.blue,
        },
      };
    },
  },
```

Although we passed in an object to `navigationOptions` for the `Contacts` screen, we also can pass in a function. Passing a function gives us access to the `navigation` prop. This is useful when we want our options to be derived from the navigation parameters. Here, we get the name of our contact and use the `split`[72] method to only render her or his first name as the title

We also modify the colors of our header by using `headerTintColor`, which allows us to change the text color, and `headerStyle` to pass in an object of styles for the header. We change the `backgroundColor` to blue.

If we try navigating to the `Profile` screen now, we'll see our header styled appropriately.

[72] https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/String/split



Profile

Notice on iOS that the title on the left of the header defaults to the `title` of the previous screen. We have control over this with the `headerBackTitle` property of navigation options if we need to modify this.

For a full list of navigator configuration options provided by `createStackNavigator`, refer to the documentation[73].

[73] https://reactnavigation.org/docs/navigators/stack

Default Navigation Options

Although we can specify all of our navigation options for each screen separately, it may be useful to set default navigation options for multiple screens if they all share the same configurations. We can do this by defining `navigationOptions` at the level of the navigator. For example:

```
const StackNavigator = createStackNavigator({
  Contacts: {
    screen: Contacts,
    navigationOptions: {
      headerStyle: {
        backgroundColor: 'white',
      },
    },
  },
  Profile: {
    screen: Profile,
  },
}, {
  navigationOptions: {
    headerStyle: {
      backgroundColor: colors.blue,
    },
  },
});
```

Screen-specific navigation options for the same configuration will overwrite those defined for the navigator. In this example, all the screens within this navigator will have a default background color of blue for their header components. The `Contacts` screen however will have a white background color that overwrites the default setting.

Although we can add all of our screen-specific navigation options where we define our navigators in `routes.js`, that file can quickly become quite large if we have a lot of screens and configuration settings. We can instead define each screen's navigation options inside each component.

Let's begin with `Contacts`. We'll remove the `navigationOptions` property from our

`routes.js` file and add it as a static class method to the `Contacts` component:

contact-list/4/screens/Contacts.js

```
export default class Contacts extends React.Component {
  static navigationOptions = {
    title: 'Contacts',
  };

  state = {
```

This is the same technique we've used previously for `propTypes` and `defaultProps`. We can now do the same thing for `Profile`:

contact-list/4/screens/Profile.js

```
export default class Profile extends React.Component {
  static navigationOptions = ({
    navigation: { state: { params } },
  }) => {
    const { contact: { name } } = params;
    return {
      title: name.split(' ')[0],
      headerTintColor: 'white',
      headerStyle: {
        backgroundColor: colors.blue,
      },
    };
  };

  render() {
```

Without the `navigationOptions` properties, we can clean up our `routes.js` file:

contact-list/4/routes.js

```
import { createStackNavigator } from 'react-navigation';

import Contacts from './screens/Contacts';
import Profile from './screens/Profile';

const StackNavigator = createStackNavigator({
  {
    Contacts,
    Profile,
  },
  {
    initialRouteName: 'Contacts',
  },
});

export default createAppContainer(StackNavigator);
```

Since the screen components are the only route configurations we have for both screens, we've simplified things here by just using the shorthand format.

The only new addition here is the `initialRouteName` property. Without this property, the first screen listed is the default screen. Explicitly defining the initial route is optional, but it can make things more obvious to anyone unfamiliar with the API. It also reduces the risk of the wrong screen being displayed as the default if any screens are added or removed.

Now, wherever this navigator is loaded in the application, the first screen that shows will be the `Contacts` screen.

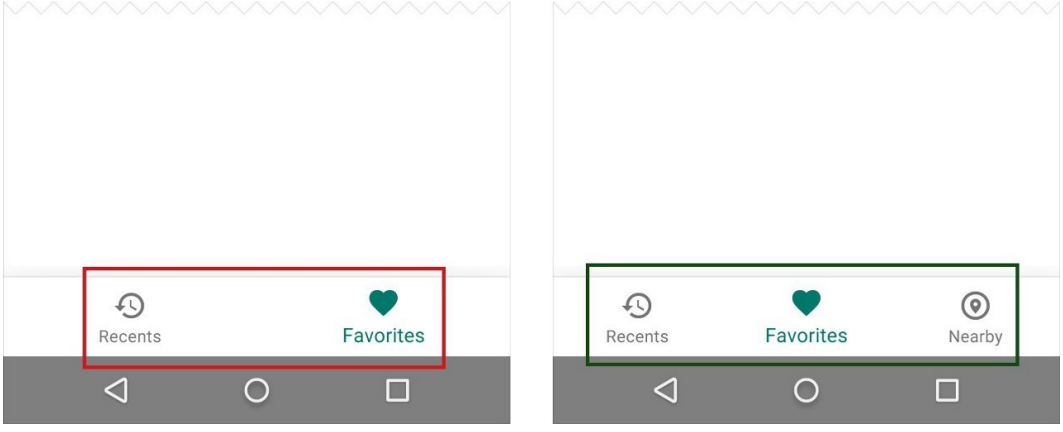
Like `initialRouteName`, React Navigation allows us to modify a number of different configuration properties for stack navigators besides `navigationOptions`. The documentation[74] goes into more detail on each of them.

[74] https://reactnavigation.org/docs/stack-navigator.html#stacknavigatorconfig

Tab navigation

A single stack navigator might suffice for a small mobile app with just two or three screens. However, most applications have more than a few screens and only using stack navigation may not be the most efficient way to navigate throughout the entire app. This is where another navigation paradigm, like tabs, can be useful.

We can use tab navigation to allow the user to navigate to a number of different screens at the root level. Tabs are suitable when a number of screens carry roughly equal importance.



Bottom navigation - (from Material Design documentation - Components)

Favorites

Before we begin adding tab navigation components to our application, we'll need to build a few more screens. Let's build the `Favorites` screen of our application first. We can create a `Favorites.js` file within the screens directory and begin with its imports:

contact-list/5/screens/Favorites.js

```
import React from 'react';
import {
  StyleSheet,
  Text,
  View,
  FlatList,
  ActivityIndicator,
} from 'react-native';

import { fetchContacts } from '../utils/api';

import ContactThumbnail from '../components/ContactThumbnail';
```

As we briefly described earlier in this chapter, this screen will be responsible for showing a list of favorited contacts.

The `Favorites` component will not be a child of the `Contacts` component. And because we'll be using tab navigation as opposed to stack navigation, we can't pass `contacts` to favorites via a navigation prop.

Therefore, we'll use the `fetchContacts()` function to fetch this data directly from the API. We usually want to avoid making numerous API calls to obtain the same data on every screen. Once we include a state container later in the chapter, we'll remove this.

Note that we've set up the `fetchContacts` API call to randomly "favorite" contacts by setting the `favorites` boolean on the `contact` object to `true`. That way, we should always have some contacts displayed on this screen.

contact-list/5/screens/Favorites.js

```
export default class Favorites extends React.Component {
  static navigationOptions = {
    title: 'Favorites',
  };

  state = {
    contacts: [],
    loading: true,
    error: false,
  };

  async componentDidMount() {
    try {
      const contacts = await fetchContacts();

      this.setState({
        contacts,
        loading: false,
        error: false,
      });
    } catch (e) {
      this.setState({
        loading: false,
        error: true,
      });
    }
  }
```

The screen's `render` function:

contact-list/5/screens/Favorites.js

```
  renderFavoriteThumbnail = ({ item }) => {
    const { navigation: { navigate } } = this.props;
    const { avatar } = item;

    return (
      <ContactThumbnail
        avatar={avatar}
        onPress={() => navigate('Profile', { contact: item })}
      />
    );
  };

  render() {
    const { loading, contacts, error } = this.state;
    const favorites = contacts.filter(contact => contact.favorite);

    return (
      <View style={styles.container}>
        {loading && <ActivityIndicator size="large" />}
        {error && <Text>Error...</Text>}

        {!loading &&
          !error && (
            <FlatList
              data={favorites}
              keyExtractor={keyExtractor}
              numColumns={3}
              contentContainerStyle={styles.list}
              renderItem={this.renderFavoriteThumbnail}
            />
          )}
      </View>
    );
  }
```

In `render`, we filter our list of contacts using a `favorites` flag. Using the same pattern we used in `Contacts`, we show a loading indicator while the request is still being made, an error message if the request fails, or the list of contacts.

We're making use of the `numColumns` prop for `FlatList` to render three contacts in every row. The `renderFavoriteThumbnail` method is responsible for every item in the list where we use our `ContactThumbnail` component to display the user's avatar. Notice how we've also passed in a `navigate` action to the `onPress` prop. This allows the user to navigate to the contact's profile screen by pressing an avatar on the `Favorites` screen - just like when they press a contact on the `Contacts` screen.

Since we're using `FlatList` again, we can hook up a `keyExtractor` method once more:

contact-list/5/screens/Favorites.js

```
import ContactThumbnail from '../components/ContactThumbnail';

const keyExtractor = ({ phone }) => phone;

export default class Favorites extends React.Component {
```

And we can finish things off here by adding a few styles:

contact-list/5/screens/Favorites.js

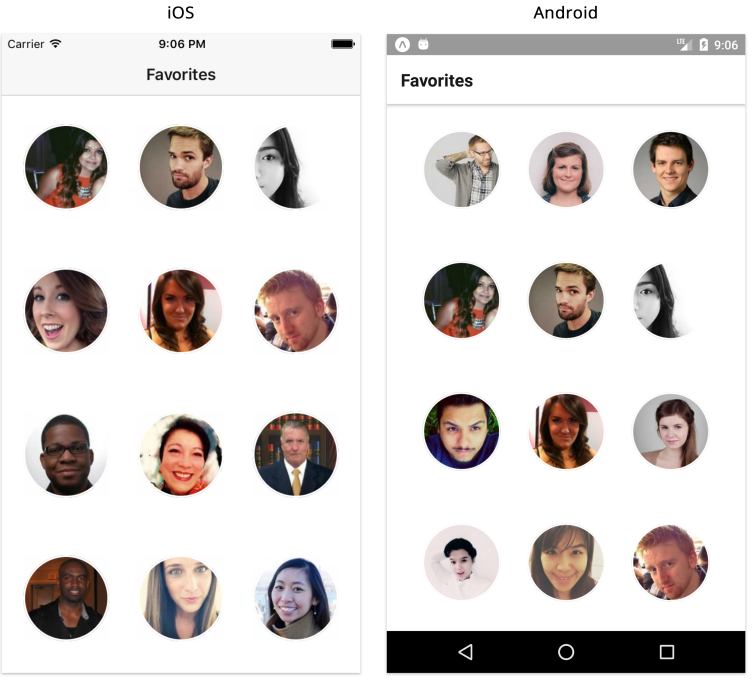
```
const styles = StyleSheet.create({
  container: {
    backgroundColor: 'white',
    justifyContent: 'center',
    flex: 1,
  },
  list: {
    alignItems: 'center',
  },
});
```

Try it out

In a moment, we'll build the `Users` screen then add tab navigation to our app. Before we do, let's add `Favorites` to our stack navigator just so we can see what it looks like. We'll set it as our initial route:

contact-list/routes.js

```
import { createStackNavigator } from 'react-navigation';

import Contacts from './screens/Contacts';
import Profile from './screens/Profile';
import Favorites from './screens/Favorites';

const StackNavigator = createStackNavigator(
  {
    Contacts,
    Profile,
    Favorites,
  },
  {
    initialRouteName: 'Favorites',
  },
);

export default createAppContainer(StackNavigator);
```



Favorites

Note that pressing on any avatar navigates to the `Profile` screen.

As `Favorites` will not be a part of our stack navigation, go ahead and revert the changes here to the original route configurations.

User screen

Let's now build the third root screen, `User`, which displays the details of the user of the app. We'll begin with its imports:

contact-list/5/screens/User.js

```
import React from 'react';
import {
  StyleSheet,
  Text,
  View,
  ActivityIndicator,
} from 'react-native';

import ContactThumbnail from '../components/ContactThumbnail';

import colors from '../utils/colors';
import { fetchUserContact } from '../utils/api';
```

We're using another method, `fetchUserContact`, from our API utility file. This fetches a single contact.

We define the header styles at the top of the component:

contact-list/5/screens/User.js

```
export default class User extends React.Component {
  static navigationOptions = {
    title: 'Me',
    headerTintColor: 'white',
    headerStyle: {
      backgroundColor: colors.blue,
    },
  };
```

Similar to the `Profile` screen, we're displaying a blue header bar with white text.

Our local state and `componentDidMount` method will follow the same pattern as other screens:

contact-list/5/screens/User.js

```
  state = {
    user: [],
    loading: true,
    error: false,
  };

  async componentDidMount() {
    try {
      const user = await fetchUserContact();

      this.setState({
        user,
        loading: false,
        error: false,
      });
    } catch (e) {
      this.setState({
        loading: false,
        error: true,
      });
    }
  }
```

Our `render` method will show the `ContactThumbnail` with the user's name, avatar and phone number:

contact-list/5/screens/User.js

```
  render() {
    const { loading, user, error } = this.state;
    const { avatar, name, phone } = user;

    return (
      <View style={styles.container}>
        {loading && <ActivityIndicator size="large" />}
        {error && <Text>Error...</Text>}

        {!loading && (
          <ContactThumbnail
            avatar={avatar}
            name={name}
            phone={phone}
          />
        )}
      </View>
    );
  }
```

And finally, we'll style our container to have a blue background as well as place our thumbnail in the center of our screen:

contact-list/5/screens/User.js

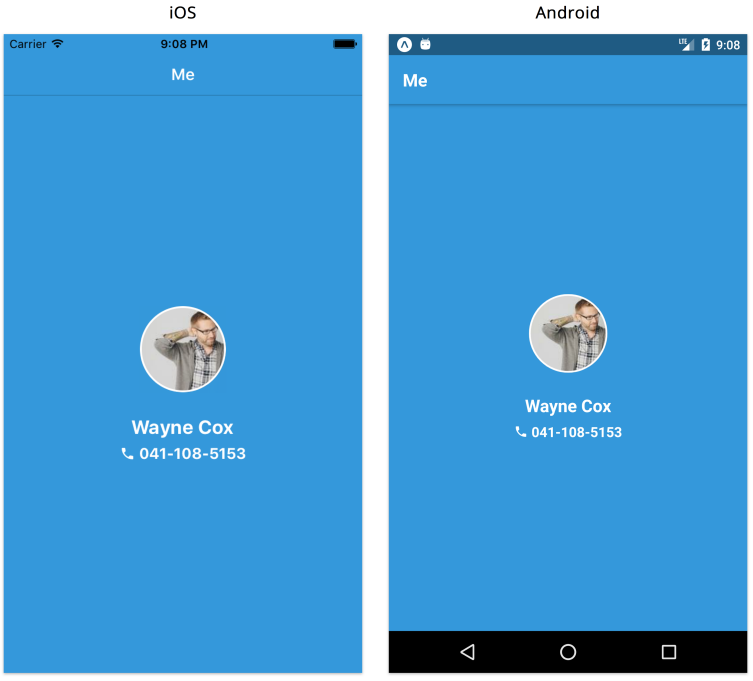
```
const styles = StyleSheet.create({
  container: {
    flex: 1,
    alignItems: 'center',
    justifyContent: 'center',
    backgroundColor: colors.blue,
  },
});
```

Try it out

We'll again temporarily modify our `routes.js` file to test out this component:

contact-list/routes.js

```
import { createStackNavigator } from 'react-navigation';

import Contacts from './screens/Contacts';
import Profile from './screens/Profile';
import User from './screens/User';

const StackNavigator = createStackNavigator(
  {
    Contacts,
    Profile,
    User,
  },
  {
    initialRouteName: 'User',
  },
);

export default createAppContainer(StackNavigator);
```



User

Nested navigators

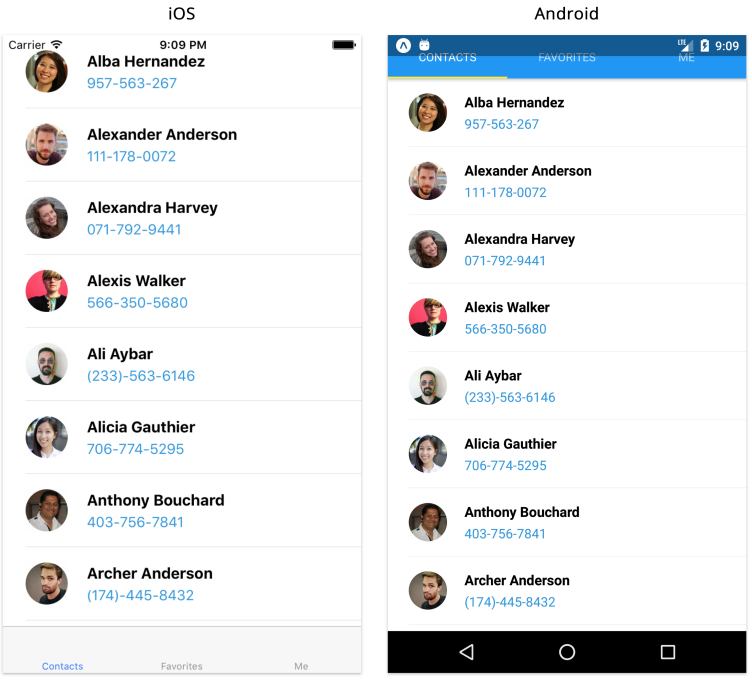
Now that we have all the screens that make up our tabs, we can start putting our tab navigation logic in place. Let's import and use `createBottomTabNavigator` in our `routes.js` file:

contact-list/routes.js

```
import { createBottomTabNavigator } from 'react-navigation';

import Contacts from './screens/Contacts';
import Favorites from './screens/Favorites';
import User from './screens/User';

const TabNavigator = createBottomTabNavigator({
  Contacts,
```

```
  Favorites,
  User,
});

export default createAppContainer(TabNavigator);
```

If we run the app, we'll see tabs with labels at the bottom of the iOS device screen and at the top of the Android screen. These tabs allow us to switch between the three screens.



Tabs

We'll modify the styling of our tabs in a little bit. At the moment, we have a bigger problem. We don't have our header component anymore and if we try pressing any of the contacts in the `Contacts` or `Favorites` screens, nothing happens. This is because we've removed our stack navigator entirely and only have a single tab navigation system in place. What we want to do is *compose* our two navigators together.

Let's update our route configurations. We'll begin with the imports since we'll be

including a few new ones:

contact-list/5/routes.js

```
import React from 'react';
import { createStackNavigator, createBottomTabNavigator, createAppConta\
iner } from 'react-navigation';
import { MaterialIcons } from '@expo/vector-icons';

import Favorites from './screens/Favorites';
import Contacts from './screens/Contacts';
import Profile from './screens/Profile';
import User from './screens/User';

import colors from './utils/colors';
```

We're importing both navigators from `react-navigation` as well as `MaterialIcons` from Expo's `vector-icons` package.

This package is a wrapper around `react-native-vector-icons`[75], a library that contains a number of vector icons. Creating icons is done by using JSX to define icon components. For this reason, we've imported `React` to this file as well.

You can find a list of all the icons provided by the library here[76]. There are a number of different icon sets that can be used (such as `FontAwesome`). We'll only be using the `MaterialIcons` icon set for this application.

Although we are customizing the look and feel of the tab bar ourselves in this application, a separate API, `createMaterialBottomTabNavigator`[77], is also provided by `react-navigation` to make it simpler to create a bottom tab bar with a material design theme.

To compose stack navigation and tab navigation, each tab will have its own separate navigation stack. This means that instead of passing specific screens to each tab, we'll

[75] https://github.com/oblador/react-native-vector-icons
[76] https://expo.github.io/vector-icons/
[77] https://reactnavigation.org/docs/en/material-bottom-tab-navigator.html#docsNav

pass in a *stack* (a `createStackNavigator` component) that contains every possible screen within that tab.

For example, we want the contacts list to still use a stack navigator. That way, the user can navigate to individual profiles. That stack navigator will reside inside our app's broader tab navigator.

Let's write our stack navigator for the contacts list. It looks the same as before, with one additional configuration:

contact-list/5/routes.js

```
const ContactsScreens = createStackNavigator(
  {
    Contacts,
    Profile,
  },
  {
    initialRouteName: 'Contacts',
    navigationOptions: {
      tabBarIcon: getTabBarIcon('list'),
    },
  },
);
```

For the "Contacts" tab, we want to first show the `Contacts` screen and allow the user to be able to navigate to the `Profile` screen.

Notice how we've also added navigation options to specify this navigator's `tabBarIcon`. We're passing in a `getTabIcon` helper method to retrieve a `list` icon component. Let's define this function right after our imports:

contact-list/5/routes.js

```
import colors from './utils/colors';

const getTabBarIcon = icon => ({ tintColor }) => (
  <MaterialIcons name={icon} size={26} style={{ color: tintColor }} />
);

const ContactsScreens = createStackNavigator(
```

The `tabBarIcon` option expects a function. It will call that function with a single object that has the properties `focused` and `tintColor`.

The `getTabIcon` function returns a function that returns a specific icon component from the `MaterialIcons` icon set given its name. When we define our our tab navigator, we'll assign the tint colors for all icons in each of our tabs.

Higher-order functions

The `tabBarIcon` parameter in our navigation options expects a function that takes an object with `focused` and `tintColor` as attributes. It looks like the following:

```
tabBarIcon: (params) => (
  <MaterialIcons
    name="list"
    size={26}
    style={{ color: params.tintColor }}
  />
),
```

The focused argument allows us to render something different depending on whether the current tab is focused in view or not. We're not doing anything for the different states so we do not even use `focused` at all. We only use `tintColor` in order to give our tab icons an appropriate active or inactive color defined as options in `createBottomTabNavigator`.

With parameter context matching[a], we can simplify how we pass in our arguments:

```
    tabBarIcon: ({ tintColor }) => (
      <MaterialIcons
        name="list"
        size={26}
        style={{ color: tintColor }}
      />
    ),
```

Since every icon in each of the tabs have the same tint color and size, we simplify how we render our icons by defining a single `getTabIcon` function:

```
const getTabBarIcon = icon => ({ tintColor }) => (
  <MaterialIcons name={icon} size={26} style={{ color: tintColor }} />
);

// ...
tabBarIcon: getTabBarIcon('list'),
```

The `getTabIcon` function takes an icon string as a parameter and returns a *function* that takes the correct parameters expected by `tabBarIcon` (an object with `tintColor` and `focused`).

[a] appendix_higher_order_components

Let's do the same for our other two tabs, `Favorites` and `User`:

contact-list/5/routes.js

```
const FavoritesScreens = createStackNavigator(
  {
    Favorites,
    Profile,
  },
  {
    initialRouteName: 'Favorites',
    navigationOptions: {
      tabBarIcon: getTabBarIcon('star'),
```

```
    },
  },
);

const UserScreens = createStackNavigator(
  {
    User,
  },
  {
    initialRouteName: 'User',
    navigationOptions: {
      tabBarIcon: getTabBarIcon('person'),
    },
  },
);
```

For the `Favorites` tab, the idea is similar. We want to default to the `Favorites` screen but still allow the user to navigate to the `Profile` screen for any specific contact. The `User` stack navigator only has one screen at the moment, but we'll add a second screen a little later.

Now that we've defined our stack navigators, we can write up our tab navigator underneath:

contact-list/5/routes.js

```
const TabNavigator = createBottomTabNavigator(
  {
    Contacts: ContactsScreens,
    Favorites: FavoritesScreens,
    User: UserScreens,
  },
  {
    initialRouteName: 'Contacts',
    tabBarPosition: 'bottom',
    tabBarOptions: {
      style: {
```

```
        backgroundColor: colors.greyLight,
      },
      showLabel: false,
      showIcon: true,
      activeTintColor: colors.blue,
      inactiveTintColor: colors.greyDark,
    },
  },
);
```

And at the very end of the file, we connect our top-level tab navigation to the app container.

contact-list/5/routes.js

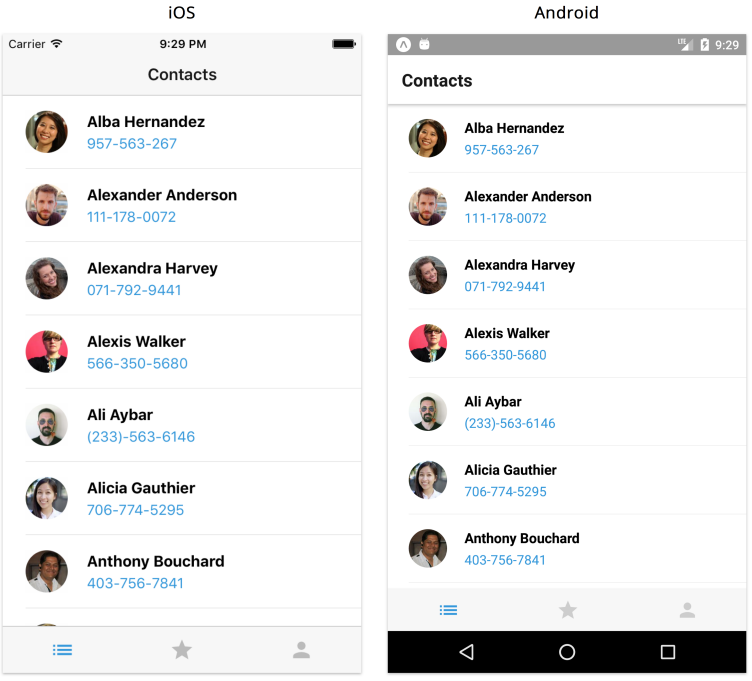
```
export default createAppContainer(TabNavigator);
```

We pass each stack navigator as the *screen* for their corresponding tab. React Navigation allows us to pass entire navigators as a tab `screen` and the first screen of the stack will be the default screen for that tab.

`tabBarOptions` allow us to modify styling for our tabs. We first define the tab background color using the `style` object. Since we only want icons to show, we've also specified `showLabel` to be false and `showIcon` to true. We set our icon colors for both active (where the user is currently viewing) and inactive tabs.

Try it out

If we try running the application now, we'll see our complete tab logic working!



Contacts

Try navigating between the different tabs as well as pressing a contact list item or thumbnail to navigate to the `Profile` screen. You'll notice that navigating to the `Profile` screen in one tab will only show that screen there. Composing both tab and stack navigation allows for more complex navigation architectures where each stack in a tab maintains the history of its own navigated screens independently from the others.

Modal navigation

We'll introduce our final screen in the app, `Options`, to demonstrate how stack navigators can be modified to render new screens with a **modal**. This is only for iOS and does not work for Android.

We can begin by creating an `Options.js` file in the `screens/` directory:

contact-list/screens/Options.js

```
import React from 'react';
import { StyleSheet, View } from 'react-native';
import { MaterialIcons } from '@expo/vector-icons';

import DetailListItem from '../components/DetailListItem';
import colors from '../utils/colors';

export default class Options extends React.Component {
  static navigationOptions = ({ navigation: { goBack } }) => ({
    title: 'Options',
    headerLeft: (
      <MaterialIcons
        name="close"
        size={24}
        style={{ color: colors.black, marginLeft: 10 }}
        onPress={() => goBack()}
      />
    ),
  });

  render() {
    return (
      <View style={styles.container}>
        <DetailListItem title="Update Profile" />
        <DetailListItem title="Change Language" />
        <DetailListItem title="Sign Out" />
      </View>
    );
  }
}

const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: 'white',
```

```
  },
});
```

In this screen, we render a few `DetailListItem` components to represent options that the user can press to modify their profile settings. We've included a `headerLeft` attribute for the screen's navigation options that renders a `close` icon. We've added a callback to the icon's `onPress` prop that fires `navigate.goBack` to close the current screen and return to the previous one.

Let's build the functionality to allow the user to navigate to this screen. We'll do this in the `User` screen by adding an icon to our header:

contact-list/screens/User.js

```
  static navigationOptions = ({ navigation: { navigate } }) => ({
    title: 'Me',
    headerTintColor: 'white',
    headerStyle: {
      backgroundColor: colors.blue,
    },
    headerRight: (
      <MaterialIcons
        name="settings"
        size={24}
        style={{ color: 'white', marginRight: 10 }}
        onPress={() => navigate('Options')}
      />
    ),
  });
```

Don't forget to import `MaterialIcons` in this file.

Now, in `routes.js`, we'll import our `Options` screen:

contact-list/routes.js

```
import Options from './screens/Options';
```

Then add it to the `UserScreens` stack navigator within `routes.js`:

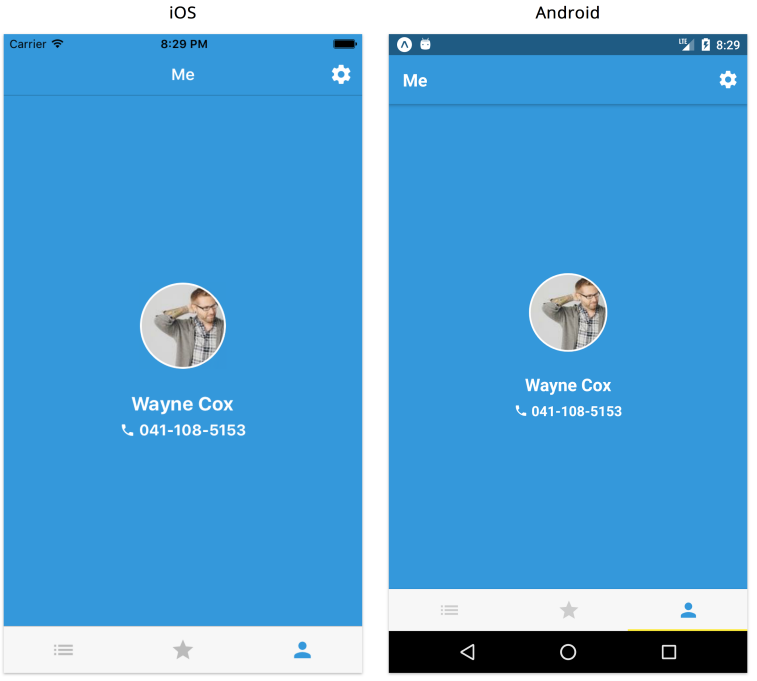
contact-list/routes.js

```
const UserScreens = createStackNavigator(
  {
    User,
    Options,
  },
  {
    mode: 'modal',
    initialRouteName: 'User',
    navigationOptions: {
      tabBarIcon: getTabBarIcon('person'),
    },
  },
);
```

We use the `mode` attribute to specify this navigator should have `modal` transitions for iOS.

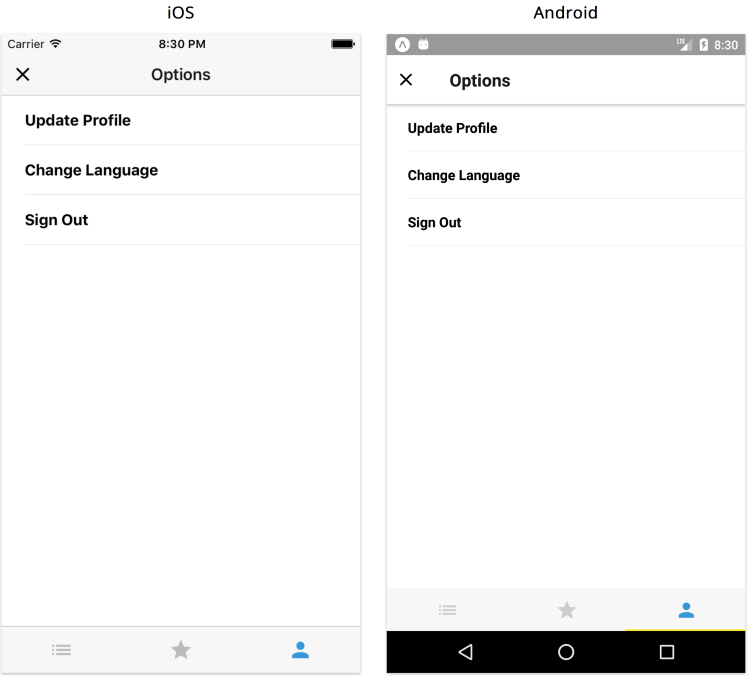
Try it out

Start the app and give it a shot! You'll be able to navigate directly to the `Options` screen through `User`.



User

By pressing the icon on the right of our header bar, you'll notice that the screen moves up from the bottom if you own an iOS device.



Options

If you try on Android device or emulator, the screen will fade in just like any of the other screens in the stack.

Drawer navigation

Another navigation pattern that is commonly used is **drawer navigation**, where views are accessible through a drawer that slides in from the left side of the screen.

Navigation drawer - (from Material Design documentation - Components)

Just like tab navigation, a drawer navigator allows users to switch between equally important views quickly.

Neither of these patterns is better than the other. Choosing the right pattern depends on both preferences as well as the number of root screens that the user can access.

A good rule of thumb is that tabs work well when there are three to five of them. If there are many important, unrelated screens that the user should be able to access without navigating through a stack, then drawer navigation may be more suitable.

Although our final app only includes tab navigation for our three core views, let's explore what using drawer navigation would look like. We'll swap in `DrawerNavigator` for `TabNavigator`.

Let's modify our `routes.js` file:

contact-list/6/routes.js

```
import React from 'react';
import { createStackNavigator, createDrawerNavigator, createAppContaine\
r } from 'react-navigation';
import { MaterialIcons } from '@expo/vector-icons';

import Favorites from './screens/Favorites';
import Contacts from './screens/Contacts';
import Profile from './screens/Profile';
import User from './screens/User';
import Options from './screens/Options';

const getDrawerItemIcon = icon => ({ tintColor }) => (
  <MaterialIcons name={icon} size={22} style={{ color: tintColor }} />
);

const ContactsScreens = createStackNavigator(
  {
    Contacts,
    Profile,
  },
  {
    initialRouteName: 'Contacts',
    navigationOptions: {
      drawerIcon: getDrawerItemIcon('list'),
    },
  },
);

const FavoritesScreens = createStackNavigator(
  {
    Favorites,
    Profile,
  },
  {
    initialRouteName: 'Favorites',
```

```
    navigationOptions: {
      drawerIcon: getDrawerItemIcon('star'),
    },
  },
);

const UserScreens = createStackNavigator(
  {
    User,
    Options,
  },
  {
    mode: 'modal',
    initialRouteName: 'User',
    navigationOptions: {
      drawerIcon: getDrawerItemIcon('person'),
    },
  },
);

const DrawerNavigator = createDrawerNavigator(
  {
    Contacts: ContactsScreens,
    Favorites: FavoritesScreens,
    User: UserScreens,
  },
  {
    initialRouteName: 'Contacts',
  },
);

export default createAppContainer(DrawerNavigator);
```

Note that instead of the `tabBarIcon` option, we use `drawerIcon` to display an icon near the menu item within the drawer. We also change the name of the method that

returns our icon from `getTabIcon` to `getDrawerIcon`.

Although the drawer can be accessed by swiping on the left edge of the device screen towards the right, it also helps to have a menu icon in each of the main screens that can open and close the drawer. We'll begin with the `Contacts` screen:

contact-list/6/screens/Contacts.js

```
  static navigationOptions = ({ navigation: { openDrawer } }) => ({
    title: 'Contacts',
    headerLeft: (
      <MaterialIcons
        name="menu"
        size={24}
        style={{ color: colors.black, marginLeft: 10 }}
        onPress={() => openDrawer()}
      />
    ),
  });
```

We've added a `menu` icon on the left hand side of the header. With React Navigation, we can fire the `openDrawer` and `closeDrawer` methods to open and close the drawer respectively. `toggleDrawer` will fire either of those depending on the current state of the navigation drawer. This allows us to toggle the drawer with a single method. In this application, we only need to use `openDrawer`.

We can add this same icon to the `Favorites` screen:

contact-list/6/screens/Favorites.js

```
  static navigationOptions = ({ navigation: { openDrawer } }) => ({
    title: 'Favorites',
    headerLeft: (
      <MaterialIcons
        name="menu"
        size={24}
        style={{ color: colors.black, marginLeft: 10 }}
        onPress={() => openDrawer()}
      />
```

```
    ),
  });
```

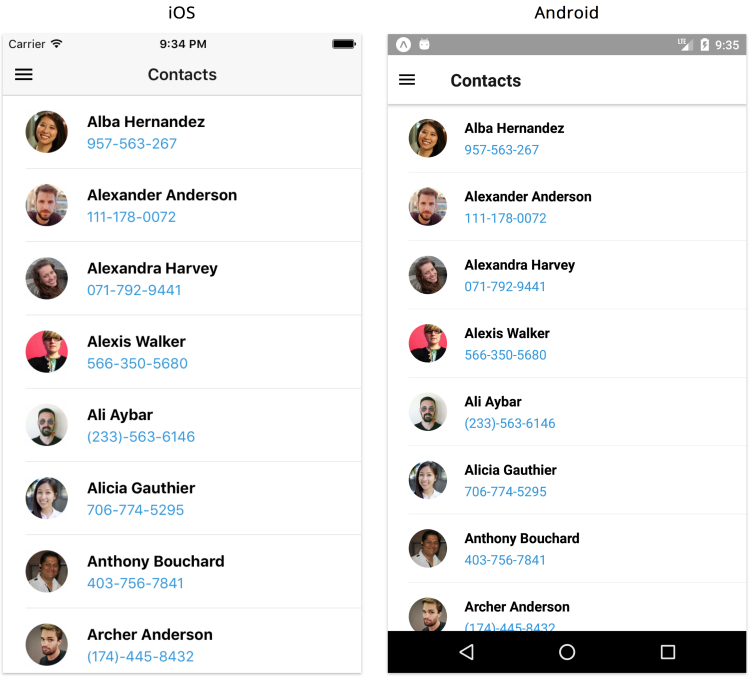
And the `User` screen:

contact-list/6/screens/User.js

```
  static navigationOptions = ({ navigation: { openDrawer, navigate } })\
=> ({
    title: 'Me',
    headerTintColor: 'white',
    headerStyle: {
      backgroundColor: colors.blue,
    },
    headerLeft: (
      <MaterialIcons
        name="menu"
        size={24}
        style={{ color: 'white', marginLeft: 10 }}
        onPress={() => openDrawer()}
      />
    ),
    headerRight: (
      <MaterialIcons
        name="settings"
        size={24}
        style={{ color: 'white', marginRight: 10 }}
        onPress={() => navigate('Options')}
      />
    ),
  });
```

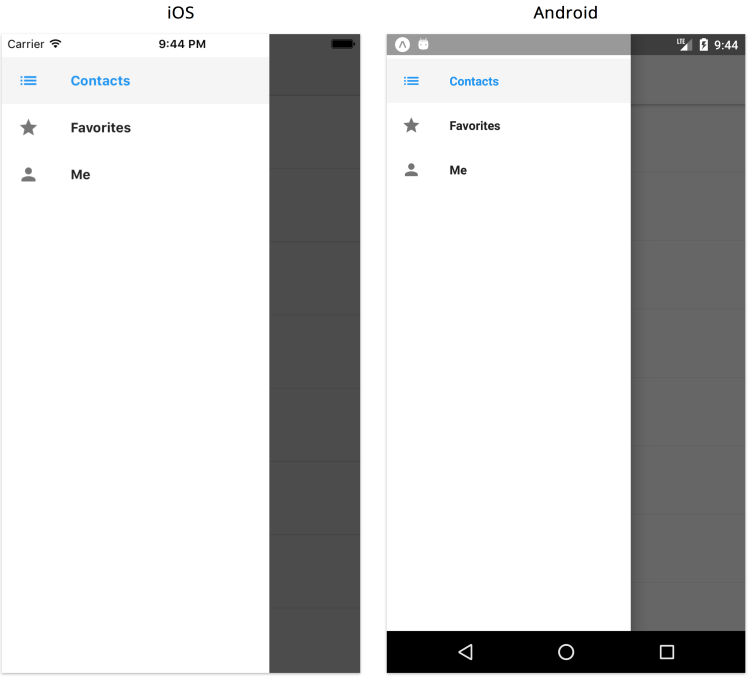
Try it out

Try running the application with these drawer settings enabled. We can see a menu icon in either of our three root screens.



Contacts Screen - Drawer

We can open and close our drawer by swiping right on the left edge of the screen or by pressing the menu icon.



Drawer

Sharing state between screens

So far, we've built our entire application using local component state. While doing so, we noticed some of the challenges that applications with multiple screens have when data must be shared between screens.

For example, our `Favorites` screen uses the same list of contacts as the `Contacts` screen. But we had to make an API call for each screen, fetching the list twice. It would be better to fetch the list just once and share data between screens.

There are a few different ways we can make this better. One way is to define all the data within our application in the `App` component. We can then use the `initialRouteParams` property that React Navigation provides for our root tab navigator to assign the state to its initial route - `Contacts`. With this approach, we can continue to pass our entire data to every other screen we navigate using navigation parameters similar to how we pass contact information from `Contacts` to `Profile`.

This method of maintaining state is not ideal due to the fact that every screen now has access to all the data in the entire app. Moreover, this will most likely create performance issues as we would need to re-render every screen to reflect changes to the state being modified in a specific screen.

State containers

React Native applications that contain a navigation architecture generally handle data flow differently than we've done in our apps so far. So far, we've stored data in the root and screen components of our apps, and we've passed data down from parent to child as props. In this app, we'll use a *state container* to manage all of our application data in a separate external location outside of our components.

This can be useful to separate the UI and data concerns in our application. In a typical application with multiple top-level screens, this approach allows us to pass parts of our state to each of our screens.

Third-party libraries

One approach to including a state container is to use a third-party library. Redux[78] and MobX[79] are two popular examples that allow users to maintain their entire application state in a single location. They also impose certain restrictions on how this state object can be modified.

Using a community-supported library means we don't have to spend the time trying to build the logic ourselves. There are packages that exist in both the Redux and MobX ecosystem that allow us to bind our React or React Native components directly to the global store. Modifying our state requires an *action* to be dispatched which gives us more explicit control to modify our state in only specific parts of our application. We can also take advantage of *middlewares* to intercept any of our actions before it reaches our state. This can allow us to log all of our state changes for easier debugging as well as fire asynchronous operations as part of our actions if we need to.

Downsides of using an external library include the learning curve needed to learn its API and specific requirements. Redux, for example, adheres to the use of *pure*

[78] https://github.com/reactjs/redux
[79] https://github.com/mobxjs/mobx

functions (or functions without any side effects) and requires a decent amount of boilerplate code in order to connect a component to our store with appropriate actions. MobX uses the concept of *reactive programming* and *observables* in order to have our state update when our data is changed. Using either of these libraries or another state management tool altogether means that we would need to fully understand how they work.

Custom state container

Instead of using a community-supported library, we always have the option of building our own state container in our application. This can be useful when we want complete control over how we manage our data, or when we don't want to introduce a complex dependency.

While suitable for our needs in this app, a simple state container built from scratch will not have nearly as many features or plugins as a third-party library. Most medium and large React Native applications use Redux or MobX. These libraries have a bit of a learning curve and require more boilerplate code, but they make things more predictable by constraining how we manage our state. They can help us build consistent applications that are easier to test, debug and analyze using different built-in or external plugins.

To demonstrate the overall approach of how to manage state in a central location with navigation, we'll use an extremely simple state container of our own instead of relying on a third-party solution.

Copy over the the `contact-list/store.js` file in the sample code to the root of you application. If you like, take a look at the file to get a better understanding of how it works.

In this file, we've defined all of our application state as a single object called `state`:

contact-list/store.js

```
let state = {
  isFetchingContacts: true,
  isFetchingUser: true,
  contacts: [],
  user: {},
  error: false,
};
```

Each of the field values in this object are the default values when our application is first launched. We then export three methods that can be used throughout our application:

- `getState` returns the application state.
- `setState` takes in new values and updates our state. We don't mutate the current state object directly, but instead create a new copy with our updated values.
- `onChange` allows us to listen for changes in our state.

Let's begin by including it to our `Contacts` screen. We'll start with importing our `store`:

contact-list/7/screens/Contacts.js

```
import store from '../store';
```

Now we can make use of our store methods:

contact-list/7/screens/Contacts.js

```
export default class Contacts extends React.Component {
  static navigationOptions = {
    title: 'Contacts',
  };

  state = {
    contacts: store.getState().contacts,
    loading: store.getState().isFetchingContacts,
    error: store.getState().error,
  };

  async componentDidMount() {
    this.unsubscribe = store.onChange(() =>
      this.setState({
        contacts: store.getState().contacts,
        loading: store.getState().isFetchingContacts,
        error: store.getState().error,
      }),
    );

    const contacts = await fetchContacts();

    store.setState({ contacts, isFetchingContacts: false });
  }

  componentWillUnmount() {
    this.unsubscribe();
  }
```

We've set up our local state by connecting its attributes to the correct global store attributes. Notice how we've defined `loading` to be equal to the global state attribute of `isFetchingContacts`. This component does not need to know anything else in the state that it is not using (and this includes the `isFetchingUser` boolean that would

be used in the `User` screen). We have complete control of how we want to refer and define our state relevant to the context of this component.

In `componentDidMount`, we set our `onChange` method to update our local component state using `this.setState`. When we get the results of our API call, we use our *store* `setState` method to update our shared store and since we also use `onChange` - our local component state will also update to reflect this change. We make sure to unsubscribe from our change listener when our component unmounts as well.

Now in our render method, we'll need to update which parameters we look for within our state:

contact-list/7/screens/Contacts.js

```
  render() {
    const { contacts, loading, error } = this.state;

    const contactsSorted = contacts.sort((a, b) =>
      a.name.localeCompare(b.name),
    );

    return (
      <View style={styles.container}>
        {loading && <ActivityIndicator size="large" />}
        {error && <Text>Error...</Text>}
        {!loading &&
          !error && (
            <FlatList
              data={contactsSorted}
              keyExtractor={keyExtractor}
              renderItem={this.renderContact}
            />
          )}
      </View>
    );
  }
```

Let's do the same thing for `Favorites`:

contact-list/7/screens/Favorites.js

```
export default class Favorites extends React.Component {
  static navigationOptions = {
    title: 'Favorites',
  };

  state = {
    contacts: store.getState().contacts,
    loading: store.getState().isFetchingContacts,
    error: store.getState().error,
  };

  async componentDidMount() {
    const { contacts } = this.state;

    this.unsubscribe = store.onChange(() =>
      this.setState({
        contacts: store.getState().contacts,
        loading: store.getState().isFetchingContacts,
        error: store.getState().error,
      }),
    );

    if (contacts.length === 0) {
      const fetchedContacts = await fetchContacts();

      store.setState({
        contacts: fetchedContacts,
        isFetchingContacts: false,
      });
    }
  }

  componentWillUnmount() {
    this.unsubscribe();
  }
```

We technically shouldn't need to submit fetch our contacts from the API again. We know that when the user loads the application for the first time, the contacts are retrieved within the `Contacts` screen, which is the first tab. However, it's generally better not rely on the order each screen loads to ensure our data is ready. This is both for testability (we can easily run this screen individually), and because if we later add the capability to navigate to this screen without loading the `Contacts` screen first, our application will fail. A good example of when this might happen is when we allow a user to *deep link* to a specific screen from outside the application entirely. We'll explore this concept in a bit.

Similarly, we can update our `render` method as well:

contact-list/7/screens/Favorites.js

```
  render() {
    const { contacts, loading, error } = this.state;
    const favorites = contacts.filter(contact => contact.favorite);

    return (
      <View style={styles.container}>
        {loading && <ActivityIndicator size="large" />}
        {error && <Text>Error...</Text>}

        {!loading &&
          !error && (
            <FlatList
              data={favorites}
              keyExtractor={keyExtractor}
              numColumns={3}
              contentContainerStyle={styles.list}
              renderItem={this.renderFavoriteThumbnail}
            />
          )}
      </View>
    );
  }
```

And finally, we can update our `User` screen to follow this same approach:

contact-list/7/screens/User.js

```
export default class User extends React.Component {
  static navigationOptions = {
    title: 'Me',
    headerTintColor: 'white',
    headerStyle: {
      backgroundColor: colors.blue,
    },
  };

  state = {
    user: store.getState().user,
    loading: store.getState().isFetchingUser,
    error: store.getState().error,
  };

  async componentDidMount() {
    this.unsubscribe = store.onChange(() =>
      this.setState({
        user: store.getState().user,
        loading: store.getState().isFetchingUser,
        error: store.getState().error,
      }),
    );

    const user = await fetchUserContact();

    store.setState({ user, isFetchingUser: false });
  }

  componentWillUnmount() {
    this.unsubscribe();
  }
```

```
  render() {
    const { user, loading, error } = this.state;
    const { avatar, name, phone } = user;

    return (
      <View style={styles.container}>
        {loading && <ActivityIndicator size="large" />}
        {error && <Text>Error...</Text>}

        {!loading && (
          <ContactThumbnail
            avatar={avatar}
            name={name}
            phone={phone}
          />
        )}
      </View>
    );
  }
}
```

Don't forget to import `store` within `Favorites` and `User`!

Try it out

If we try running the application at this point, we'll notice everything works exactly the same. Again, the difference now is that each top level screen in our application uses the same shared data object in our application.

Instead of being more specific about which parts of our central store we wanted to connect to in each screen, we could have just connected the entire store using `state = store.getState();`. However, connecting only parts of the global state to our component not only improves how we encapsulate which state parameters we need, but it can also improve re-render performance. In React Native, a component re-renders if any part of its state changes. With this approach, we can have our component re-render only when the state specific to it changes.

Although a centralized store allowed us to handle how data is managed across a number of top-level screens, it's important to remember that this adds an extra layer of abstraction to our application. Not only do we now pass presentational data from parent components to child components, we also pass data through navigation parameters when we navigate through certain screens *and* use a top-level state container that manages all the data in our application.

Deep Linking

The last major topic we'll explore in this chapter is **deep linking**. Deep linking means launching the app and navigating to a specific screen automatically. A deep link bypasses the tab, stack, and drawer navigation, taking the user directly to the desired screen. This can be useful when launching your app from a webpage, a push notification, or another app.

Imagine the user gets a push notification that a new contact has been added. When the user taps the notification, they should be taken directly to the profile screen for that contact, rather than having to navigate their way from the initial screen of the app.

Deep links are similar to typing a URI (Uniform Resource Identifier) into a web browser. On the web, `https://www.fullstackreact.com` might load the homepage for the website, while `https://www.fullstackreact.com/react-native` will load a different page. Similarly in mobile applications, we perform a deep link using a URI, where each URI generally takes us to a different screen.

Using a navigation library for a mobile app helps us build our app in terms of screens – this makes it easy to connect any screen of our app to a specific URI.

Let's explore how we can add deep linking to our current application by allowing the user to navigate to a specific contact's profile directly. With Expo, the base URI is different based on the state of the application:

- `exp://localhost:19000/+` or `exp://10.2.8.358:19000/+` is the URI we use during development. `10.2.8.358` is our IP address and `19000` is the port that the app is running. We can see our IP address and the port right underneath the QR code printed to the terminal when we start the application with `yarn start`.

- `exp://exp.host/@fullstackio/contact-list/+` is what we can use if our app is published to the Expo client. If you have the final version of this app installed on your device through the client, try typing this address into a web browser on your mobile device and you'll navigate directly to it.
- For standalone apps published outside of Expo, the URI can be defined in `app.json`. For example:

app.json

```
{
  "expo": {
    "scheme": "contact-list"
  }
}
```

This will give us a URI of `contact-list://+`.

Instead of having to take care of all of these different possible URI values, Expo provides us with a `linkingUri` attribute from a `Constants` object that will resolve to the correct URI depending on the state of the application.

Now let's begin adding deep linking to our contact list application! Our goal is to allow a user to navigate to a specific contact only using his or her first name. For example, `exp://{linkingUri}/+?name=ali` will navigate directly to Ali's profile. If the contact doesn't exist, we'll have the user remain in the `Contacts` screen and not be navigated anywhere. For a real production application however, it would make more sense to show a user-friendly error message if this happens.

We'll begin with importing `Linking` and `Constants` into our `Contacts` screen:

contact-list/screens/Contacts.js

```
import React from 'react';
import {
  StyleSheet,
  Text,
  View,
  FlatList,
  ActivityIndicator,
  Linking,
} from 'react-native';
```

The `Linking` API provides methods that allow us to handle incoming deep links as well as open external links. We'll add two of these methods to the lifecycle hook that fires after our component mounts:

contact-list/screens/Contacts.js

```
  async componentDidMount() {
    this.unsubscribe = store.onChange(() =>
      this.setState({
        contacts: store.getState().contacts,
        loading: store.getState().isFetchingContacts,
        error: store.getState().error,
      }),
    );

    const contacts = await fetchContacts();

    store.setState({ contacts, isFetchingContacts: false });

    Linking.addEventListener('url', this.handleOpenUrl);

    const url = await Linking.getInitialURL();
    this.handleOpenUrl({ url });
  }
```

Let's go over the two methods we added:

- The `getInitialURL` method will fire when a URI associated with the app is accessed externally. This method allows a user to deep link to a particular part of the application when the app is closed and not running in the background. In here, we pass the URL obtained to a `handleOpenUrl` method.
- For instances where the app is running in the background, we can listen to URL events and provide a callback to handle these situations. This is why we use `addEventListener` and pass a handler to the same `handleOpenUrl` method.

Like any event listener, we'll need to make sure it is removed when our component is destroyed/unmounted:

contact-list/screens/Contacts.js

```
  componentWillUnmount() {
    Linking.removeEventListener('url', this.handleOpenUrl);
    this.unsubscribe();
  }
```

Now that we've handled incoming deep links in our component, let's create our handler method to respond appropriately to the correct URL:

contact-list/screens/Contacts.js

```
  handleOpenUrl(event) {
    const { navigation: { navigate } } = this.props;
    const { url } = event;
    const params = getURLParams(url);

    if (params.name) {
      const queriedContact = store
        .getState()
        .contacts.find(
          contact =>
            contact.name.split(' ')[0].toLowerCase() ===
            params.name.toLowerCase(),
```

```
        );

      if (queriedContact) {
        navigate('Profile', { id: queriedContact.id });
      }
    }
  }
```

We use a `getURLParams` utility function to extract query parameters from a given string and return an object.

For example:

`getURLParams(exp://localhost:19000/+?name=abby)`

will return:

`{name: 'abby'}`.

If the name parameter exists, we check our state for a contact with the same *first* name and if so - navigate to the `Profile` screen for that user.

We'll also need to import the `getURLParams` utility function at the top of our file:

contact-list/screens/Contacts.js

```
import getURLParams from '../utils/getURLParams';
```

Although deep linking to a contact by `name` is straightforward, this approach is flawed. If two contacts have the same name, our logic will fail, always returning the first contact it finds that meets the condition. Ideally, we would want to pass the contact's ID as a URI parameter. In this example application however, we generate random UUIDs for each contact every time we load our application. For this reason, we've shown the `name`-based approach for simplicity.

Try it out

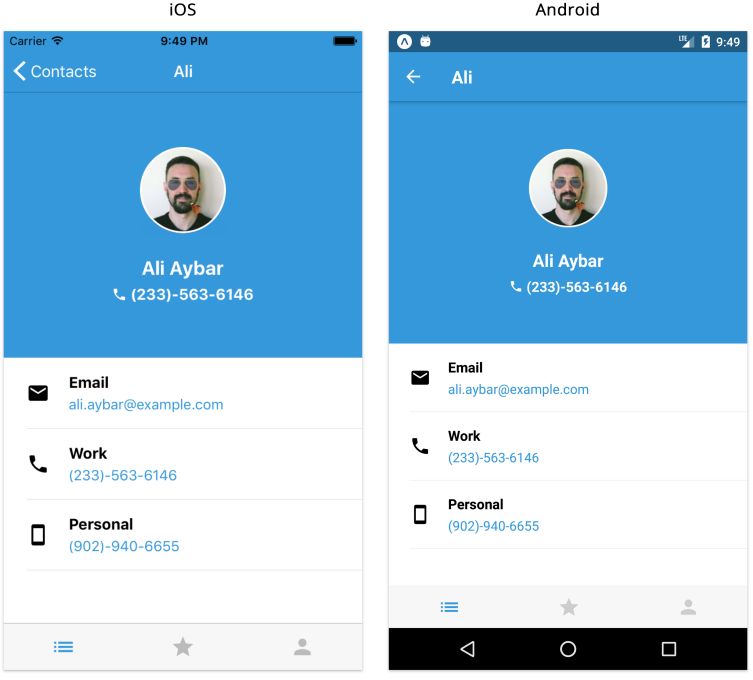
While developing locally, you can try deep linking with different methods depending on which platform you're using:

- If you're using the iOS simulator or an actual device connected to the same network, you can open Safari and type `exp://localhost:19000/+?name=ali` into the address bar.
- On an Android emulator on the same network, you can test it through a terminal command:

```
adb shell am start -W -a "android.intent.action.VIEW" -d "exp://localho\
st:19000/+?name=ali"
```

If `localhost:19000` isn't working, the application may be running on a different port. Take a look at the terminal to see which port is being used.

You'll notice you'll be navigated directly to his profile screen:



Deep Linking

If we try navigating to a contact with a name that doesn't exist, we'll remain in the `Contacts` screen.

Summary

Navigation is one of the most crucial elements of building an application that requires multiple screens. In this chapter, we looked at different navigation patterns as well as how they can be composed to allow for a complete navigation system. We built out a complete contact list example app to explore this in-depth, using all of the navigators provided by React Navigation. We then moved on to building a small state container to further understand how data can be shared between top-level screens. Finally, we finished the chapter by including deep linking functionality in a specific part of our application.

While discussing the differences between native and JavaScript navigation libraries, we briefly touched on how JavaScript implementaions use their own custom components by relying on React Native components and the `Animated` API. Animations and gestures are important topics in mobile development and the next two chapters will dive deeper into how they work in React Native.

Animation

In order to animate a component on the screen, we'll generally update its size, position, color, or other style attributes continuously over time. We often use animations to imitate movement in the real world, or to build interactivity similar to familiar physical objects.

We've seen several examples of animation already:

- In our weather app, we saw how the `KeyboardAvoidingView` shrinks to accommodate room for the keyboard.
- In our messaging app, we used the `LayoutAnimation` API to achieve similar keyboard-related animations.
- In our contacts app, we used `react-nagivation`, which automatically coordinates transition animations between screens.

In this chapter and the next, we'll explore animations in more depth by building a simple puzzle game app. React Native offers two main animation APIs: `Animated` and `LayoutAnimation`. We'll use these to create a variety of different animations in our game. Along the way, we'll learn the advantages and disadvantages of each approach.

The next chapter ("Gestures") will primarily focus on a closely related topic: gestures. Gestures help us build components that respond to tapping, dragging, pinching, rotating, etc. Combining gestures and animations enables us to build intuitive, interactive experiences in React Native.

Animation challenges

Building beautiful animations can be tricky. Let's look at a few of the challenges we'll face, and how we can overcome them.

Performance challenges

To achieve animations that look smooth, we'll want our UI to render at 60 frames-per-second (fps). In other words, we need to render 1 frame roughly every 16 milliseconds (1000 milliseconds / 60 frames). If we perform expensive computations that take longer than 16 milliseconds within a single frame, our animations may start to look choppy and uneven. Thus, we must constantly pay attention to performance when working with animation.

Performance issues tend to fall into a few specific categories:

- **Calculating new layouts during animation**: When we change a style attribute that affects the size or position of a component, React Native usually re-calculates the entire layout of the UI. This calculation happens on a native thread, but is still an expensive calculation that can result in choppy animations. In this chapter, we'll learn how we can avoid this by animating the `transform` style attribute of a component.
- **Re-rendering components**: When a component's `state` or `props` change, React must determine how to reconcile these changes and update the UI to reflect them. React is fairly efficient by default, so components generally render quickly enough that we don't optimize their performance. With animation, however, a large component that takes a few milliseconds to render may lead to choppy animations. In this chapter, we'll learn how we can reduce re-renders with `shouldComponentUpdate` to acheive smoother animations.
- **Communicating between native code and JavaScript**: Since JavaScript runs asynchronously, JavaScript code won't start executing in response to a gesture until the frame *after* the gesture happens on the native side. If React Native must pass values back and forth between the native thread and the JavaScript engine, this can lead to slow animations. In this chapter, we'll learn how we can use `useNativeDriver` with our animations to mitigate this.

Complex control flow challenges

When working with animations, we tend to write more asynchronous code than normal. We must often wait for an animation to complete before starting another

animation (using an imperative API) or unmounting a component. The asynchronous control flow and imperative calls can quickly lead to confusing, buggy code.

To keep our code clear and accurate, we'll use a state machine[80] approach for our more complex components. We'll define a set of named states for each component, and define transitions from one state to another. This is similar to the React component lifecycle: our component will transition through different states (similar to mounting, updating, unmounting, etc), and we can run a specific function every time the state changes.

If you're familiar with state machines, you might be wondering how our state machine approach will differ from normal usage of React component `state`. React `state` is an *implicit* state machine, which we often use without defining specific states. In our case, we're going to be *explicit* about our states, naming them and defining transitions between them. Ultimately though, we're just using React `state` in a slightly more structured way than normal.

If you're not familiar with state machines, that's fine. We'll be building ours together as we go through the chapter. Even if you're not familiar with the term "state machine," the coding style will probably look familiar, since we've used it elsewhere in this book already (e.g. the `INPUT_METHOD` from the "Core APIs" chapter).

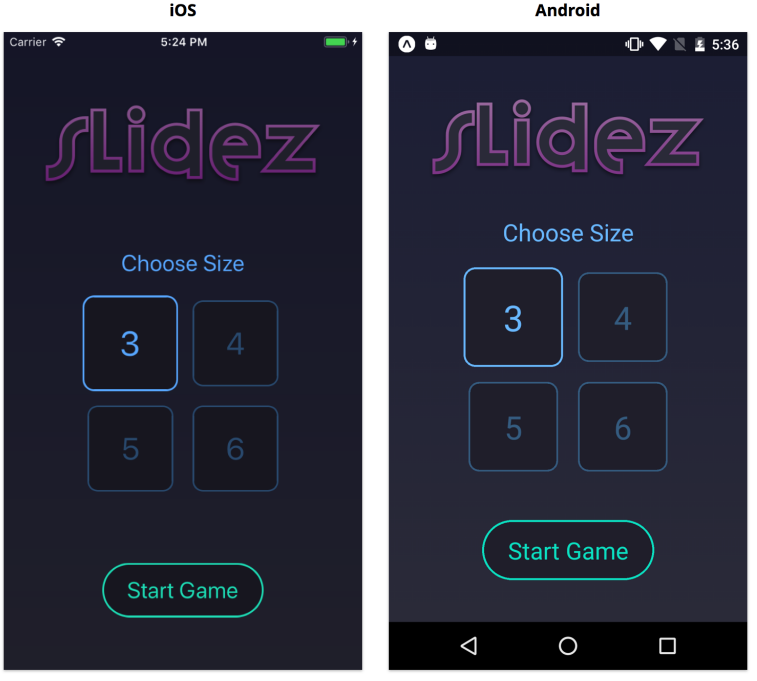
Building a puzzle game

In this chapter, we'll learn how to use the React Native animation APIs to build a slider-puzzle game.

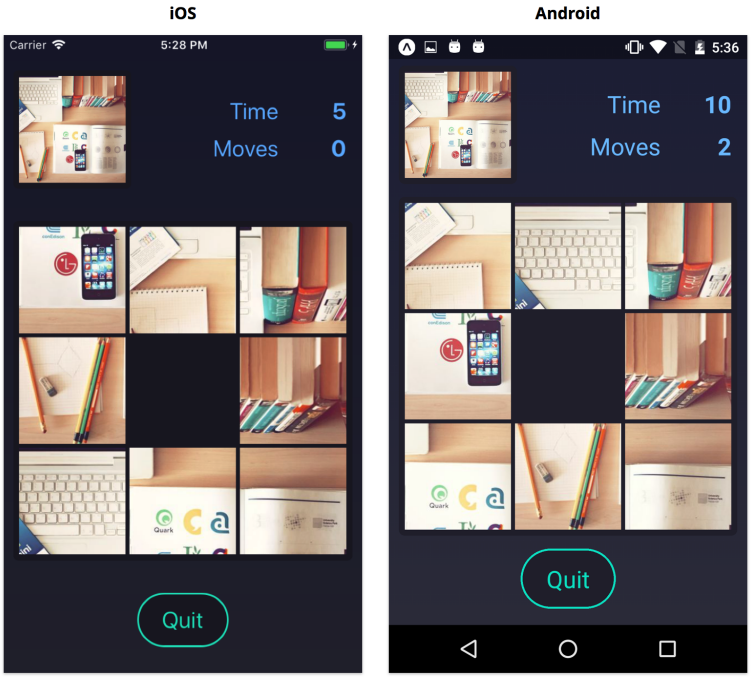
You can try the completed app on your phone by scanning this QR code from within the Expo app:

[80] https://en.wikipedia.org/wiki/Finite-state_machine

Our app will have two screens. The first screen let's us choose the size of the puzzle and start a new game:



The second screen opens when we start the game. The goal of the game is to rearrange the squares of the puzzle to complete the image displayed in the top left:



Project setup

In this chapter, we'll work out of the sample code directory for the project. Throughout this book we've already set up several projects and created many components from scratch, so for this project the `import` statements, `propTypes`, `defaultProps`, and `styles` are already written for you. We'll be adding the animations and interactivity to these components as we go.

In the sample code there's a directory called `checkpoints`, which contains 2 different iterations of the puzzle app, `checkpoints/puzzle-1` and `checkpoints/puzzle-2`. The *finished* project is in the `puzzle` directory.

We'll use the contents of `checkpoints/puzzle-1` as a foundation for our app. Since this project includes a lot of existing code, we're going to work out of the `checkpoints/puzzle-1` directory directly, rather than selectively copying over its contents. If you prefer, you may move or copy the entire `puzzle-1` directory somewhere else on your computer.

Navigate into the `checkpoints/puzzle-1` directory and install `node_modules` using `yarn`:

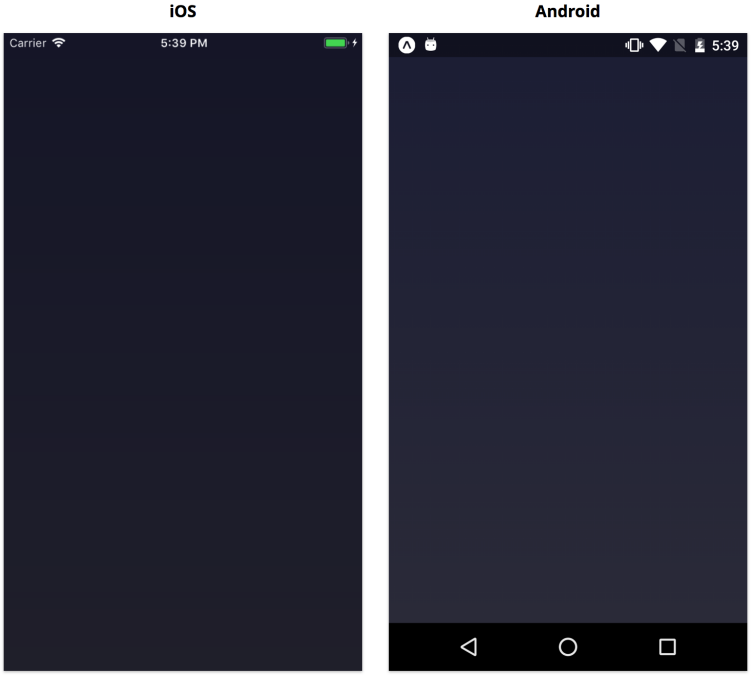
```
$ cd checkpoints/puzzle-1
$ yarn
```

It's normal to see tens of (yellow) warnings in the console as `yarn` installs your `node_modules`. Only (red) errors indicate a problem that likely needs resolving.

Once this finishes, choose one of the following to launch the app:

- **`yarn start`** - Start the Packager and display a QR code to open the app on your phone
- **`yarn ios`** - Start the Packager and launch the app on the iOS simulator
- **`yarn android`** - Start the Packager and launch the app on the Android emulator

You should see a dark full-screen gradient (it's subtle), which looks like this:



Project Structure

Let's take a look at the files in the directory we copied:

```
├── App.js
├── README.md
├── app.json
├── assets
│   ├── logo.png
│   ├── logo@2x.png
│   └── logo@3x.png
├── components
│   ├── Board.js
│   ├── Button.js
│   ├── Draggable.js
│   ├── Logo.js
│   ├── Preview.js
│   ├── Stats.js
│   └── Toggle.js
├── package.json
├── screens
│   ├── Game.js
│   └── Start.js
├── utils
│   ├── api.js
│   ├── clamp.js
│   ├── configureTransition.js
│   ├── controlFlow.js
│   ├── formatElapsedTime.js
│   ├── grid.js
│   ├── puzzle.js
│   └── sleep.js
├── validators
│   └── PuzzlePropType.js
└── yarn.lock
```

Here's a quick overview of the most important parts:

- The `App.js` file is the entry point of our code, as with our other apps.
- The `assets` directory contains a logo for our puzzle app.
- The `components` directory contains all the component files we'll use in this chapter. Some of them have been written already, while others are scaffolds that need to be filled out.
- The `screens` directory contains the two screen components in our app: the `Start` screen and the `Game` screen. The `App` coordinates the transitions between these two screens.
- The `utils` directory contains a variety of utility functions that let us build a complex app like this more easily. Most of these functions aren't specific to React Native, so you can think of them as a "black box" – we'll cover the relevant APIs, but the implementation details aren't too important to understand.
- The `validators` directory contains a custom `propTypes` function that we'll use in several different places.

Now that we're familiar with the project structure, let's dive into the code!

App

Let's walk through how the `App` component coordinates different parts of the app. Open up `App.js`.

App state

`App` stores the state of the current game and renders either the `Start` screen or the `Game` screen. A "game" in our app is represented by the state of the puzzle and the specific image used for the puzzle. To start a new game, the app generates a new puzzle state and chooses a new random image.

If we look at the `state` object, we can see there are 3 fields:

checkpoints/puzzle-1/App.js

```
  state = {
    size: 3,
    puzzle: null,
    image: null,
  };
```

- `size` - The size of the slider puzzle, as an integer. We'll allow puzzles that are 3x3, 4x4, 5x5, or 6x6. We'll allow the user to choose a different size before starting a new game, and we'll initialize the new puzzle with the chosen size.
- `puzzle` - Before a game begins or after a game ends, this value is null. If there's a current game, this object stores the state of the game's puzzle. The state of the puzzle should be considered immutable. The file `utils/puzzle.js` includes utility functions for interacting with the puzzle state object, e.g. moving squares on the board (which returns a new object).
- `image` - The image to use in the slider puzzle. We'll fetch this image prior to starting the game so that (hopefully) we can fully download it before the game starts. That way we can avoid showing an `ActivityIndicator` and delaying the game.

App screens

Our app will contain two screens: `Start.js` and `Game.js`. Let's briefly look at each.

Start screen

Open `Start.js`. The `propTypes` have been defined for you:

checkpoints/puzzle-1/screens/Start.js

```
  static propTypes = {
    onChangeSize: PropTypes.func.isRequired,
    onStartGame: PropTypes.func.isRequired,
    size: PropTypes.number.isRequired,
  };
```

When we write the rest of this component, we'll be building the buttons that allow switching the `size` of the puzzle board. We'll receive the current `size` as a prop, and call `onChangeSize` when we want to update the `size` in the `state` of `App`. We'll also build a button for starting the game. When the user presses this button, we'll call the `onStartGame` prop so that `App` knows to instantiate a puzzle object and transition to the `Game` screen.

The `state` object for this component includes a field `transitionState`:

checkpoints/puzzle-1/screens/Start.js

```
  state = {
    transitionState: State.Launching,
  };
```

This `transitionState` value indicates the current state of our state machine. Each possible state is defined in an object called `State` near the top of the file:

checkpoints/puzzle-1/screens/Start.js

```
const State = {
  Launching: 'Launching',
  WillTransitionIn: 'WillTransitionIn',
  WillTransitionOut: 'WillTransitionOut',
};
```

This object defines the possible states in our *state machine*. We'll set the component's `transitionState` to each of these values as we animate the different views in our component. We'll then use `transitionState` in the `render` method to determine how to render the component in its current state.

We define the possible states as constants in `State`, rather than assigning strings directly to `transitionState`, both to avoid small bugs due to typos and to clearly document all the possible states in one place.

We can see that the `Start` screen begins in the `Launching` state, since `transitionState` is initialized to `State.Launching`. The `Start` component will transition from `Launching` when the app starts, to `WillTransitionIn` when we're ready to fade in the UI, to `WillTransitionOut` when we're ready to transition to the `Game` screen.

We'll use this pattern of `State` and `transitionState` throughout the components in this app to keep our asynchronous logic clear and explicit.

Game screen

Now open `Game.js`. Again, the `propTypes` have been defined for you:

checkpoints/puzzle-1/screens/Game.js

```
  static propTypes = {
    puzzle: PuzzlePropType.isRequired,
    image: Image.propTypes.source,
    onChange: PropTypes.func.isRequired,
    onQuit: PropTypes.func.isRequired,
  };
```

The `puzzle` and `image` props are used to display the puzzle board. When we want to change the `puzzle`, we'll pass an updated puzzle object to `App` using the `onChange` prop. We'll also present a button to allow quitting the game. When the user presses this button, we'll call `onQuit`, initiating a transition back to the `Start` screen.

Like in `Start.js`, we'll use a state machine to simplify our code:

checkpoints/puzzle-1/screens/Game.js

```
const State = {
  LoadingImage: 'LoadingImage',
  WillTransitionIn: 'WillTransitionIn',
  RequestTransitionOut: 'RequestTransitionOut',
  WillTransitionOut: 'WillTransitionOut',
};
```

We'll cover these states in more detail when we build the screen.

Now that you have an overview of how the state and screens of our app will work, we can dive in to building animations!

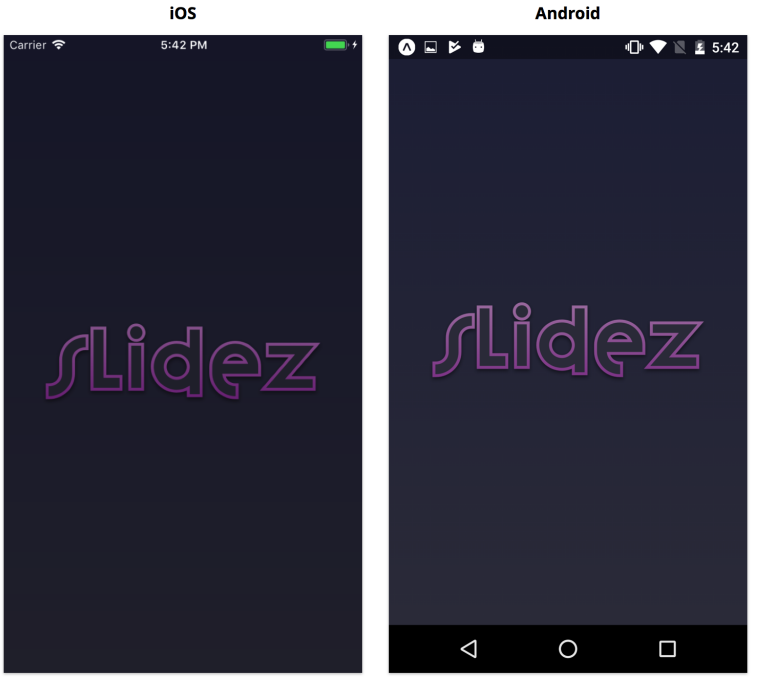
Building the Start screen

In order to build the `Start` screen, we'll use the two main building blocks of animation: `LayoutAnimation` and `Animated`. Each of these come with their own strengths and weaknesses. With `LayoutAnimation` we can easily transition our entire UI, while `Animated` gives us more precise control over individual values we want to animate.

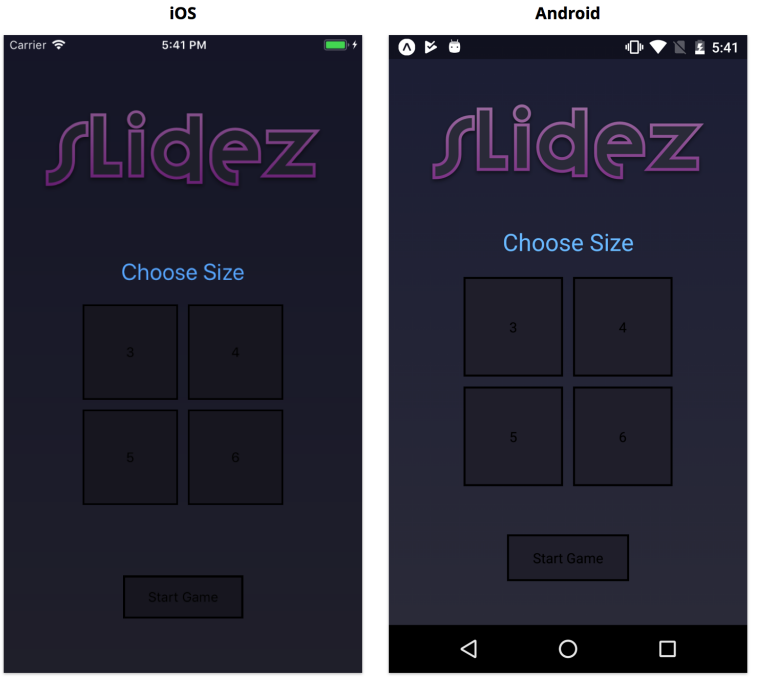
Initial layout

Let's use `LayoutAnimation` to animate the position of a logo from the center of the screen to the top of the screen.

Initially we'll show this:



Then we'll animate the position of the logo to turn it into this:



We're rendering placeholder buttons for now. We'll style the buttons and add some custom animations soon.

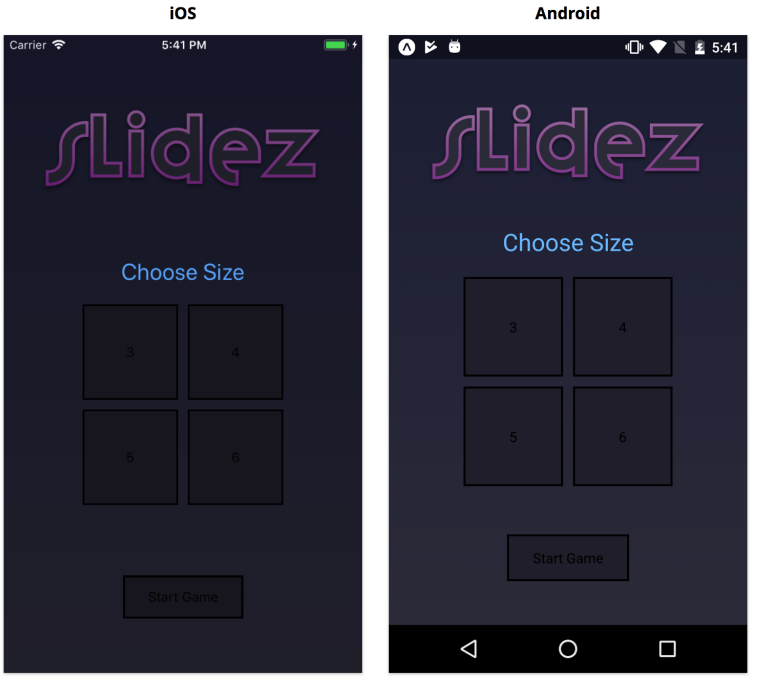
Open up `Start.js`. You'll notice the component's `import` statements, `propTypes`, `state`, and `styles` are already defined.

Let's start by returning the `Logo` and a few other components from our `render` method. Add the following to `render`:

puzzle/screens/Start.js

```
// ...

render() {
  const { size, onChangeSize } = this.props;
  const { transitionState } = this.state;

  return (
    <View style={styles.container}>
      <View style={styles.logo}>
        <Logo />
      </View>
      <View>
        <Toggle
          options={BOARD_SIZES}
          value={size}
          onChange={onChangeSize}
        />
      </View>
      <View>
        <Button title={'Start Game'} onPress={() => {}} />
      </View>
    </View>
  );
}

// ...
```

After saving `Start.js`, you should see the end state of our animation:



We touched on `LayoutAnimation` in the second half of the "Core APIs" chapter, but let's revisit how it works before we use it.

LayoutAnimation

`LayoutAnimation` automatically animates the entire UI of our application from its current layout to the next layout. Elements that change position or size will be translated or scaled. Elements that are added or removed between layouts will be animated too, and we can choose what this animation looks like.

We call `LayoutAnimation.create` to define an animation configuration, and then:

`LayoutAnimation.configureNext` to enqueue the animation to run the next time `render` is called.

The `LayoutAnimation.create` API takes three parameters:

- `duration` - The duration of the animation

- `easing` - The curve of the animation. We choose from a predefined set of curves: `spring`, `linear`, `easeInEaseOut`, `easeIn`, `easeOut`, `keyboard`.
- `creationProp` - The style to animate when a new element is added: `opacity` or `scaleXY`.

The main advantages of `LayoutAnimation` are:

- We can animate our entire UI with a single function call, rather than starting one or several animations for each individual component.
- We can animate flexbox layout attributes like `justifyContent` and `alignItems`, so we don't have to specify movement in terms of coordinates.
- The API fits nicely with React's declarative rendering pattern – we specify the start and end states of our UI by returning components from `render` as we normally would, and `LayoutAnimation` figures out the details of *how* to transition between these states.

The main disadvantages are:

- We have limited control over individual animations and individual components, since every updated layout property of every component animates simultaneously.
- We can *only* animate layout attributes, so if we want to animate other style attributes like color or opacity we'll need to use `Animated`.

Note that we've already added the boilerplate code to enable `LayoutAnimation` on Android at the top of `App.js`.

puzzle/screens/Start.js

```
if (
  Platform.OS === 'android' &&
  UIManager.setLayoutAnimationEnabledExperimental
) {
  UIManager.setLayoutAnimationEnabledExperimental(true);
}
```

As we mentioned in the Core APIs chapter, this will only be necessary until the `LayoutAnimation` implementation on Android matures.

Animating the logo

To animate our logo, we want to initially *not render* the components below it, then *start rendering* them and enqueue an animation with `LayoutAnimation.configureNext`. Since the outer `View` component rendered from our `Start` component has `justifyContent: 'space-around'` in its style, adding more content below the logo will move the logo up.

Our component starts in the `Launching` state, so let's update `render` to only render the `View` components below the logo when we're *not* in the `Launching` state:

puzzle/screens/Start.js

```
// ...

render() {
  const { size, onChangeSize } = this.props;
  const { transitionState } = this.state;

  return (
    <View style={styles.container}>
      <View style={styles.logo}>
        <Logo />
      </View>
      {transitionState !== State.Launching && (
        <View>
          <Toggle
            options={BOARD_SIZES}
            value={size}
            onChange={onChangeSize}
          />
        </View>
      )}
      {transitionState !== State.Launching && (
        <View>
          <Button title={'Start Game'} onPress={() => {}} />
        </View>
      )}
```

```
    </View>
  );
}

// ...
```

When the app is in the `Launching` state, only the logo will appear. If we were to save `Start.js` now, our app would render the logo in the center of the screen indefinitely.

When we shift the `transitionState` from `Launching` to `WillTransitionIn`, `render()` will return the two `View` components below the logo. This will push the logo up towards the top of the screen. We can use `LayoutAnimation` to animate the logo's movement and the other two components' entrances.

Let's write a `componentDidMount` method and call `LayoutAnimation.configureNext` within it and set our `transitionState` to `WillTransitionIn`. We'll also add a little delay using `await` and our utility function `sleep` so we see the logo in the initial state for a short period of time before starting the animation.

Add the following to `Start.js`:

puzzle/screens/Start.js

```
// ...

async componentDidMount() {
  await sleep(500);

  const animation = LayoutAnimation.create(
    750,
    LayoutAnimation.Types.easeInEaseOut,
    LayoutAnimation.Properties.opacity,
  );

  LayoutAnimation.configureNext(animation);

  this.setState({ transitionState: State.WillTransitionIn })
}
```

```
// ...
```

After saving `Start.js`, you should see the animation! The logo should move up toward the top of the screen, and the "Choose Size" text and placeholder buttons will fade in.

Awaiting `LayoutAnimation`

Suppose we want to change the timing of the animations so that the buttons don't fade in until *after* the logo finishing moving toward the top of the screen. To do this, we'll need to know when our `LayoutAnimation` completes.

We can use the second parameter of `LayoutAnimation.configureNext(animation, completionCallback)`, the `completionCallback`, to wait for an animation to finish. However, as of React Native 0.52, this callback currently only works on iOS. To overcome this limitation, we're going to use a utility function that approximates the completion callback on Android (we're going to assume that the animation will complete in the duration we specified for the animation, e.g. 750 milliseconds).

Since we're going to use the same animation in several different places throughout this app, the utility function can also encapsulate some of the animation's configuration parameters. We'll also use a promise-based API for our utility function for convenience.

The utility function is a little tricky, so we've already written it for you in

`configureTransition.js`:

puzzle/utils/configureTransition.js

```
import { LayoutAnimation, Platform } from 'react-native';

export default function configureTransition(onConfigured = () => {}) {
  const animation = LayoutAnimation.create(
    750,
    LayoutAnimation.Types.easeInEaseOut,
    LayoutAnimation.Properties.opacity,
  );

  const promise = new Promise(resolve => {
    // Workaround for missing LayoutAnimation callback support on Andro\
id
    if (Platform.OS === 'android') {
      LayoutAnimation.configureNext(animation);
      setTimeout(resolve, 750);
    } else {
      LayoutAnimation.configureNext(animation, resolve);
    }
  });

  onConfigured();

  return promise;
}
```

If you don't follow exactly what happens with the callback argument and promise, that's fine. The details of this aren't important, and the need for this function should go away in a subsequent React Native release.

We allow passing an `onConfigured` parameter so that we have a place to easily update component state with `setState` between the time we call `LayoutAnimation.create` and the time we actually schedule the animation with `LayoutAnimation.configureNext`.

If we call `LayoutAnimation.configureNext` before `setState`, most animations will still work correctly, but there are a few instances where it won't work on Android.

Let's update `componentDidMount` in `Start` to use our `configureTransition` utility function:

puzzle/screens/Start.js

```
// ...

async componentDidMount() {
  await sleep(500);

  await configureTransition(() => {
    this.setState({ transitionState: State.WillTransitionIn });
  });

  // ...
}

// ...
```

When you save the app now, you should see the exact same animation as before. The updated code is a bit simpler and handles the completion callback, so that's how we'll use `LayoutAnimation` throughout the rest of the app.

Animating buttons

Now that we can wait for the `LayoutAnimation` to complete, let's update the animation of the buttons to fade in *after* the logo finishes moving. We could use `LayoutAnimation` again, but instead we're going to learn how to make the same fade animation using the `Animated` API.

Animated

The `Animated` API lets us animate most style attributes of core components. While `LayoutAnimation` is designed to automatically transition between two states, `Animated` lets us fine-tune the timing and duration of individual style attributes. Although `Animated` gives us more control than `LayoutAnimation`, it's also more complex: we must define which style attributes we want to animate individually, and imperatively call functions to start these animations.

There are two parts to `Animated`:

- `Animated.Value` - This is a class that wraps a primitive value (number, string, etc) for use in component styles. The `Animated` API includes functions for modifying the primitive value within the wrapper, e.g. `Animated.add`.
- `Animated.createAnimatedComponent(Component)` - Components must be specially wrapped with `Animated.createAnimatedComponent` in order to handle `Animated.Value` in their styles. The `Animated` API exports a wrapped version of some of the most common components: `Animated.View`, `Animated.Text`, `Animated.Image`, and `Animated.ScrollView`. These are just for convenience – `Animated.View` is equivalent to `Animated.createAnimatedComponent(View)`.

Running animations

It's time to make the fade animation for our buttons! Let's begin by instantiating two `Animated.Value` instances. One will represent the opacity of the `Toggle` component, and the other will represent the opacity of the start `Button` component. While we could animate both components with a single `Animated.Value`, by instead instantiating one for each component, we can animate the components independently. In our case, we'll use an animation option called `delay` to stagger the animations independently.

We'll instantiate these animated values as instance properties of our `Start` component. We'll add them below where we instantiate the initial state:

puzzle/screens/Start.js

```
  state = {
    transitionState: State.Launching,
  };

  toggleOpacity = new Animated.Value(0);
  buttonOpacity = new Animated.Value(0);
```

We initialize each `Animated.Value` with a primitive value of `0`. For our animation, this primitive value will represent that opacity of our components: `0` represents a fully transparent style and `1` represents a fully opaque style.

To perform a fade-in animation, we instruct the `Animated.Value` to change its primitive value from `0` to `1` over a some duration using an animation curve. There are variety of different animation curves we can use to update the value:

- `Animated.timing` - This animates a value using an easing curve over a specified duration. E.g. `Animated.timing(this.buttonOpacity, { toValue: 1, duration: 500, easing: Easing.inOut(Easing.ease) })`. The `Easing` API provides most of the common easing curve functions used for animation. If we don't provide a value for `easing`, the default is `Easing.inOut(Easing.ease)`, which generally looks pretty good.
- `Animated.spring` - This animates a value using a simulated spring. The tension and friction of the spring are customizable. E.g. `Animated.spring(this.buttonOpacity, { toValue: 1, friction: 7, tension: 40 })`.
- `Animated.decay` - This animates a value by simulating motion and kinetic energy. The animated value will decay to `0`, using the provided velocity and deceleration. E.g. `Animated.decay(this.buttonOpacity, { velocity: 1, deceleration: 0.997 })`.

Both `Animated.timing` and `Animated.spring` accept a `delay` option which will delay when the animation begins. We'll use this `delay` to stagger the animations.

Calling any of these animation functions returns an object with two methods:

- `start(completionCallback?)` - We must always `start()` an animation when we want it to run (which is often immediately). We can optionally provide a callback that's invoked when the animation completes (or is stopped).
- `stop()` - We can force an animation to stop at any time by calling `stop()`. If we passed a `completionCallback` to the `start` function, it will be invoked with `{ finished: false }`.

We'll use `Animated.timing` for our animations, configuring the animations to last for 500 milliseconds. We'll set the first animation to start 500 milliseconds after the `LayoutAnimation` finishes, and we'll set the second animation to start 1000 milliseconds after.

puzzle/screens/Start.js

```
  async componentDidMount() {
    await sleep(500);

    await configureTransition(() => {
      this.setState({ transitionState: State.WillTransitionIn });
    });

    Animated.timing(this.toggleOpacity, {
      toValue: 1,
      duration: 500,
      delay: 500,
      useNativeDriver: true,
    }).start();

    Animated.timing(this.buttonOpacity, {
      toValue: 1,
      duration: 500,
      delay: 1000,
      useNativeDriver: true,
    }).start();
  }
```

Any time we configure an animation, we need to start it with `.start()`. In this case, we do it right after calling `Animated.timing`.

If at any point you run an app and an animation doesn't work, double check that you're calling `.start()`! It's very easy to forget.

We'll come back to `useNativeDriver` shortly.

Lastly, we need to update the render method to use these animated values. We use animated values in the `style` prop of our components, e.g. `style={{ opacity: this.buttonOpacity }}`, just like we would if we were using a primitive value directly.

Using an `Animated.Value` within a component's `style` only works if we're using `Animated.View`, `Animated.Text`, `Animated.Image`, `Animated.ScrollView`, or a component created by calling `Animated.createAnimatedComponent(Component)` with an existing component. For this reason, we'll change some of our `View` components to `Animated.View` now that we're using styles that contain an `Animated.Value`.

puzzle/screens/Start.js

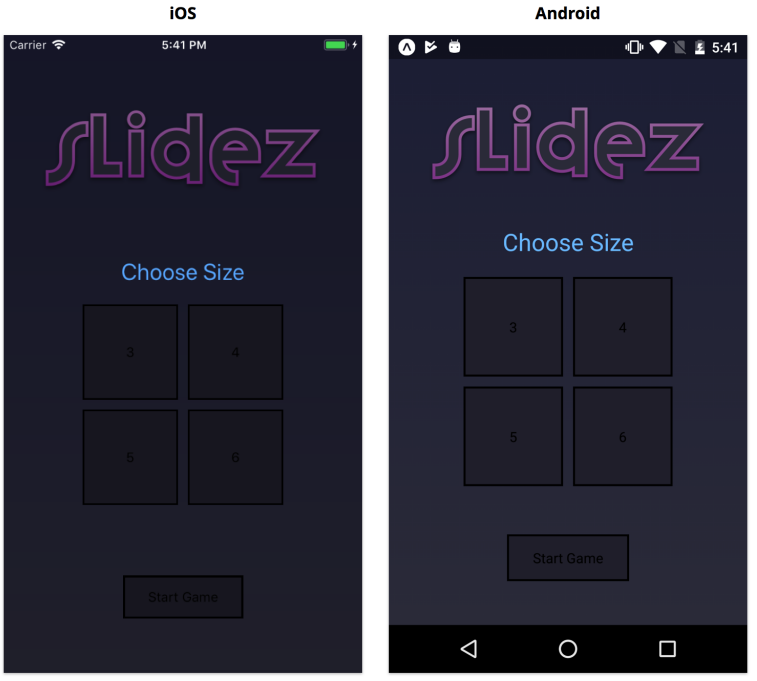
```
// ...

render() {
  // ...

  const toggleStyle = { opacity: this.toggleOpacity };
  const buttonStyle = { opacity: this.buttonOpacity };

  return (
    <View style={styles.container}>
      <View style={styles.logo}>
        <Logo />
      </View>
```

```
      {transitionState !== State.Launching && (
        <Animated.View style={toggleStyle}>
          <Toggle
            options={BOARD_SIZES}
            value={size}
            onChange={onChangeSize}
          />
        </Animated.View>
      )}
      {transitionState !== State.Launching && (
        <Animated.View style={buttonStyle}>
          <Button title={'Start Game'} />
        </Animated.View>
      )}
    </View>
  );
}

// ...
```

Try it out

Save `Start.js` and reload the app. Now the logo should animate, then the toggle buttons, then finally the start button at the bottom.

The end state should look the same as it did before:



Animated value performance

These animations should probably look pretty smooth on your device. Let's briefly discuss how they work under the hood.

Normally when we want to change how a component is rendered, we change either the props or state of the component, and this triggers a re-render. However, re-rendering 60 times per second (to achieve 60fps) is often too slow. Thus, animations must happen outside of the lifecycle of our components.

You might have noticed that we didn't store our `Animated.Value` instances in the `state` of our `Start` component. The `Animated.Value` is a **reference** to a class instance that wraps a primitive value. When we change the underlying primitive value with `Animated.timing` and `start`, this doesn't change the `Animated.Value` reference. Even if we were to store the animated value in `state`, the component wouldn't re-render when we call `Animated.timing` or `start`.

Animated values *can* be stored in component `state`, even though they will never trigger a re-render. By convention, animated values are either stored in `state` or as instance properties. Both are common conventions – it's up to you which you prefer.

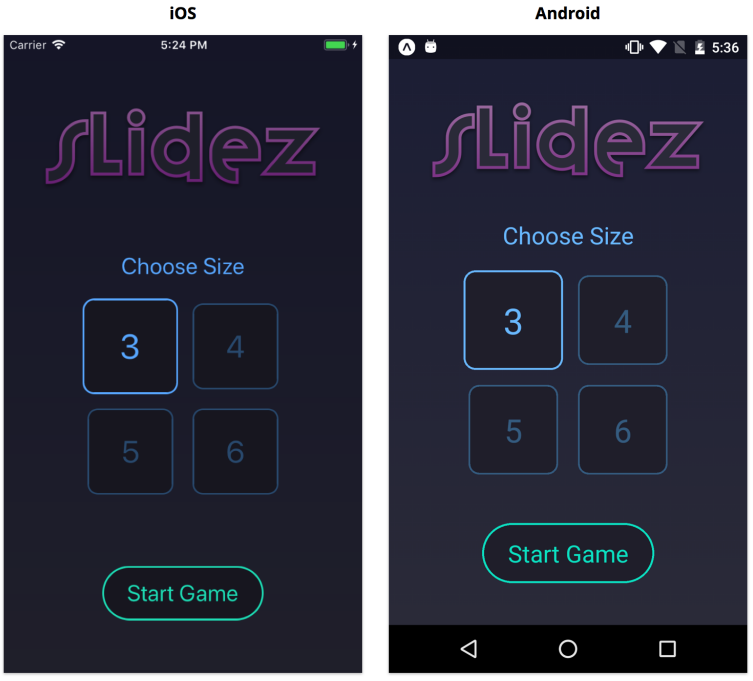
When we call `Animated.start`, the JavaScript animation driver (the thing that actually runs our animations) uses `requestAnimationFrame` to update our component's styles in a way that doesn't require a component to re-render (called `setNativeProps`) every frame.

You may have noticed that we also added `useNativeDriver` to our animation configurations. This option is purely for improved animation performance. This option tells React Native to perform the animation solely on the native thread using the native animation driver, rather than passing values back and forth between JavaScript and React Native. We can only use `useNativeDriver` when animating styles that don't affect layout, such as `opacity`, `backgroundColor`, or `transform`. We can't use `useNativeDriver` when animating `width` or `top`, for example, since these affect layout.

Advanced `Animated.Value`

Now that we've covered the basics of `Animated.Value`, we can try some more advanced animations.

Let's replace the placeholder buttons that sit below the logo on the `Start` screen with some that look nicer:



So far when we've created buttons in this book, we've used `TouchableOpacity` and `TouchableHighlight`. The animations for these are pre-defined to change the opacity and background color of the button's view. But what if we want a custom button-press animation? In this section, we'll use the `Animated` API to animate the border color, text color, and scale of our own custom `Button` component.

Updating our buttons

We're already rendering this `Button` in our `Start` screen, and it's used within the `Toggle` component, which we also render from `Start`. We'll make the height, color, font size, and border radius of the button configurable so that we can use the same component in both places.

Open up `components/Button.js`. Once again, the `import` statements, `propTypes`, and `styles` have been filled out for you. There's also a render method that was used to render our placeholder buttons, but we'll replace that entirely.

Let's begin by writing the `constructor`. Here, we'll track whether or not the button

is currently `pressed` within the component's `state`. We use the `disabled` prop to determine if the component is currently selected (in our toggle component) or not. We'll also initialize a new `Animated.Value` to represent the color and scale of the button, which we'll store as `this.value`:

puzzle/components/Button.js

```
  constructor(props) {
    super(props);

    const { disabled } = props;

    this.state = { pressed: false };
    this.value = new Animated.Value(getValue(false, disabled));
  }
```

You'll notice we call a utility function, `getValue`, to get the initialize the primitive value wrapped by an `Animated.Value`. This function has already been written for you at the top of the file:

puzzle/components/Button.js

```
const getValue = (pressed, disabled) => {
  const base = disabled ? 0.5 : 1;
  const delta = disabled ? 0.1 : 0.3;

  return pressed ? base - delta : base;
};
```

This utility function returns a different number depending on the state and props of the component. The exact numbers were chosen arbitrarily to make the animation look nice, but let's go into a little more detail about what these will be used for.

When we used `Animated.Value` for opacity previously (our components below the logo), we used a value between `0` and `1` to represent the opacity. We were able to use the `Animated.Value` directly, since opacity is also a number between `0` and `1`. In this case, however, we want to animate a color value, rather than a number. An `Animated.Value` always wraps a primitive number value, but we can use the

`interpolate` method of an animated value to interpolate the number into a different range (including a range of colors!). For example, we could use `0` to represent black and `1` to represent white, and interpolate any value between `0` and `1` into a gray color in the range between black and white.

For this component, we'll be using a number between `0.1` and `1` to represent the various visual states of our button. The exact number isn't important, since we're mapping it into a different range. In this case, lower numbers will render our component smaller and dimmer, and higher numbers will render it bigger and brighter – but we could've made it so that higher numbers render the button smaller.

We want to animate the button whenever the `disabled` prop or the `pressed` state changes. In order to make the button look and feel good, we'll animate it to a slightly different size and color for each combination of `disabled` and `pressed`, and we'll call `getValue` to get the correct value for each combination.

The utility function is useful since we don't need to remember which values to use for each combination of `disabled` and `pressed`. Since `getValue` is a pure function, we'll always get the same result for any given `pressed` and `disabled` arguments we pass.

Next, we'll create a utility method to update this `Animated.Value` whenever the component's state or props change. We want to start a new `Animated.timing` animation whenever `disabled` or `pressed` change, and we'll use `getValue` to determine the desired end value of our `Animated.Value` for the animation:

puzzle/components/Button.js

```
  updateValue(nextProps, nextState) {
    if (
      this.props.disabled !== nextProps.disabled ||
      this.state.pressed !== nextState.pressed
    ) {
      Animated.timing(this.value, {
        duration: 200,
        toValue: getValue(nextState.pressed, nextProps.disabled),
        easing: Easing.out(Easing.quad),
      }).start();
```

```
    }
  }
```

We want to run this animation every time the component will update or receive new props:

puzzle/components/Button.js

```
  componentWillUpdate(nextProps, nextState) {
    this.updateValue(nextProps, nextState);
  }

  componentWillReceiveProps(nextProps, nextState) {
    this.updateValue(nextProps, nextState);
  }
```

We'll also create functions for updating the `pressed` state, which we'll soon use in the `render` method:

puzzle/components/Button.js

```
  handlePressIn = () => {
    this.setState({ pressed: true });
  };

  handlePressOut = () => {
    this.setState({ pressed: false });
  };
```

Rendering with `Animated.Value`

Now we're ready to render our button.

We'll start by rendering a `TouchableWithoutFeedback` to handle touches. This is similar to `TouchableOpacity` and `TouchableHighlight`, except that there's no visual

feedback for the user when tapped. That's what we want in this case, since we're defining our own visual feedback with the `Animated` API.

In addition to the `onPress` prop that we've used with `TouchableOpacity`, the `TouchableWithoutFeedback` components allows us to pass props that handle the pressing down and releasing of the button separately. The `onPressIn` prop fires when we touch the button, and the `onPressOut` prop fires when we release the button. We can use these to update the visual/animation state of the button by updating `pressed` in state. It's best to use `onPressIn` and `onPressOut` for visual feedback, and to continue using `onPress` for the behavior of a button (calling the `onPress` function prop passed into `Button`).

We want to render a `TouchableWithoutFeedback`, passing it an `onPress`, `onPressIn`, and `onPressOut` prop. Go ahead and *delete the existing render method* (we don't need it anymore), and replace it with the following one:

puzzle/screens/Start.js

```
// ...

render() {
  const {
    props: { title, onPress, color, height, borderRadius, fontSize },
  } = this;

  // ...

  return (
    <TouchableWithoutFeedback
      onPress={onPress}
      onPressIn={this.handlePressIn}
      onPressOut={this.handlePressOut}
    >
      {/* ... */}
    </TouchableWithoutFeedback>
  );
}
```

```
// ...
```

Note that we propagate the `onPress` prop from our `Button` component into the `TouchableWithoutFeedback`.

Within the `TouchableWithoutFeedback`, we'll render an `Animated.View` and an `Animated.Text` component:

puzzle/screens/Start.js

```
// ...

render() {
  // ...

  return (
    <TouchableWithoutFeedback
      onPress={onPress}
      onPressIn={this.handlePressIn}
      onPressOut={this.handlePressOut}
    >
      <Animated.View style={/* ... */}>
        <Animated.Text style={/* ... */}>
          {title}
        </Animated.Text>
      </Animated.View>
    </TouchableWithoutFeedback>
  );
}

// ...
```

For both the `Animated.View` and `Animated.Text`, we want to use `this.value` to modify their color – we can do this with `this.value.interpolate`. As mentioned previously, the `interpolate` method lets us interpolate an `Animated.Value` into a different range. In this case, we'll interpolate a number between `0` and `1` into a color between `black` and the `color` prop, where `0` represents `black` and `1` represents fully

colored. In `render()`, let's make a new variable above the return statement to hold this color:

puzzle/components/Button.js

```
  const animatedColor = this.value.interpolate({
    inputRange: [0, 1],
    outputRange: ['black', color],
  });
```

We can use the output of `this.value.interpolate` as a style attribute for any attribute that accepts a color. Similarly, we'll interpolate `this.value` into a suitable range to update the `scale` of the button:

puzzle/components/Button.js

```
  const animatedScale = this.value.interpolate({
    inputRange: [0, 1],
    outputRange: [0.8, 1],
  });
```

In this case, 0 will map to 0.8 and 1 will map to 1. These numbers were chosen by testing the animation and trying a few different values to see what looked best.

Next we'll create a style object for our `Animated.View`:

puzzle/components/Button.js

```
  const containerStyle = {
    borderColor: animatedColor,
    borderRadius,
    height,
    transform: [{ scale: animatedScale }],
  };
```

Transform

By using the `transform` attribute of a component's `style`, we can apply a transformation matrix to the component before rendering it. This allows us to scale, rotate, translate, or skew the component.

Transformations applied this way don't affect the layout of other components. Even if we make a component bigger by setting a `{ scale: 2 }` transformation, the sibling and parent components will remain in the exact same position. If components overlap after a transformation is applied, the component rendered last will render on top (unless `zIndex` is used for re-ordering).

Because `transform` doesn't affect the layout of our components, we're able to animate it with `useNativeDriver` for improved performance. For this reason, we generally use `transform` whenever we can for animations. Rather than animating `top` or `left`, we can `translate`. Rather than animating `width` and `height`, consider a `scale` transformation. Some of the time we'll still need to animate layout properties, but it's good to consider whether a `transform` can accomplish the same thing.

If you're coming from CSS, you might be familiar with the `transform` attribute already. The idea is the same, although the API is fairly different. The API in React Native might seem unusual: the `transform` attribute takes an array of objects, each with a single key. This object-based description of transformations, e.g. `{ scale: 2 }`, lets React Native expose a type-safe API when used with the Flow language. By contrast, the API in CSS is string-based, e.g. `scale(2)`, which can't be fully type-checked in Flow. We can't simplify the API by combining the array of objects into a single object, since it's possible to apply several of the same kind of transformation, e.g. `[{ scale: 2 }, { rotateX: '45deg' }, { scale: 1.2 }]`.

To see all the transformations you can apply to components, check out the React Native documentation[a].

[a] https://facebook.github.io/react-native/docs/transforms.html

And a style object for our `Animated.Text`:

puzzle/components/Button.js

```
  const titleStyle = {
    color: animatedColor,
    fontSize,
  };
```

Update the return value as follows:

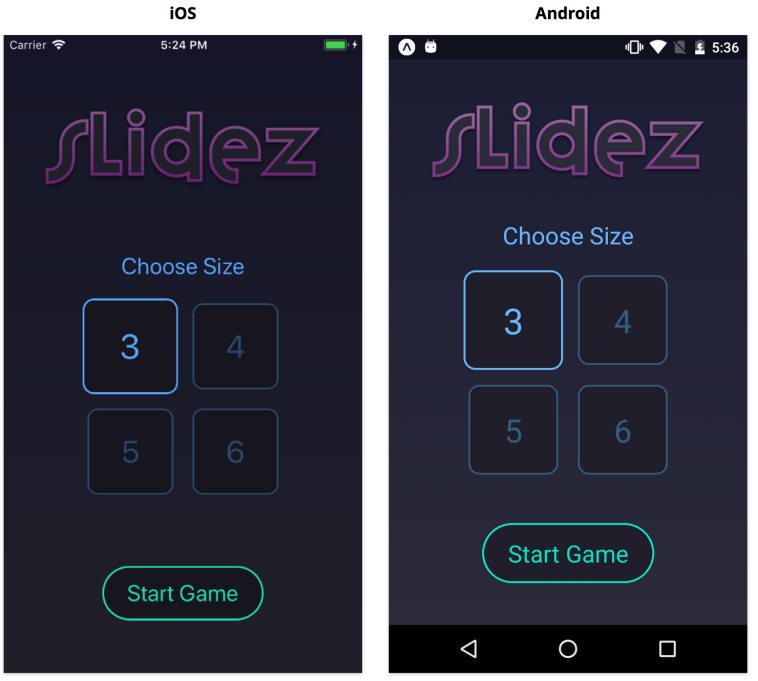
puzzle/components/Button.js

```
  return (
    <TouchableWithoutFeedback
      onPress={onPress}
      onPressIn={this.handlePressIn}
      onPressOut={this.handlePressOut}
    >
      <Animated.View style={[styles.container, containerStyle]}>
        <Animated.Text style={[styles.title, titleStyle]}>
          {title}
        </Animated.Text>
      </Animated.View>
    </TouchableWithoutFeedback>
  );
```

Remember to use wrapped components like `Animated.View` when working with animations! It's very easy to forget. If you pass an `Animated.Value` in the style of a normal `View`, you'll get seemingly-unrelated error messages that are hard to decipher.

Try it out

Save `Button.js`. Once the app reloads, you should see the button component we just wrote on the `Start` screen. We use it both for choosing the size of the puzzle and for the "Start Game" button:



If you try tapping the button, you should see the border color, text color, and scale animate when you press and when you release your finger.

Starting the game

The last thing we need to do on the start screen is enable the transition to the game screen. We'll transition when the user taps the "Start Game" button at the bottom of the screen.

Open up `Start.js` again. We're going to add a function `handlePressStart` that sets the `transitionState` to `WillTransitionOut`, and configures a `LayoutAnimation` using the `configureTransition` utility function we wrote earlier. After the animation completes we'll call the `onStartGame` prop, which tells the `App` to unmount this screen and render the game screen instead. Add the following function to the `Start` component:

puzzle/screens/Start.js

```
  handlePressStart = async () => {
    const { onStartGame } = this.props;

    await configureTransition(() => {
      this.setState({ transitionState: State.WillTransitionOut });
    });

    onStartGame();
  };
```

Then we'll update the render method with two new things.

- We'll pass the `handlePressStart` function to our `Button` component's `onPress` prop.
- If we're in the `WillTransitionOut` state, we don't want to render anything. This will cause the components on the screen to fade out, due to the `LayoutAnimation` we configured. In order to achieve this, we'll only render our components when `transitionState !== State.WillTransitionOut`.

Update the render method to the following:

puzzle/screens/Start.js

```
  render() {
    const { size, onChangeSize } = this.props;
    const { transitionState } = this.state;

    const toggleStyle = { opacity: this.toggleOpacity };
    const buttonStyle = { opacity: this.buttonOpacity };

    return (
      transitionState !== State.WillTransitionOut && (
        <View style={styles.container}>
          <View style={styles.logo}>
            <Logo />
```

```
          </View>
          {transitionState !== State.Launching && (
            <Animated.View style={toggleStyle}>
              <Toggle
                options={BOARD_SIZES}
                value={size}
                onChange={onChangeSize}
              />
            </Animated.View>
          )}
          {transitionState !== State.Launching && (
            <Animated.View style={buttonStyle}>
              <Button
                title={'Start Game'}
                onPress={this.handlePressStart}
              />
            </Animated.View>
          )}
        </View>
      )
    );
  }
```

Try it out

Save `Start.js`. Once the app reloads, tap the "Start Game" button. You should see the components on this screen fade out.

Wrapping up the Start screen

We've successfully created the start screen for our puzzle game. To do this we used two types of animations:

- `LayoutAnimation` - These animations automatically transition our UI between two states. This is especially useful when animating many components and

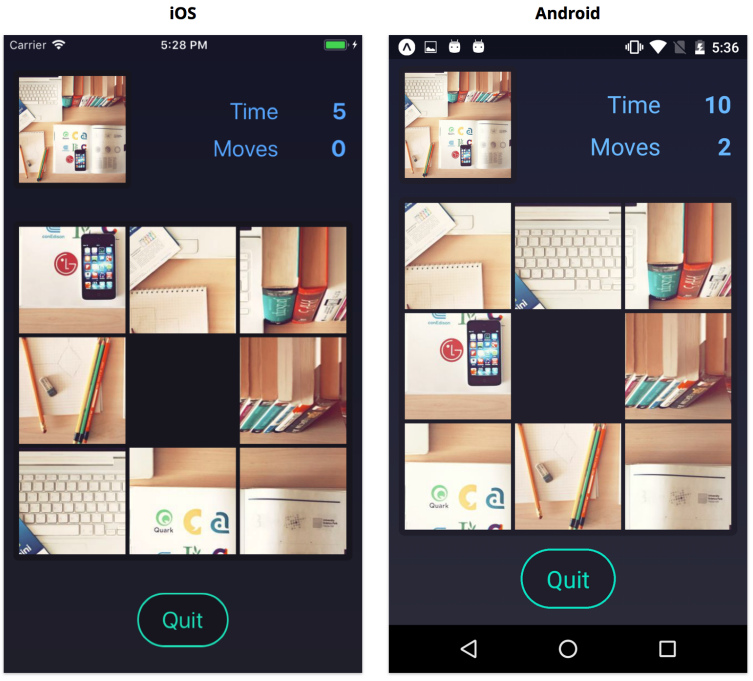
style attributes at once, or when we don't know the exact pixel values to use in the animation (e.g. with flex-based layouts). We can only animate layout attributes, such as `width` or `flex`. If we want to animate non-layout attributes like color, we'll need to use `Animated`.

- `Animated` - These animations offer us more control than `LayoutAnimation`, but also have a more complex API. We have to specify the exact starting and ending value for each animation, and start each animation at the appropriate time. We use these animations when animating multiple components independently, or when animating non-layout attributes like color. We can use `useNativeDriver` to improve the performance of our non-layout animations.

Next, we'll use these same animation techniques to make the Game screen.

Building the Game screen

The Game screen shows the current puzzle, along with a preview of the completed puzzle in the top left and a timer and moves counter in the top right:



Game lifecycle

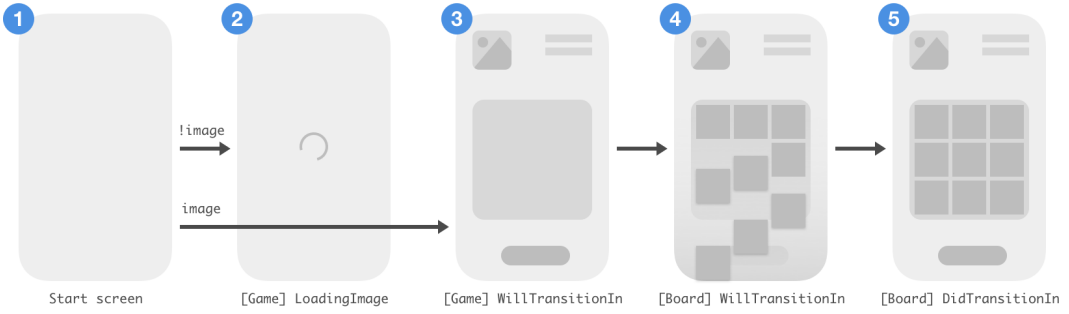
We're going to combine a lot of different animations to show and hide the game screen. Since these are all asynchronous and will span multiple components, the code can easily get complicated without careful planning. It's important that we have a clear understanding of how the animations should work before we attempt to code them.

Let's think about the "lifecycle" of the Game screen. There are two phases of the lifecycle: the "transition in" phase where the screen transitions into view, and the "transition out" phase where it transitions out of view.

The Game screen renders the `Board` component as a child. The `Board` handles a lot of the animations. In the "transition in" phase, we must first display the Game before we display the Board. In the "transition out" phase, we must hide the Board before we hide the Game – we do this to give the board time to animate before unmounting it.

The “transition in” phase

Let’s consider the following diagram of the “transition in” phase:



Here’s what needs to happen at each step:

1. After the user presses the start button on the `Start` screen, the `Start` screen fades out, and the `App` renders the `Game` screen. The `App` passes an image and a puzzle state as props to the `Game`.

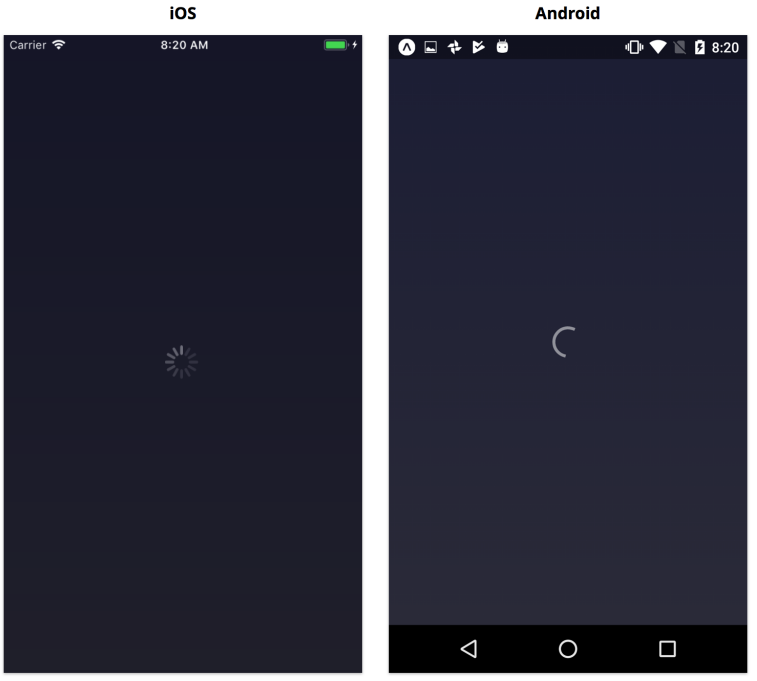
The possible states of the `Game` screen are:

puzzle/screens/Game.js

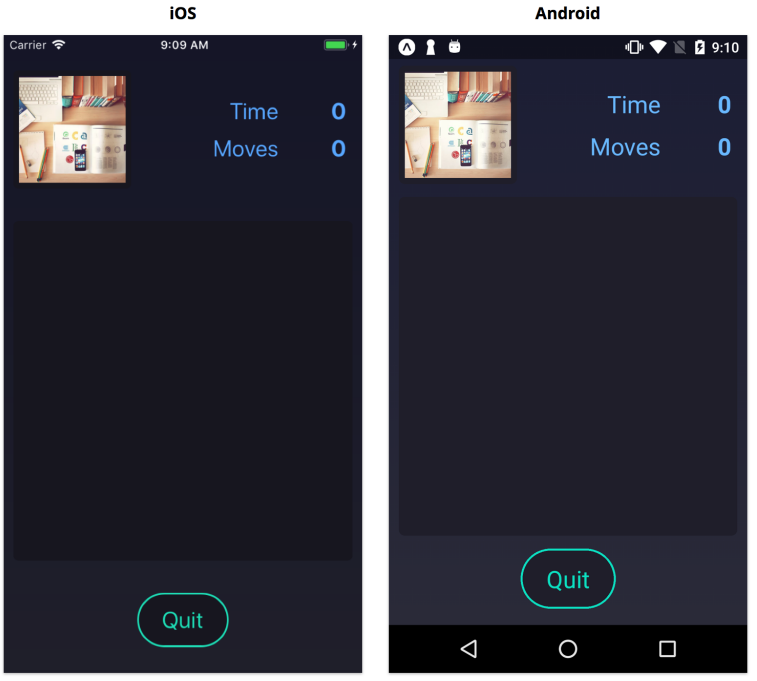
```
const State = {
  LoadingImage: 'LoadingImage',
  WillTransitionIn: 'WillTransitionIn',
  RequestTransitionOut: 'RequestTransitionOut',
  WillTransitionOut: 'WillTransitionOut',
};
```

The `Game` begins in either the `LoadingImage` or `WillTransitionIn` state.

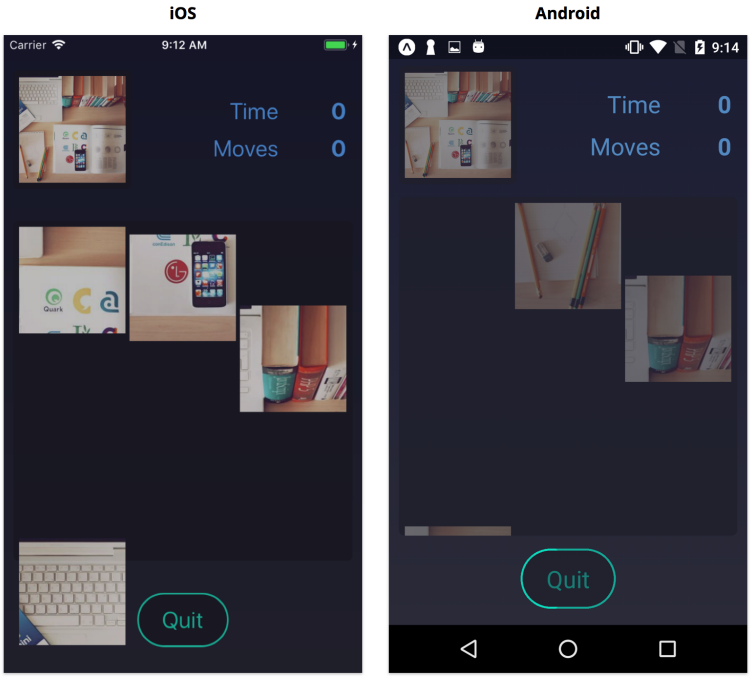
2. Since the `image` may not have fully downloaded yet, it may be null to begin with. If that’s the case, the `Game` begins in the `LoadingImage` state and renders an `ActivityIndicator` until the image loads:



3. Otherwise, the `Game` begins in the `WillTransitionIn` state. In this state, the `Game` will render the top and bottom of the screen, along with an empty game board in the middle:



4. After the `WillTransitionIn` state, it's the `Board` component's turn to animate things. The `Board` component handles animating the puzzle pieces into view:



The possible states of the `Board` component are:

puzzle/components/Board.js

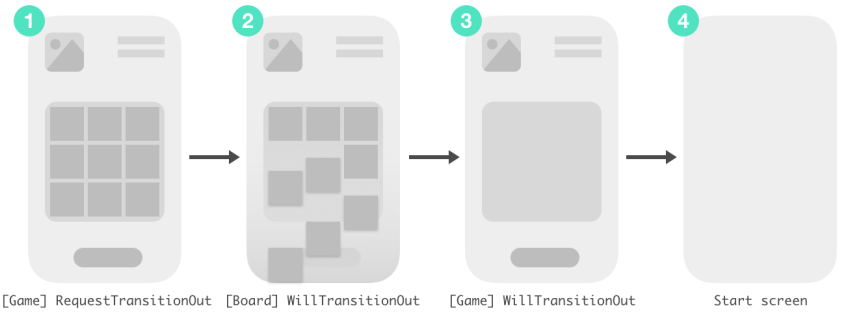
```
const State = {
  WillTransitionIn: 'WillTransitionIn',
  DidTransitionIn: 'DidTransitionIn',
  DidTransitionOut: 'DidTransitionOut',
};
```

The `Board` begins in the `WillTransitionIn` state, and starts animating each puzzle piece from beneath the screen into the center of the screen. Once these animations finish, it will enter the `DidTransitionIn` state and call its `onTransitionIn` prop (passed in from `Game`).

5. The `Game` listens the `Board` to call `onTransitionIn`. Once it's called, the `Game` will start the timer in the top right. Now the game has begun!

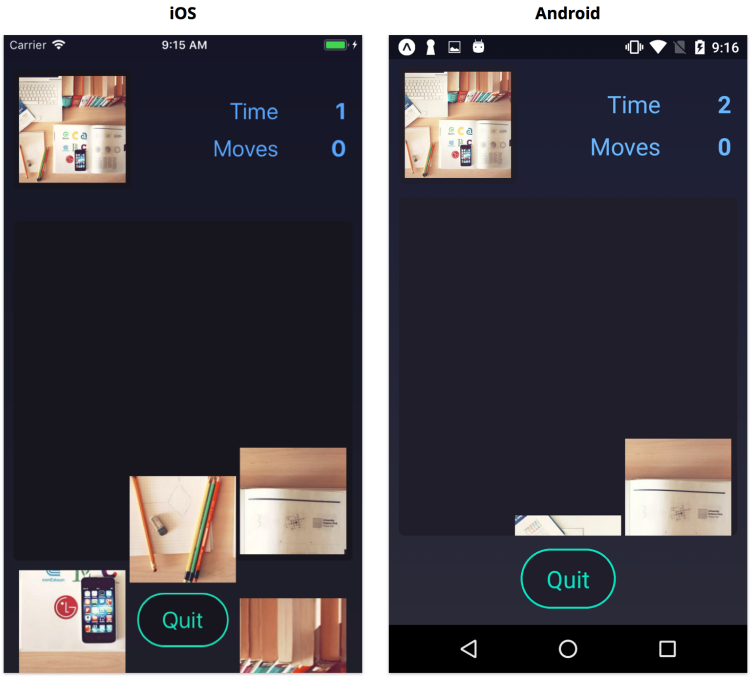
The “transition out” phase

Now let’s consider how the `Game` and `Board` transition out of view:



1. Once the user completes the puzzle or presses the quit button, the game enters the `RequestTransitionOut` state. In this state, the `Game` tells the `Board` to do any cleanup it needs by passing the prop `teardown={true}`.

2. Upon receiving the `teardown` prop, the `Board` transitions animates each puzzle piece out of view. Once this cleanup is done, the `Board` will transition to the `DidTransitionOut` state and call `onTransitionOut`. We do this to give the `Board` a chance to animate before we unmount the component:



3. When the `onTransitionOut` prop is called, the `Game` transitions to its final state, `WillTransitionOut`. In the `WillTransitionOut` state, the `Game` will fade out the entire UI in preparation for displaying the `Start` screen again.

Transitioning in and out

Now that we have a plan, we can start our implementation! Open `screens/Game.js`. Once again, some of the skeleton of the screen has already been written for you.

You can ignore the `handlePressSquare` function for now; we'll come back to that later.

Let's begin by writing the constructor for the `Game` screen. Here we'll use the existence of the `image` prop to determine whether we should begin in the `LoadingImage` or `WillTransitionIn` state. We'll run our `configureTransition` utility to enqueue a `LayoutAnimation` on initial render. This covers step 1 of the "transition in" phase described previously.

Open up `Game.js` and add the following constructor:

puzzle/screens/Game.js

```
  constructor(props) {
    super(props);

    const { image } = props;

    this.state = {
      transitionState: image
        ? State.WillTransitionIn
        : State.LoadingImage,
      moves: 0,
      elapsed: 0,
      previousMove: null,
      image: null,
    };

    configureTransition();
  }
```

If the game begins in the `LoadingImage` state, then we want to watch for when the `image` prop changes so we know when to transition to the `WillTransitionIn` state. This is step 2 of the "transition in". Add the following `componentWillReceiveProps` to do this:

puzzle/screens/Game.js

```
  componentWillReceiveProps(nextProps) {
    const { image } = nextProps;
    const { transitionState } = this.state;

    if (image && transitionState === State.LoadingImage) {
      configureTransition(() => {
        this.setState({ transitionState: State.WillTransitionIn });
      });
```

```
    }
  }
```

We can update the render method to handle these first few states. If we're still loading an image (`Game` is in the `LoadingImage` state) we want to show an `ActivityIndicator`. If we've finished loading the image, we want to show the stats and image preview at the top of the screen. Let's update our render method to the following:

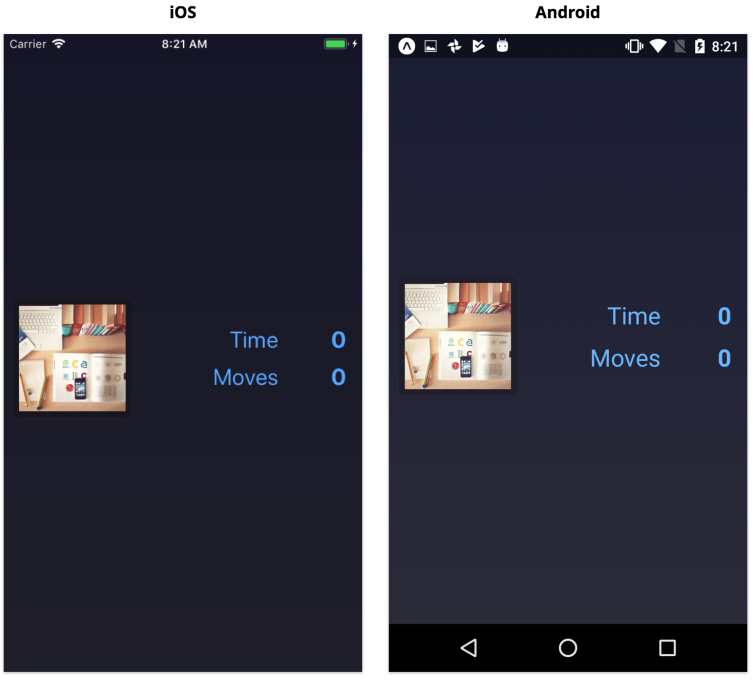
puzzle/screens/Game.js

```
// ...

render() {
  const { puzzle, puzzle: { size }, image } = this.props;
  const {
    transitionState,
    moves,
    elapsed,
    previousMove,
  } = this.state;

  return (
    <View style={styles.container}>
      {transitionState === State.LoadingImage && (
        <ActivityIndicator
          size={'large'}
          color={'rgba(255,255,255,0.5)'}
        />
      )}
      {transitionState !== State.LoadingImage && (
        <View style={styles.centered}>
          <View style={styles.header}>
            <Preview image={image} boardSize={size} />
            <Stats moves={moves} time={elapsed} />
          </View>
          {/* ... */}
        </View>
```

```
      )}
    </View>
  );
}

// ...
```

Try it out

Save `Game.js` and reload the app. If you tap the "Start Game" button, you should see the start screen fade out and the first few components of the game screen fade in.



Transitioning in and out, continued

Now let's add the game board. The `Board` component will handle its own transitions once rendered from `Game`. Rendering the `Board` completes step 3 of the "transition

in" phase, and step 4 will be completed within the `Board` component. Let's create the methods we need to pass as props to the `Board` component. We'll start by creating a method for handling when the `Board` finishes transitioning.

The timer in the top right of the screen counts how much time has elapsed since the game started. Once the board fully transitions in, it will call its `onTransitionIn` prop. That's when we want to start the timer. We'll use `setInterval` to increment `state.elapsed` every second. Let's add a `handleBoardTransitionIn` method that we can pass to `onTransitionIn` to do this:

puzzle/screens/Game.js

```
  handleBoardTransitionIn = () => {
    this.intervalId = setInterval(() => {
      const { elapsed } = this.state;

      this.setState({ elapsed: elapsed + 1 });
    }, 1000);
  };
```

This completes the last step of the transition in phase. However, we'll want to add a few more things before we update the render method. Let's consider how the `Game` screen should transition out.

The game ends either when the puzzle is finished or when the user presses the "Quit" button. In both of these scenarios, we want to enter the `transitionState` called `RequestTransitionOut`. In this state, we give the `Board` time to run its transition animation.

Let's add a `requestTransitionOut` function to `Game` that handles updating `transitionState`. We also want to stop the timer in the top right once we call this:

puzzle/screens/Game.js

```
  requestTransitionOut = () => {
    clearInterval(this.intervalId);

    this.setState({ transitionState: State.RequestTransitionOut });
  };
```

Pressing the quit button should also set the `transitionState` to `RequestTransitionOut`. We can call the same `requestTransitionOut` function for this. When the quit button is pressed, we'll handle it with a new function `handlePressQuit`. We'll use the `Alert` API, which we covered in the "Core APIs" chapter, to ask the user if they are sure they want to quit. Add the following function to `Game`:

puzzle/screens/Game.js

```
  handlePressQuit = () => {
    Alert.alert(
      'Quit',
      'Do you want to quit and lose progress on this puzzle?',
      [
        { text: 'Cancel', style: 'cancel' },
        {
          text: 'Quit',
          style: 'destructive',
          onPress: this.requestTransitionOut,
        },
      ],
    );
  };
```

That handles step 1 of the "transition out" phase. The `Board` component will handle step 2 internally. Once the board transitions out (remember, we had to give it time to transition before unmounting), it will call its `onTransitionOut` prop. When this happens, we want to fade out the components on this game screen. We can do that using our `configureTransition` utility function. After that we want to call the `onQuit()` prop, which will return us to the start screen. Let's write a `handleBoardTransitionOut` function which we'll pass to `onTransitionOut`:

puzzle/screens/Game.js

```
  handleBoardTransitionOut = async () => {
    const { onQuit } = this.props;

    await configureTransition(() => {
      this.setState({ transitionState: State.WillTransitionOut });
    });

    onQuit();
  };
```

That completes the "transition out" phase! Now we can update the render method to render both the `Board` and the "Quit" `Button`.

Before returning anything, we'll first check if we're in the `WillTransitionOut` state – if we are, we don't want to render anything, since we want our `LayoutAnimation` to fade the entire screen out. We also need to remember to pass the `teardown` prop to the `Board` when `Game` is in the `RequestTransitionOut` state.

Let's update the render method to the following:

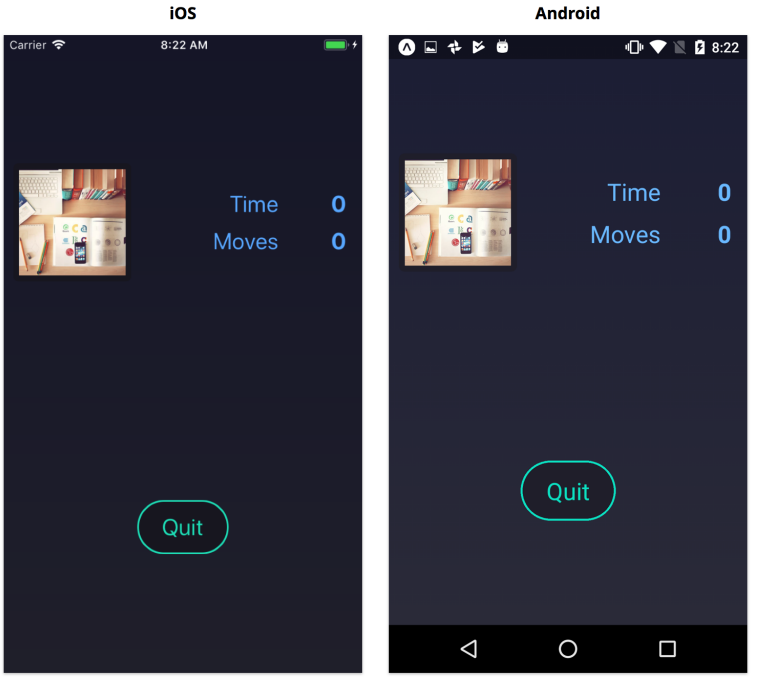
puzzle/screens/Game.js

```
  render() {
    const { puzzle, puzzle: { size }, image } = this.props;
    const {
      transitionState,
      moves,
      elapsed,
      previousMove,
    } = this.state;

    return (
      transitionState !== State.WillTransitionOut && (
        <View style={styles.container}>
          {transitionState === State.LoadingImage && (
            <ActivityIndicator
```

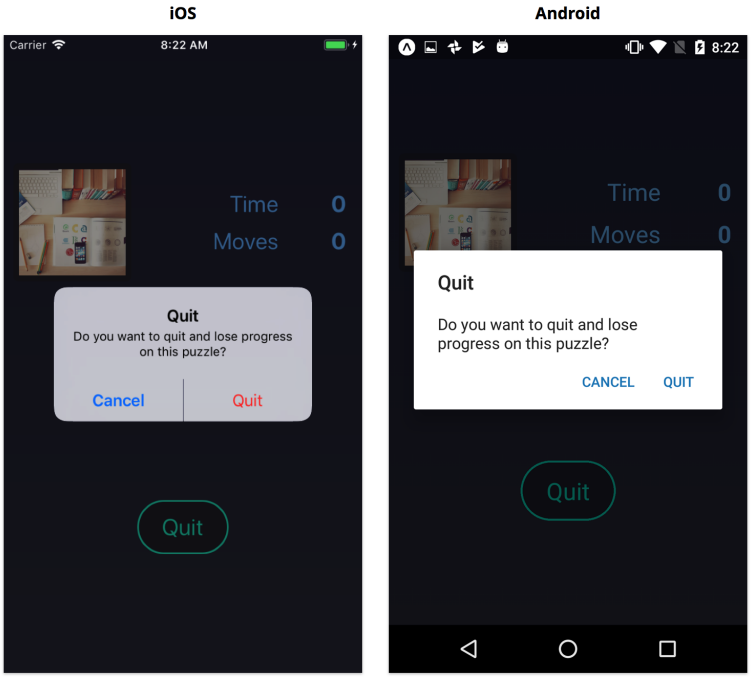
```
            size={'large'}
            color={'rgba(255,255,255,0.5)'}
          />
        )}
        {transitionState !== State.LoadingImage && (
          <View style={styles.centered}>
            <View style={styles.header}>
              <Preview image={image} boardSize={size} />
              <Stats moves={moves} time={elapsed} />
            </View>
            <Board
              puzzle={puzzle}
              image={image}
              previousMove={previousMove}
              teardown={
                transitionState === State.RequestTransitionOut
              }
              onMoveSquare={this.handlePressSquare}
              onTransitionOut={this.handleBoardTransitionOut}
              onTransitionIn={this.handleBoardTransitionIn}
            />
            <Button title={'Quit'} onPress={this.handlePressQuit} />
          </View>
        )}
      </View>
    )
  );
}
```

Try it out

Save `Game.js` and reload the app. If you tap the "Start Game" button, you should see the start screen fade out and the game screen fade in:



The board won't render yet, but we'll add that in the next chapter. If you tap the "Quit" button, you should see a dialog with options to "Cancel" or "Quit":



These won't do anything yet though, since the `Board` will never call its `onTransitionOut` prop.

That completes the `Game` screen, for now. In the next chapter, we'll build the `Board`.

Summary

In this chapter, we used the two main animation APIs included in React Native: `Animated` and `LayoutAnimation`. We used `LayoutAnimation` to move components around the screen, and to fade components into and out of view. We used `Animated` to animate non-layout styles like colors and when we wanted more control over individual animations.

In the next chapter ("Gestures"), we'll finish our puzzle game. We'll build the `Board` component and allow the user to rearrange puzzle pieces by dragging. Gestures rely heavily on `Animated`, so we'll see a few more ways we can use the `Animated` API, while ensuring smooth, high-performance animations.

Gestures

Gestures are fundamental to building mobile apps. Well-designed gestures can make mobile apps feel intuitive and easy to use. Just like with animations, we often use gestures to imitate movement in the real world or to build interactivity similar to familiar physical objects. For this reason, most gestures are accompanied by animations – physical objects rarely teleport from one place to another, so neither should components in our UI. We can leverage the `Animated` API from the previous chapter to build gestures that feel natural.

Simple gestures are supported out-of-the-box by React Native components. When we want to add a tap gesture, we can use `TouchableOpacity` or `TouchableHighlight`. For more advanced gestures, however, we'll need to create our own components using lower-level APIs. In this chapter we'll explore gestures by adding an interactive game board to the puzzle app we started in the previous chapter.

Picking up where we left off

We successfully built the start screen and we started the game screen for our puzzle app. Next, we're going to add the interactive board.

This is a **code checkpoint**. If you haven't been coding along with us through the Animations chapter but would like to start now, we've included a snapshot of our current progress in the `checkpoints/puzzle-2` directory of the sample code. You can follow along by working directly within the `checkpoints/puzzle-2` directory, although you're welcome to copy it somewhere else on your computer.

To get started, navigate into that directory and install `node_modules` using `yarn`.

```
$ cd checkpoints/puzzle-2
$ yarn
```

It's normal to see tens of (yellow) warnings in the console as `yarn` installs your `node_modules`. Only (red) errors indicate a problem that likely needs resolving.

Building the board

Our `Board` component is responsible for animating the puzzle pieces into view when the components mount, handling the drag gesture as the user moves the pieces, and animating the pieces out of view when the game ends.

The `Board` component has already been started for you. Let's take a look at what's already there. Open `Board.js`.

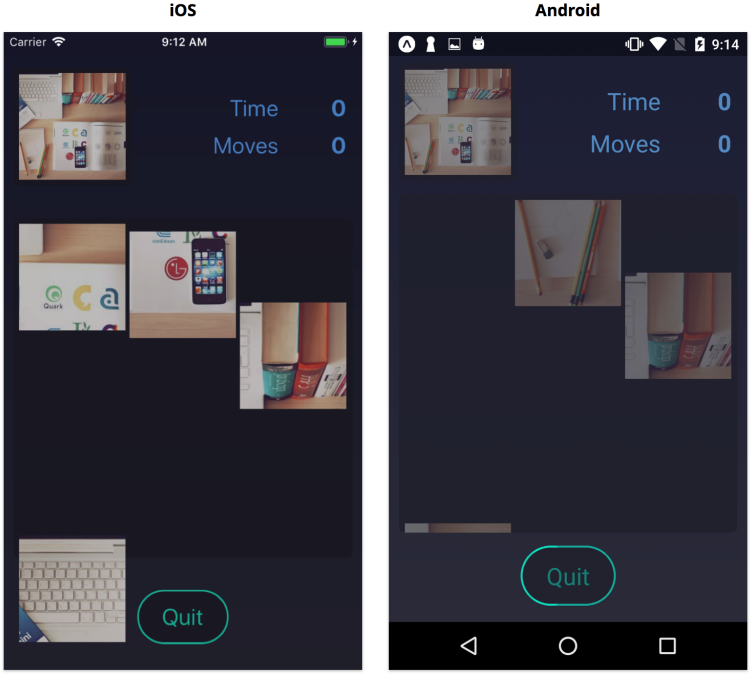
Transition states

Just like with the `Start` and `Game` screens we built in the previous chapter, we'll use a `transitionState` prop to control the various transitions in the `Board`. These are the states of the board:

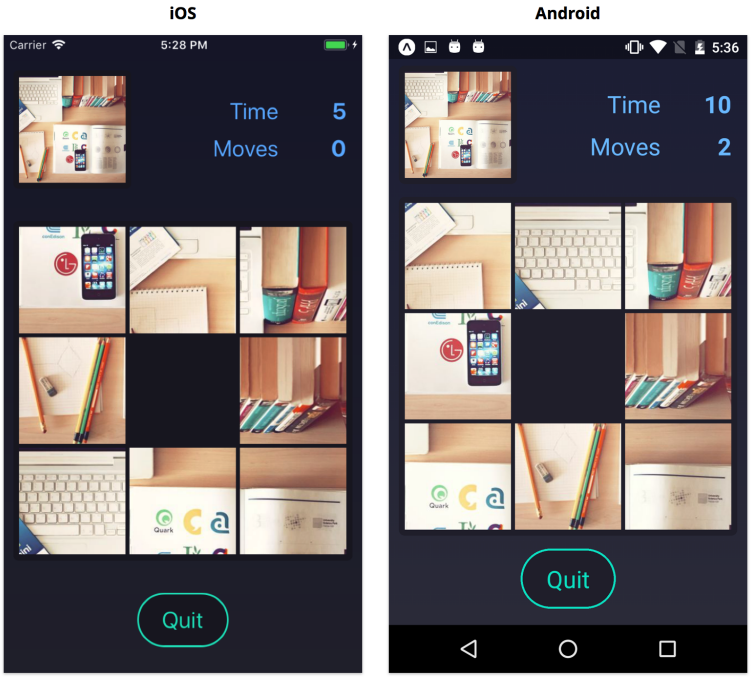
puzzle/components/Board.js

```
const State = {
  WillTransitionIn: 'WillTransitionIn',
  DidTransitionIn: 'DidTransitionIn',
  DidTransitionOut: 'DidTransitionOut',
};
```

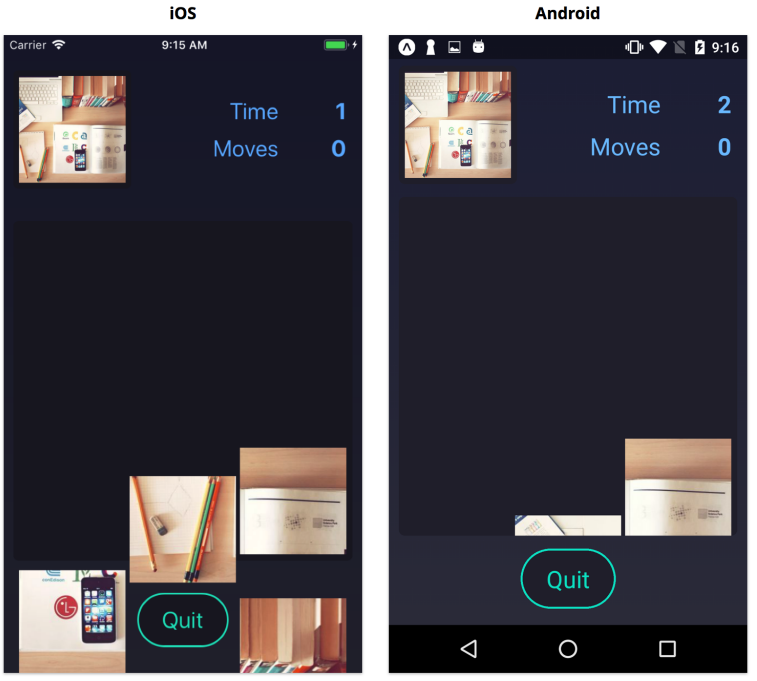
The `Board` begins in the `WillTransitionIn` state, and starts animating each puzzle piece from beneath the screen into the center of the screen:



Once these animations finish, it will enter the `DidTransitionIn` state and call its `onTransitionIn` prop (passed in from `Game`). At this point, the puzzle pieces become interactive:



The `Game` will tell the board when the game is finished and it's time to cleanup by passing the `teardown` prop. Upon receiving the `teardown` prop, the `Board` transition animates each puzzle piece out of view:



Once this cleanup is done, the `Board` will transition to the `DidTransitionOut` state and call `onTransitionOut`.

Board props

Next lets look at the `propTypes` for this component:

checkpoints/puzzle-2/1/components/Board.js

```
  static propTypes = {
    puzzle: PuzzlePropType.isRequired,
    teardown: PropTypes.bool.isRequired,
    image: Image.propTypes.source,
    previousMove: PropTypes.number,
    onMoveSquare: PropTypes.func.isRequired,
    onTransitionIn: PropTypes.func.isRequired,
    onTransitionOut: PropTypes.func.isRequired,
  };
```

The board is passed the current state of the `puzzle`, the `image`, and the `previousMove`. From these, the board can determine how to render the puzzle. The board will never modify the state of the puzzle – instead, the board will call `onMoveSquare` to inform the `Game` component that a piece has been moved.

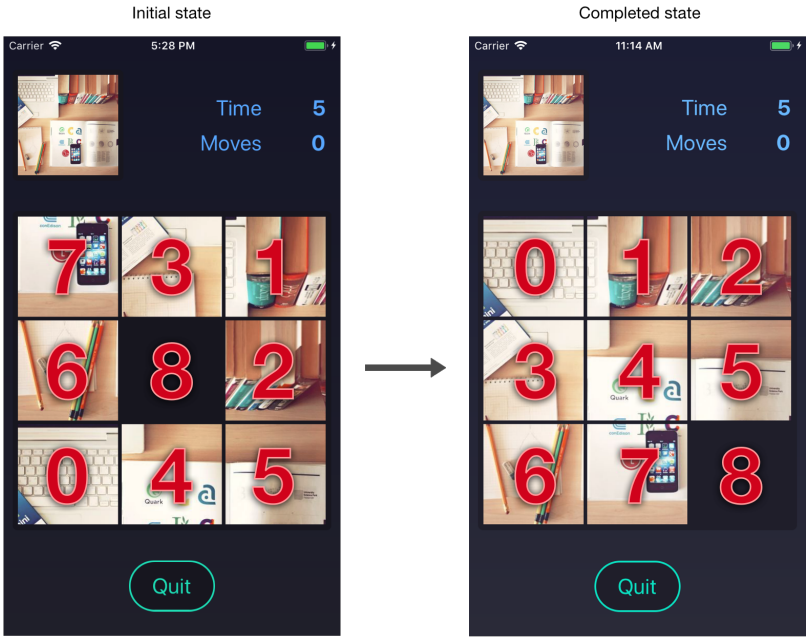
We use a `PropTypes.shape` to validate the fields within the puzzle object:

puzzle/validators/PuzzlePropType.js

```
import PropTypes from 'prop-types';

export default PropTypes.shape({
  size: PropTypes.number.isRequired,
  empty: PropTypes.number.isRequired,
  board: PropTypes.arrayOf(PropTypes.number.isRequired).isRequired,
});
```

The puzzle object contains the `size` of the board, the arrangement of pieces on the `board`, and an indicator recording which piece is the `empty` piece. Each piece is represented by a number. In its finished state, the piece numbers will be properly sorted from small to large within `board`. In other words, the number represents the "correct" or "final" position of the piece in the completed puzzle. The `empty` value refers to the number of a piece (not to an index in the `board` array).

If we overlay these numbers on top of the puzzle board, we can see how each number corresponds with a piece:



For this example, the initial state of a puzzle object is:

```
{
  size: 3,
  empty: 8,
  board: [7, 3, 1, 6, 8, 2, 0, 4, 5]
}
```

When completed, the puzzle object will be:

```
{
  size: 3,
  empty: 8,
  board: [0, 1, 2, 3, 4, 5, 6, 7, 8]
}
```

We'll use the piece numbers directly when rendering the board. We'll use utility functions for determining anything else from the puzzle object.

> If you recall from the previous chapter, each puzzle uses a random image fetched from a remote API. When we render the puzzle, we'll need to "split up" the image into a grid of puzzle pieces.
>
> We won't actually modify the raw image data – instead we'll render the same image multiple times, once for each piece, and offset the image's position. We can use a style with `overflow: hidden` to hide the excess parts of the image we don't want to show. We'll use the piece's number to calculate the position of the image for that piece.

You'll notice at the top of the file we import two utility functions:

```
import { availableMove, getIndex } from '../utils/puzzle';
```

We'll use `availableMove` to determine which directions the user may drag any given piece. And we'll use `getIndex` to determine the current position of any given piece.

The other props, `teardown`, `onTransitionIn`, and `onTransitionOut`, are all used to communicate state changes between the `Game` and `Board` components.

Initializing the board

We'll start by writing a simplified version of the game board where the pieces don't move. After we have the pieces showing up in the correct positions, we'll add the animation and gestures.

Each piece on the board will use an `Animated.Value` to represent its `top`, `left`, and `scale`. This gives us fine-grained control over the animations of each piece. We can use a helper function, `calculateItemPosition`, already imported at the top of the file to determine the correct starting `top` and `left` position of each piece.

Our constructor needs to do 2 things:

- Initialize the `transitionState` to `WillTransitionIn`
- Create an `Animated.Value` for the `top`, `left`, and `scale` of each piece

Add the following `constructor` to `components/Board.js`:

checkpoints/puzzle-2/1/components/Board.js

```
  constructor(props) {
    super(props);

    const { puzzle: { size, board } } = props;

    this.state = { transitionState: State.WillTransitionIn };
    this.animatedValues = [];

    board.forEach((square, index) => {
      const { top, left } = calculateItemPosition(size, index);

      this.animatedValues[square] = {
        scale: new Animated.Value(1),
        top: new Animated.Value(top),
        left: new Animated.Value(left),
      };
    });
  }
```

Recall from the previous chapter that an `Animated.Value` wraps a number. We need to instantiate a separate `Animated.Value` for the `top`, `left`, and `scale` of each puzzle piece on the board, since we want to animate all of these values independently.

We'll render each puzzle piece with an `absolute` position, so that it renders at the top-left of the board. Then we'll use the `top` and `left` animated values to position the piece relative to the top-left of the board.

Now that we have our constructor, we'll also need a `componentDidMount` method where we:

- Start the initial animation (where the puzzle pieces fly onto the board)
- Set `transitionState` to `DidTransitionIn` once the animation completes

- Call `onTransitionIn` to inform the `Game` that the transition animation has completed and the game has begun

We'll handle starting the transition animation later in the chapter, so for now, let's add a `componentDidMount` method that sets the `transitionState` and calls `onTransitionIn`:

checkpoints/puzzle-2/1/components/Board.js

```
  async componentDidMount() {
    const { onTransitionIn } = this.props;

    this.setState({ transitionState: State.DidTransitionIn });

    onTransitionIn();
  }
```

Rendering the board

Next, let's render each piece on the game board. In order to determine the proper size of the board and each piece, we'll use two utility functions that have already been imported at the top of the file:

- `calculateContainerSize()` - This function returns the size to render the board, in pixels. Since the board is a square, we'll use this size for both the `width` and `height`.
- `calculateItemSize(size)` - This function uses `puzzle.size` to divide the board into an even number of rows and columns. We'll use the returned pixel size for the `width` and `height` of each piece.

We'll represent the board with a `View`. We'll map each puzzle piece in `puzzle.board` into an `Animated.View` that contains an `Image`.

Add the following `render` method to `components/Board.js`:

checkpoints/puzzle-2/1/components/Board.js

```
  render() {
    const { puzzle: { board } } = this.props;
    const { transitionState } = this.state;

    const containerSize = calculateContainerSize();
    const containerStyle = {
      width: containerSize,
      height: containerSize,
    };

    return (
      <View style={[styles.container, containerStyle]}>
        {transitionState !== State.DidTransitionOut &&
          board.map(this.renderSquare)}
      </View>
    );
  }
```

Notice that we map each piece in the `board` through `this.renderSquare`. Let's write the `renderSquare` method now. This method is called with two arguments:

- `square` - The numeric value of the piece in `puzzle.board`
- `index` - The index of the square within the `puzzle.board` array

In other words, the `square` represents the "correct" position of the puzzle piece (within the original image), while the `index` represents the current position of the puzzle piece (within the rearranged image).

When the board is in the `DidTransitionOut` state, we don't render any pieces. This *shouldn't* be necessary, since the pieces should have already animated off-screen. However, there's a bug that occurs when combining `Animated` and `useNativeDriver` that causes the pieces to render without their `transform` styles.

Let's write `renderSquare` now. We'll start by declaring the method and destructuring the props and state we'll need:

checkpoints/puzzle-2/1/components/Board.js

```
  renderSquare = (square, index) => {
    const { puzzle: { size, empty }, image } = this.props;
    const { transitionState } = this.state;
```

If the `square` is the empty square of the puzzle (`puzzle.empty`), then we shouldn't render it:

checkpoints/puzzle-2/1/components/Board.js

```
  renderSquare = (square, index) => {
    const { puzzle: { size, empty }, image } = this.props;
    const { transitionState } = this.state;

    if (square === empty) return null;
```

Next, we'll call `calculateItemSize` to get the pixel size of the puzzle piece. This value will be the same for every piece:

checkpoints/puzzle-2/1/components/Board.js

```
    if (square === empty) return null;

    const itemSize = calculateItemSize(size);
```

We can use the `itemSize` to create a style, `itemStyle`, for the `Animated.View` that we'll render. The view should have a `width` and `height` equal to `itemSize`, and use a `transform` to correctly position it on the board. This is where the `Animated.Value` array we set up earlier comes in:

checkpoints/puzzle-2/1/components/Board.js

```
    const itemSize = calculateItemSize(size);

    const itemStyle = {
      position: 'absolute',
      width: itemSize,
      height: itemSize,
      overflow: 'hidden',
      transform: [
        { translateX: this.animatedValues[square].left },
        { translateY: this.animatedValues[square].top },
        { scale: this.animatedValues[square].scale },
      ],
    };
```

Note that we use a `transform` with `translateX` and `translateY`, instead of `left` and `top`. If you recall from the previous chapter, this allows us to animate these values with `useNativeDriver` for improved performance. In this chapter, we use the names `top` and `left` to refer to a piece's position for simplicity, even though we're actually setting the `translateX` and `translateY`.

Within the `Animated.View` that uses this style, we'll render the image of the puzzle piece. With some clever math, we can offset the image to display the correct portion for each piece:

checkpoints/puzzle-2/1/components/Board.js

```
  const imageStyle = {
    position: 'absolute',
    width: itemSize * size + (itemMargin * size - 1),
    height: itemSize * size + (itemMargin * size - 1),
    transform: [
      {
        translateX:
          -Math.floor(square % size) * (itemSize + itemMargin),
      },
      {
        translateY:
          -Math.floor(square / size) * (itemSize + itemMargin),
      },
    ],
  };
```

The exact calculations here and elsewhere in the chapter are specific to this game, so we won't cover them in much detail. However, animation and gesture code in general tends to rely on manual calculations, so you may find it useful to try to understand the calculations and utility functions in this chapter.

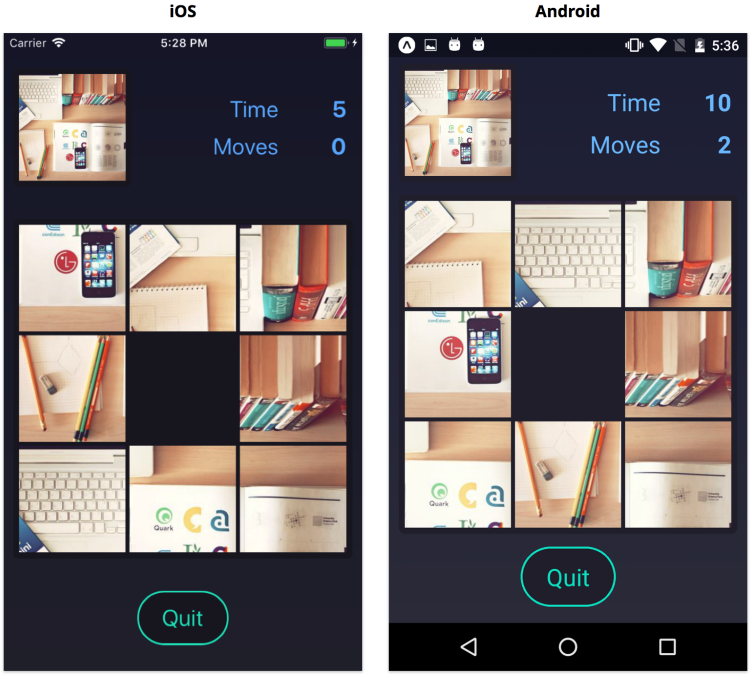
Lastly, we can put everything together by rendering an `Animated.View` and an `Image`:

checkpoints/puzzle-2/1/components/Board.js

```
    return (
      <Animated.View key={square} style={itemStyle}>
        <Image style={imageStyle} source={image} />
      </Animated.View>
    );
  };
```

Try it out!

Save `Board.js`. After the app reloads, press the start button, and you should see the board fade in!



Making pieces draggable

Now that we're rendering our puzzle pieces, we can focus on making them draggable. In order to do this, we'll need to learn how to use the **Gesture Responder System**.

Gesture Responder System

React Native provides the Gesture Responder System for building complex interactions like dragging. The Gesture Responder System gives us fine-grained control over which components should receive and respond to touch events.

Each time the user touches the screen, moves their finger, or lifts their finger, the operating system records an independent event called a "touch event." Interpreting one or more of these independent touch events results in a gesture. A tap gesture may consist of the user touching the screen and lifting their finger immediately. A drag gesture may consist of a user touching the screen, moving their finger around the screen, and then lifting their finger.

Touch events can interact in complex ways in mobile apps. Imagine a horizontally draggable slider within a vertical scrollview – how do we determine which finger movements should affect the slider and which should affect the scrollview? The Gesture Response System gives us a set of callbacks which help us handle the right touch events from the right component.

Responder lifecycle

Let's look at how touch events flow between components in the responder system.

At its core, the responder system determines which view owns the global "interaction lock" at any given time. When granted the interaction lock, a view is known as the "responder", since it responds to touch events. Generally the responder view should show visual feedback, such as highlighting or moving. While a touch gesture is occuring, the interaction lock may be transferred to an ancestor view of the responder.

There are function props a view can implement to *request* the interaction lock:

- `View.props.onStartShouldSetResponder: (e) => true` - If a touch gesture begins on this view, should this view become the responder?
- `View.props.onMoveShouldSetResponder: (e) => true` - If the user moves their finger over this view during a touch gesture, should this view become the responder?

If one of these functions returns true, then the view has requested the interaction lock. If no other view currently owns the interaction lock, then the requesting view automatically becomes the responder. If a view *does* own the interaction lock, then the owner's `onResponderTerminationRequest` function prop will be called – the owner can decide whether to keep or hand off the interaction lock.

One of the following props will be called for the view requesting the interaction lock:

- `View.props.onResponderGrant: (e) => {}` - The request for the interaction lock was granted! The requesting view is now the responder. The view may want to respond to receiving the interaction lock in some way, e.g. by setting some state that renders a highlight.
- `View.props.onResponderReject: (e) => {}` - The request for the interaction lock was rejected. The view that owned the interaction lock refused to give it up.

The responder view's props will be called as the touch gesture continues:

- `View.props.onResponderMove: (e) => {}` - This is called whenever the user moves their finger.
- `View.props.onResponderRelease: (e) => {}` - This is called when the user lifts their finger.
- `View.props.onResponderTerminationRequest: (e) => true` - Another view has requested the interaction lock. Return false to retain the lock, or `true` to hand it off.
- `View.props.onResponderTerminate: (e) => {}` - The interaction lock has been taken away.

With `View.props.onResponderTerminate`, this is generally due to returning `true` from:

`onResponderTerminationRequest`,

but there are cases where the operating system will take the interaction lock without asking (without `onResponderTerminationRequest` being called first).

For example, `onResponderTerminate` will be called upon receiving a phone call,

`onResponderTerminationRequest` will not be called, since returning `false` would not prevent the operating system from taking over control of the screen.

When a touch starts, the `onStartShouldSetResponder` prop will be called for the inner-most view containing the touch. If the view returns false (or doesn't implement the prop), then the parent's `onStartShouldSetResponder` prop will be called. This process continues up the view hierarchy.

Capture phase

Sometimes a parent view will need to request the interaction lock before any of its children have a change. In this case, we don't want the bottom-up calling order of `onStartShouldSetResponder`. There are two other props we can use that are called top-down, i.e. first the parent has a chance to become responder, then the child.

- `View.props.onStartShouldSetResponderCapture: (e) => true`
- `View.props.onMoveShouldSetResponderCapture: (e) => true`

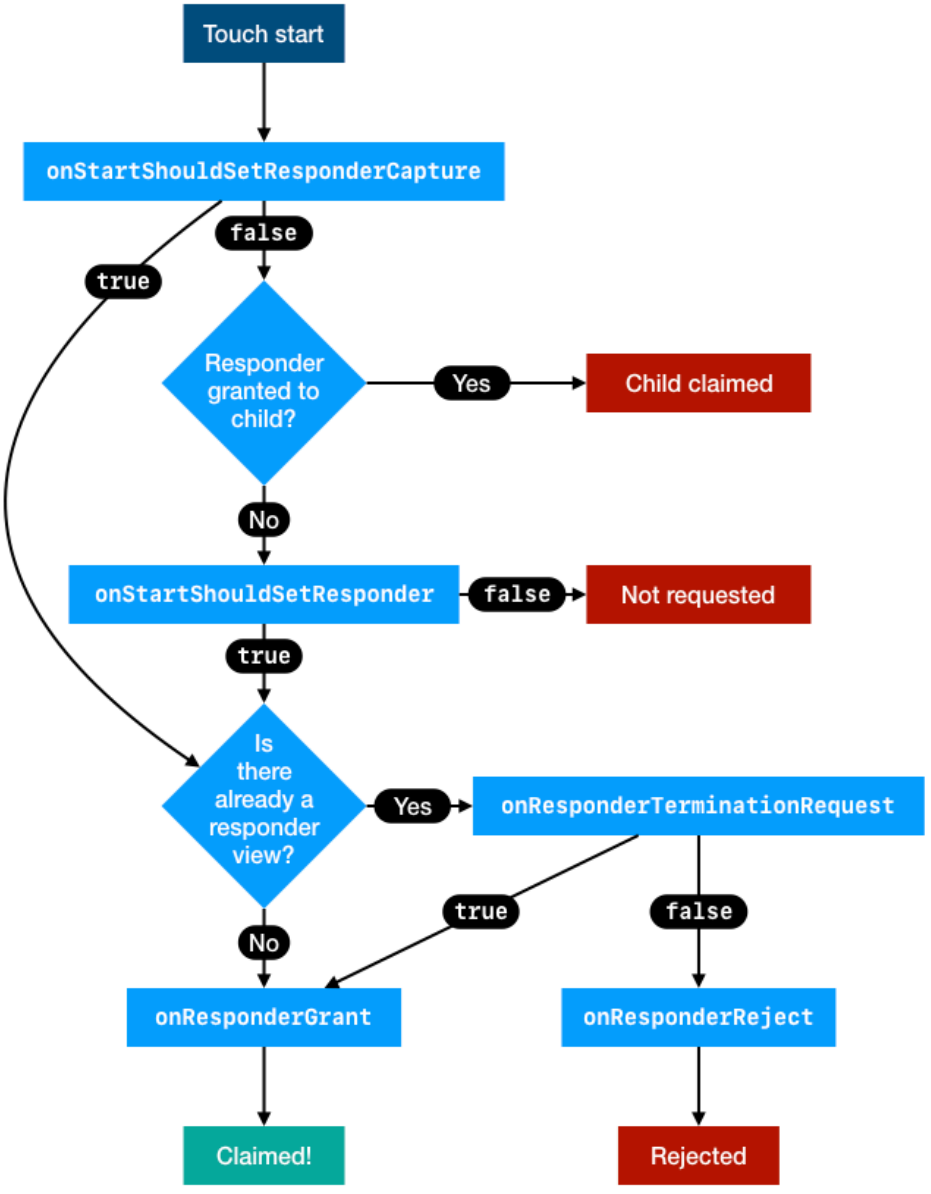
These props are analogous to `onStartShouldSetResponder` and `onMoveShouldSetResponder`. These "capture" props are called first starting from the parent, and then down the view hierarchy. If no view returns true, then `onStartShouldSetResponder` and `onMoveShouldSetResponder` will be called starting from the inner-most view.

The portion of the responder lifecycle where touches are "captured" from top to bottom is called the **capture phase**. The portion of the lifecycle where touches are capture from bottom to top is called the **bubble phase**.

If you're coming from web development, you'll probably be familiar with these terms – this part of the responder system is modeled after DOM events!

Diagram

The following diagram illustrates the responder lifecycle for new touches:



The same flow happens every time a touch moves, except that `onMoveShouldSetResponder` and `onMoveShouldSetResponderCapture` are called instead of `onStartShouldSetResponder`

and `onStartShouldSetResponderCapture`.

Touch event object

All of the responder function props are called with an event object, often abbreviated as `evt` or `e`, e.g. the argument in `onStartShouldSetResponder = (e) => {}`. The event object contains the property `nativeEvent` which is an object containing:

- `locationX` - The X position of the touch, relative to the responder view
- `locationY` - The Y position of the touch, relative to the responder view
- `pageX` - The X position of the touch, relative to the root view
- `pageY` - The Y position of the touch, relative to the root view
- `timestamp` - The time when the touch occurred
- `identifier` - The id of the touch
- `target` - The id of the view receiving the touch event
- `touches` - Array of all current touches on the screen
- `changedTouches` - Array of all touch events that have changed since the last event

You may need to access these properties to do touch-related calculations. However, React Native provides a higher-level convenience wrapper on top of the responder system that you'll likely use instead.

PanResponder

The touch event object contains raw values, such as the time and location of touches. Many interactions, however, will require the distance and velocity of the touches over time. React Native provides a higher-level API called `PanResponder`.

The `PanResponder` intercepts each responder function so that it can maintain a `gestureState` object containing the distance, velocity, and a few other computed properties. We can create a `PanResponder` with `PanResponder.create(config)`, where the config object contains any of the following functions:

- `onStartShouldSetPanResponder: (e, gestureState) => {}`

- `onStartShouldSetPanResponderCapture: (e, gestureState) => {}`
- `onMoveShouldSetPanResponder: (e, gestureState) => {}`
- `onMoveShouldSetPanResponderCapture: (e, gestureState) => {}`
- `onPanResponderReject: (e, gestureState) => {}`
- `onPanResponderGrant: (e, gestureState) => {}`
- `onPanResponderStart: (e, gestureState) => {}`
- `onPanResponderEnd: (e, gestureState) => {}`
- `onPanResponderRelease: (e, gestureState) => {}`
- `onPanResponderMove: (e, gestureState) => {}`
- `onPanResponderTerminate: (e, gestureState) => {}`
- `onPanResponderTerminationRequest: (e, gestureState) => {}`
- `onShouldBlockNativeResponder: (e, gestureState) => {}`

Each of these wraps a responder function (with roughly the same name) and then calls it with the `gestureState` object in addition to the original event object. For example, `onPanResponderMove` wraps `onResponderMove`.

The only exception is `onShouldBlockNativeResponder`, which is a totally different function from the underlying responder functions. This function is for blocking native components from becoming the responder, and only works on Android. We won't be using it.

The `gestureState` object contains the following properties:

- `stateID` - The id of the `gestureState` – persisted as long as there's at least one touch on screen
- `moveX` - The latest screen coordinates of the most recently moved touch
- `moveY` - The latest screen coordinates of the most recently moved touch
- `x0` - The screen coordinates at the time the responder was granted
- `y0` - The screen coordinates at the time the responder was granted
- `dx` - Accumulated distance of the gesture since the touch started
- `dy` - Accumulated distance of the gesture since the touch started
- `vx` - Current velocity of the gesture
- `vy` - Current velocity of the gesture
- `numberActiveTouches` - Number of touches currently on screen

Now that we've covered the fundamentals, let's put them to use!

Draggable component

For our puzzle game, we want to build a dragging gesture. In order to do this, we'll need to:

- Handle when the user touches a specific puzzle piece component
- Continously monitor the `x, y` offset as they move their finger
- Record the final `x, y` offset when they lift their finger

As the user moves their finger, we can monitor the `x, y` offset to update the puzzle piece component's `transform`. Thus the puzzle piece will follow the user's finger as it moves across the screen – this is how we simulate "dragging" in mobile apps. When the user lifts their finger, we will use the final `x, y` offset to determine how to update the `puzzle` object accordingly.

Creating a PanResponder

Let's use a `PanResponder` to make a `Draggable` component. We'll use our `Draggable` component to handle touches and to monitor the `x, y` offset of the drag.

We'll make this component fairly generic, both to better separate the dragging code from the rendering code, and to make the component easy to reuse. The component's sole purpose will be to handle the logic around touch events. It won't render anything to the UI itself. The `Draggable` component will pass a `PanResponder` and `x, y` offset to its children – its children will be responsible for using this information to render the UI. The `Draggable` component will expose callback props that notify the parent as touch events occur. We'll use these events to update the `puzzle` object.

Open up `components/Draggable.js`. The skeleton of the component has already been written for you. Take a look at the `propTypes`:

checkpoints/puzzle-2/components/Draggable.js

```
  static propTypes = {
    children: PropTypes.func.isRequired,
    onTouchStart: PropTypes.func,
    onTouchMove: PropTypes.func,
    onTouchEnd: PropTypes.func,
    enabled: PropTypes.bool,
  };
```

This component will render arbitrary children by calling the `children` function prop. When the user interacts with the component, it will call the `onTouchStart`, `onTouchMove`, and `onTouchEnd` props at the appropriate times. We've also included an `enabled` prop to prevent dragging – we'll use this when the board is mounting and unmounting so that the user can't interfere with the animation.

We chose to name our props `onTouchStart`, `onTouchMove`, and `onTouchEnd` after the touch event names on the web, in order to make our `Draggable` component feel more familiar for those with a web background. However, React Native doesn't interpret these names in any special way, and we could've named the props anything we wanted.

Using a function for children might look familiar. That's because we used this same pattern in the second part of the "Core APIs" chapter!

Let's begin by writing the constructor. In the constructor, we'll initialize `this.state` to keep track of whether this component is actively being dragged. We'll also create a new pan responder with `PanResponder.create`.

When we write the `render` method, we'll pass the value of `this.state.dragging` to the `Draggable` component's children. This allows them to render differently depending on whether a drag is occuring or not. In our case, we will use this to adjust the `zIndex` of puzzle pieces so that the piece currently being dragged renders on top of the rest.

Add the following constructor to `Draggable.js`:

puzzle/components/Draggable.js

```
  constructor(props) {
    super(props);

    this.state = {
      dragging: false,
    };

    this.panResponder = PanResponder.create({
      onStartShouldSetPanResponder: this
        .handleStartShouldSetPanResponder,
      onPanResponderGrant: this.handlePanResponderGrant,
      onPanResponderMove: this.handlePanResponderMove,
      onPanResponderRelease: this.handlePanResponderEnd,
      onPanResponderTerminate: this.handlePanResponderEnd,
    });
  }
```

We'll implement each of the pan responder functions as instance properties of our component.

PanResponder functions

Let's start by implementing `this.handleStartShouldSetPanResponder`, which we assigned to `onStartShouldSetPanResponder` when creating our pan responder. We want this component to become the responder when the `enabled` prop is true. Add the following function to the `Draggable` component:

puzzle/components/Draggable.js

```
  handleStartShouldSetPanResponder = () => {
    const { enabled } = this.props;

    return enabled;
  };
```

Next, we'll handle when this component becomes the responder in `handlePanResponderGrant`.

When this component becomes the responder, we want to set `state.dragging` to true.

Add `handlePanResponderGrant` now:

puzzle/components/Draggable.js

```
  handlePanResponderGrant = () => {
    const { onTouchStart } = this.props;

    this.setState({ dragging: true });

    onTouchStart();
  };
```

We'll pass a the `onTouchStart()` prop later to allow the parent to animate the scale of the puzzle piece when a drag begins.

Any time the user moves their finger, we'll call the `onTouchMove` prop with the offset from the initial touch position. This lets us animate the `transform` of the puzzle piece as it's dragged from within `Board`. Let's do this by adding the following `handlePanResponderMove`:

puzzle/components/Draggable.js

```
  handlePanResponderMove = (e, gestureState) => {
    const { onTouchMove } = this.props;

    // Keep track of how far we've moved in total (dx and dy)
    const offset = {
      top: gestureState.dy,
      left: gestureState.dx,
    };

    onTouchMove(offset);
  };
```

Lastly, when the user lifts their finger, or if the operating system cancels the gesture (e.g. a phone call comes in), we want to reset our `state` and call `onTouchMove` and `onTouchEnd` with the final touch position. We can handle both `onPanResponderRelease` and `onPanResponderTerminate` in the same way. Add the following `handlePanResponderEnd`:

puzzle/components/Draggable.js

```
  handlePanResponderEnd = (e, gestureState) => {
    const { onTouchMove, onTouchEnd } = this.props;

    const offset = {
      top: gestureState.dy,
      left: gestureState.dx,
    };

    this.setState({
      dragging: false,
    });

    onTouchMove(offset);
    onTouchEnd(offset);
  };
```

If the user receives a phone call, the drag gesture will end as if the user had lifted their finger. This is acceptable for our game, but in some scenarios it may be desirable to handle the `onPanResponderTerminate` case differently from an intentional touch event.

Rendering draggable pieces

When we render the `Draggable` component, we'll call the `children` prop function. We'll pass this function the `dragging` and `offset` values from `state` so that we can update the positions of the children as we render. We'll also pass `this.panResponder.panHandlers` – these are the responder functions wrapped by the pan handler to include `gestureState`.

Add the following render method:

puzzle/components/Draggable.js

```
  render() {
    const { children } = this.props;
    const { dragging } = this.state;

    // Update children with the state of the drag
    return children({
      handlers: this.panResponder.panHandlers,
      dragging,
    });
  }
```

Save `Draggable.js`. Now open `Board.js` again so we can render the `Draggable` component from our `renderSquare` method.

There are three changes we'll be making to `renderSquare`:

- We'll return a `Draggable` component. We'll move what we're currently rendering into the children function prop of `Draggable`. The children function is passed `handlers`, `dragging`, and `offset` from the `Draggable` component,

and should return the children component to render. For the other props of `Draggable`, we need to set the `enabled` prop to true once the board's pieces have transitioned in – so we'll check if the board is in the `DidTransitionIn` state. We'll also set `onTouchStart`, `onTouchMove`, and `onTouchEnd` props, which we'll write shortly.

- We'll update `itemStyle` to use the `draggable` argument of the `children` function. When `draggable` is true, we want to set the `zIndex` of the piece to `1`. This will ensure the piece renders above the adjacent pieces when its being dragged (we'll increase its scale during the drag, so it will overlap the edges of the adjacent pieces).
- We'll update the `Animated.View` by spreading the `handlers` argument of the `children` function into the `Animated.View` props. This is how we apply the `PanResponder` to a view.

Let's makes these updates to `renderSquare` now:

puzzle/components/Board.js

```
    const itemSize = calculateItemSize(size);

    return (
      <Draggable
        key={square}
        enabled={transitionState === State.DidTransitionIn}
        onTouchStart={() => this.handleTouchStart(square)}
        onTouchMove={offset =>
          this.handleTouchMove(square, index, offset)
        }
        onTouchEnd={offset =>
          this.handleTouchEnd(square, index, offset)
        }
      >
        {({ handlers, dragging }) => {
          const itemStyle = {
            position: 'absolute',
            width: itemSize,
            height: itemSize,
```

```
            overflow: 'hidden',
            transform: [
              { translateX: this.animatedValues[square].left },
              { translateY: this.animatedValues[square].top },
              { scale: this.animatedValues[square].scale },
            ],
            zIndex: dragging ? 1 : 0,
          };

          const imageStyle = {
            position: 'absolute',
            width: itemSize * size + (itemMargin * size - 1),
            height: itemSize * size + (itemMargin * size - 1),
            transform: [
              {
                translateX:
                  -Math.floor(square % size) *
                  (itemSize + itemMargin),
              },
              {
                translateY:
                  -Math.floor(square / size) *
                  (itemSize + itemMargin),
              },
            ],
          };

          return (
            <Animated.View {...handlers} style={itemStyle}>
              <Image style={imageStyle} source={image} />
            </Animated.View>
          );
        }}
      </Draggable>
    );
  };
```

The above code snippet is pretty long, but we only actually made a few changes. One of the most important lines is the one where we spread the `handlers` into the `Animated.View`:

puzzle/components/Board.js

```
            <Animated.View {...handlers} style={itemStyle}>
```

Without this, our `Draggable` component won't respond to touches!

For each of the `Draggable` props `onTouchStart`, `onTouchMove`, and `onTouchEnd`, we'll call the `Board` methods `handleTouchStart`, `handleTouchMove`, and `handleTouchEnd`, respectively. These handler methods don't exist yet, so let's write them now.

Handling touch events

When a touch begins on a piece, we want to scale the piece so that it gives the illusion of lifting it. We can do that by animating `this.animatedValues[square].scale`. We'll use the `Animated.spring` function to scale the piece to `1.1` times its original size. Add the following `handleTouchStart` method to the `Board` component:

puzzle/components/Board.js

```
  handleTouchStart(square) {
    Animated.spring(this.animatedValues[square].scale, {
      toValue: 1.1,
      friction: 20,
      tension: 200,
      useNativeDriver: true,
    }).start();
  }
```

As always, we have to call `start()` after setting up the animation.

Every time a touch moves, we want to update `this.animatedValues[square].left` and `this.animatedValues[square].top` for the piece. We'll need to restrict the piece's movement according to which square is currently empty. We can determine this by calling the `availableMove` utility function. This function returns a string, `'up'`, `'down'`, `'left'`,`'right'`, or `'none'`, depending on the state of the game board. Based on this, we can restrict the values of `top` and `left` to only allow the valid moves according to our game's rules. The exact math we use is specific to this game, so it's not important to follow it completely.

Add the following `handleTouchMove` to `Board`:

puzzle/components/Board.js

```
  handleTouchMove(square, index, { top, left }) {
    const { puzzle, puzzle: { size } } = this.props;

    const itemSize = calculateItemSize(size);
    const move = availableMove(puzzle, square);

    const {
      top: initialTop,
      left: initialLeft,
    } = calculateItemPosition(size, index);

    const distance = itemSize + itemMargin;

    const clampedTop = clamp(
      top,
      move === 'up' ? -distance : 0,
      move === 'down' ? distance : 0,
    );

    const clampedLeft = clamp(
      left,
      move === 'left' ? -distance : 0,
      move === 'right' ? distance : 0,
    );
```

```
    this.animatedValues[square].left.setValue(
      initialLeft + clampedLeft,
    );
    this.animatedValues[square].top.setValue(initialTop + clampedTop);
  }
```

We have two options for updating the `top` and `left` `Animated.Value`. We could either animate them (e.g. using `Animated.spring`), or update them immediately with `setValue`. After testing both ways, we found using `setValue` provides a slightly better experience on slower devices in this specific case.

Before we handle when touches end, let's first write a utility method, `updateSquarePosition`, that animates a piece's position. When updating a piece's position, we'll update both the `top` and `left` values at the same time for simplicity (even though a piece can only be moved along one axis at a time).

Begin the `updateSquarePosition` method with the following:

puzzle/components/Board.js

```
  updateSquarePosition(puzzle, square, index) {
    const { size } = puzzle;

    const { top, left } = calculateItemPosition(size, index);

    const animations = [
      Animated.spring(this.animatedValues[square].top, {
        toValue: top,
        friction: 20,
        tension: 200,
        useNativeDriver: true,
      }),
      Animated.spring(this.animatedValues[square].left, {
        toValue: left,
        friction: 20,
```

```
        tension: 200,
        useNativeDriver: true,
      }),
    ];
```

Since we're going to animate multiple values at once, we've created an `animations` array containing all of our animation objects. Notice that we didn't call `start()` on these animations. We need to know when *both* animations have completed, which is hard to determine if we start them independently. Fortunately, the React Native provides the `Animated.parallel` for this case.

`Animated.parallel` takes an array of animations, and returns an object with a `start(callback)` method, just like with other animations. The `callback` is called when *every* animation in the array is completed. To make our `updateSquarePosition` slightly more convenient to use (with `async/await` syntax), we'll return a `Promise` that resolves when the `callback` is called.

Update the `updateSquarePosition` method to call `Animated.parallel` and return a `Promise` now:

puzzle/components/Board.js

```
  updateSquarePosition(puzzle, square, index) {
    const { size } = puzzle;

    const { top, left } = calculateItemPosition(size, index);

    const animations = [
      Animated.spring(this.animatedValues[square].top, {
        toValue: top,
        friction: 20,
        tension: 200,
        useNativeDriver: true,
      }),
      Animated.spring(this.animatedValues[square].left, {
        toValue: left,
        friction: 20,
        tension: 200,
```

```
        useNativeDriver: true,
      }),
    ];

    return new Promise(resolve =>
      Animated.parallel(animations).start(resolve),
    );
  }
```

Now that we've finished `updateSquarePosition`, we can write the `handleTouchEnd` method to finish handling touch events.

When a touch ends, we need to do a few things:

- We need to scale the piece back to its original size (a scale value of `1`) using `Animated.spring`.
- We need to detect whether the user dragged the piece far enough to move it or not. If the piece was moved more than halfway into the empty square, then we'll consider this a move, and we'll inform the `Game` of the move by calling the `onMoveSquare` prop. If the piece was moved less than halfway into the empty square, then we won't consider this a move, and we'll instead animate the piece back to its original position.

Begin the `handleTouchEnd` with the following to reset the piece's scale:

puzzle/components/Board.js

```
  handleTouchEnd(square, index, { top, left }) {
    const { puzzle, puzzle: { size }, onMoveSquare } = this.props;

    const itemSize = calculateItemSize(size);
    const move = availableMove(puzzle, square);

    Animated.spring(this.animatedValues[square].scale, {
      toValue: 1,
      friction: 20,
      tension: 200,
```

```
      useNativeDriver: true,
    }).start();
```

Based on the direction the piece was moved, we can determine if it was moved more than halfway to its destination. We'll finish the `handleTouchEnd` method by either calling `onMoveSquare` to inform the `Game` of a successful move, or by calling `updateSquarePosition` to reset the piece's position:

puzzle/components/Board.js

```
  handleTouchEnd(square, index, { top, left }) {
    const { puzzle, puzzle: { size }, onMoveSquare } = this.props;

    const itemSize = calculateItemSize(size);
    const move = availableMove(puzzle, square);

    Animated.spring(this.animatedValues[square].scale, {
      toValue: 1,
      friction: 20,
      tension: 200,
      useNativeDriver: true,
    }).start();

    if (
      (move === 'up' && top < -itemSize / 2) ||
      (move === 'down' && top > itemSize / 2) ||
      (move === 'left' && left < -itemSize / 2) ||
      (move === 'right' && left > itemSize / 2)
    ) {
      onMoveSquare(square);
    } else {
      this.updateSquarePosition(puzzle, square, index);
    }
  }
```

After a successful move, the `Game` will update the `puzzle` object and pass it back into

the `Board` as a prop, along with the `previousMove` prop. We need to handle updates to these props in `componentWillReceiveProps`.

Whenever the `puzzle` object updates, we'll call `updateSquarePosition` to animate the piece that was last moved into its new position. To do this, add the following `componentWillReceiveProps` to `Board`:

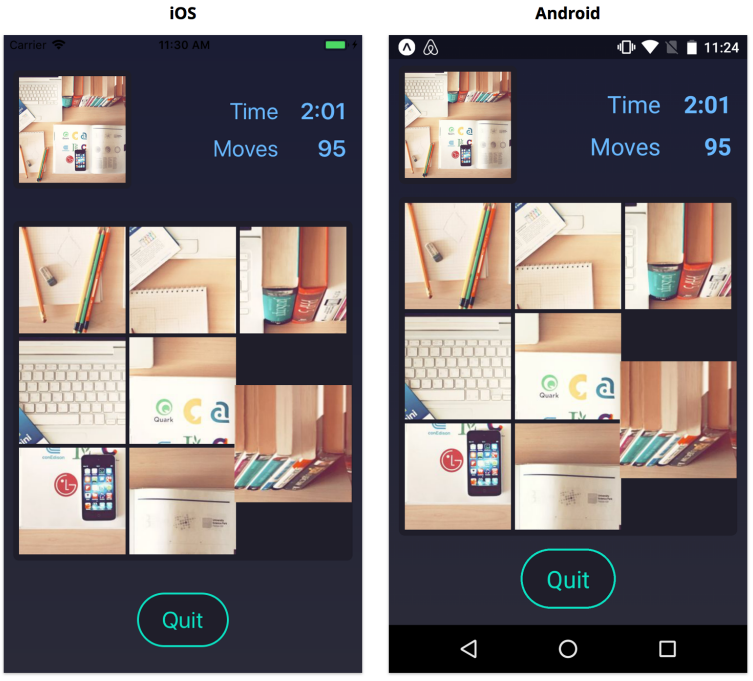
checkpoints/puzzle-2/2/components/Board.js

```
  async componentWillReceiveProps(nextProps) {
    const {
      previousMove,
      onTransitionOut,
      puzzle,
      teardown,
    } = nextProps;

    const didMovePiece =
      this.props.puzzle !== puzzle && previousMove !== null;

    if (didMovePiece) {
      await this.updateSquarePosition(
        puzzle,
        previousMove,
        getIndex(puzzle, previousMove),
      );
    }
  }
```

Great! We've finished the touch event handling.

Try it out!

Save `Board.js`. After the app reloads, press the start button to begin the game and try dragging pieces around.



You should see the pieces smoothly scale up and down as you touch and release them. You should only be able to drag pieces into the adjacent empty square on the board. The pieces should snap either to their new positions or back to their original positions, but should never get stuck in-between.

Wrapping up gesture handling

We just built a drag-and-drop gesture from scratch! Let's review what we did:

- We used a PanResponder to interact with the gesture responder system. We implemented the `onStartShouldSetPanResponder` handler to request the global interaction lock, and then we implemented `onPanResponderGrant`, `onPanResponderMove`, `onPanResponderRelease`, and `onPanResponderTerminate` to keep track of the state of the gesture.
- We created a generic `Draggable` component that provides us with a simpler interface for handling the gesture data we care about when building drag-and-drop interactions: `onTouchStart`, `onTouchMove`, and `onTouchEnd`.

- We handled touches by looking at the `offset` from the first touch event to the current one, and deciding whether or not to move the puzzle piece. We animated the scale of the puzzle piece so that it feels like we're lifting the piece off of the board. We animated the position of the puzzle piece using `Animated.spring` and `Animated.parallel` to snap it to a valid position on the board.
- If a new game state was passed in as a prop, we animated the pieces to reflect the latest state of the game board.

Putting it all together, we were able to achieve an intuitive-feeling, cross-platform drag-and-drop gesture that performs smoothly even on lower-end devices.

Here are a few recommendations for building gestures:

1. **Most gestures should use the `PanResponder` like we did in this example** rather than using the underlying `View` responder props directly.

(e.g. `onStartShouldSetPanResponder` instead of `onStartShouldSetResponder`)

This is because most gestures will need to use the values in the `gestureState` provided by the `PanResponder`, which are tricky to calculate on your own.

2. **It's often helpful to separate gesture-related code into a separate component** like we did with our `Dragging` component.

This ensures we keep the state of the gestures (e.g. `offset`) separate from the state of the board. It can also help with performance: the `Draggable` component will re-render each time its state updates, but this is significantly less costly than if we had to re-render a more complex component like the `Board`.

3. **If possible, test your gestures on different devices as you build them**.

You may find that your intuition about what *should* perform better isn't actually the case, and it's much easier to work through performance issues one-at-a-time in isolation, rather than all at once when the gesture is finished. Furthermore, if you run into a React Native bug or inconsistency across platforms (there are several of these), it's better to know sooner than later.

Speaking of performance, there's one more performance improvement we made which we haven't covered yet.

Using PureComponent

You may have noticed that our `Board` component extends `React.PureComponent` rather than `React.Component`. Components that extend `React.Component` will re-render any time their parent re-renders or any time `setState` is called internally, even if the value of state or props is the same. By contrast, components that extend `React.PureComponent` will only re-render when state or props actually change. React checks for changes using a "shallow" equality test (testing the top-level keys and values within the `state` and `props` objects using `===`). If state and props are unchanged, then the component does not re-render.

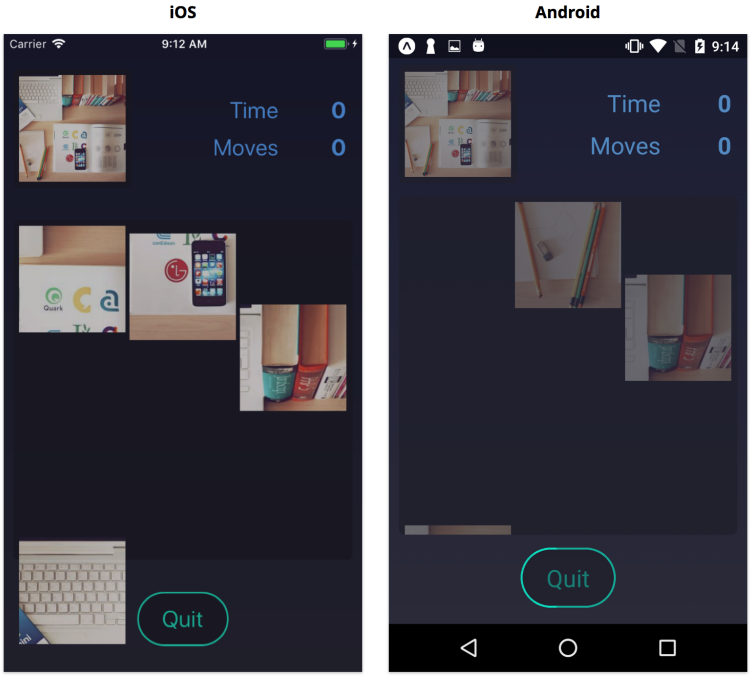
Preventing re-rendering with `PureComponent` is especially important for our `Board` component. Each time the `Game` increments the elapsed time counter in the top right, it will re-render all of its children, including `Board`. If the `Board` re-renders every second, this means it will likely re-render during a drag gesture. Re-rendering results in a noticeable stutter during the gesture. In other words, we use `PureComponent` to achieve a smooth drag gesture even as other parts of the UI update.

> If you want to see this for yourself, find this line at the top of `Board.js`:
>
> ```
> export default class Board extends React.PureComponent {
> ```
>
> Change it to:
>
> ```
> export default class Board extends React.Component {
> ```
>
> Then save `Board.js`. You'll notice the stutter as you drag pieces around, especially on slower devices. Make sure to change this back when you're done!

If we *had to* re-render the `Board` during drag gestures for some reason, we might instead consider breaking the component into smaller components, some of which can re-render more quickly or can extend `PureComponent`.

Finishing the game

We've nearly finished building the puzzle game now. The next part we'll write is the animation where the pieces fly onto and off of the board as it mounts and unmounts:



Animating all pieces

Let's start by updating the `constructor` of the board. Open `Board.js` if you don't already have it open.

We want the puzzle pieces to render off-screen to begin with. This will let us animate them into view. We can use the `Dimensions` API we learned about in the chapter "Core APIs, Part 1" to get the height of the screen, and we can use this when setting the initial `Animated.Value` for the piece's `top`.

Update the `constructor` to:

puzzle/components/Board.js

```
  constructor(props) {
    super(props);

    const { puzzle: { size, board } } = props;

    this.state = { transitionState: State.WillTransitionIn };
    this.animatedValues = [];

    const height = Dimensions.get('window').height;

    board.forEach((square, index) => {
      const { top, left } = calculateItemPosition(size, index);

      this.animatedValues[square] = {
        scale: new Animated.Value(1),
        top: new Animated.Value(top + height),
        left: new Animated.Value(left),
      };
    });
  }
```

With this, pieces will initially render exactly one screen-height below where we'll move them.

Next, we need to animate every piece onto the board. We'll write a helper method `animateAllSquares(visible)` that does this for us. This method will animate pieces onto the board when we call it with `visible` set to `true`, and it will animate pieces off of the board when we call it with `visible` set to `false`.

To perform the animation, we'll animate the `top` of each piece by mapping the `puzzle.board` to an array of `Animated.timing` animations (although remember that we're eventually rendering `translateY` instead of `top`, for performance). Just like with our `updateSquarePosition` method, we'll use `Animated.parallel` to run all the animations at once and let us easily await their completion. We can create a playful staggered animation by setting the `delay` option of the animation.

Add the following `animateAllSquares` method:

puzzle/components/Board.js

```
  animateAllSquares(visible) {
    const { puzzle: { board, size } } = this.props;

    const height = Dimensions.get('window').height;

    const animations = board.map((square, index) => {
      const { top } = calculateItemPosition(size, index);

      return Animated.timing(this.animatedValues[square].top, {
        toValue: visible ? top : top + height,
        delay: 800 * (index / board.length),
        duration: 400,
        easing: visible
          ? Easing.out(Easing.ease)
          : Easing.in(Easing.ease),
        useNativeDriver: true,
      });
    });

    return new Promise(resolve =>
      Animated.parallel(animations).start(resolve),
    );
  }
```

Notice that depending on the `visible` argument, we either animate the piece to its position on the board, `top`, or off the board, `top + height`.

Let's now update our `componentDidMount` to call `animateAllSquares`:

puzzle/components/Board.js

```
  async componentDidMount() {
    await this.animateAllSquares(true);

    const { onTransitionIn } = this.props;

    this.setState({ transitionState: State.DidTransitionIn });

    onTransitionIn();
  }
```

With that, we've completed the animation where the pieces fly onto the board! The last thing we need to hook up is the animation where the pieces fly off the board when the game finishes.

We can do this by updating our `componentWillReceiveProps` to watch for when the `teardown` prop is set to `true` by the `Game`. When the `teardown` prop first becomes `true`, we'll call `this.animateAllSquares(false)`. Once this completes, we'll set the `transitionState` to `DidTransitionOut`, and we'll call the `onTransitionOut` prop to inform that `Game` that the `Board` animations are finished and it's ready to be unmounted.

Update `componentWillReceiveProps` to:

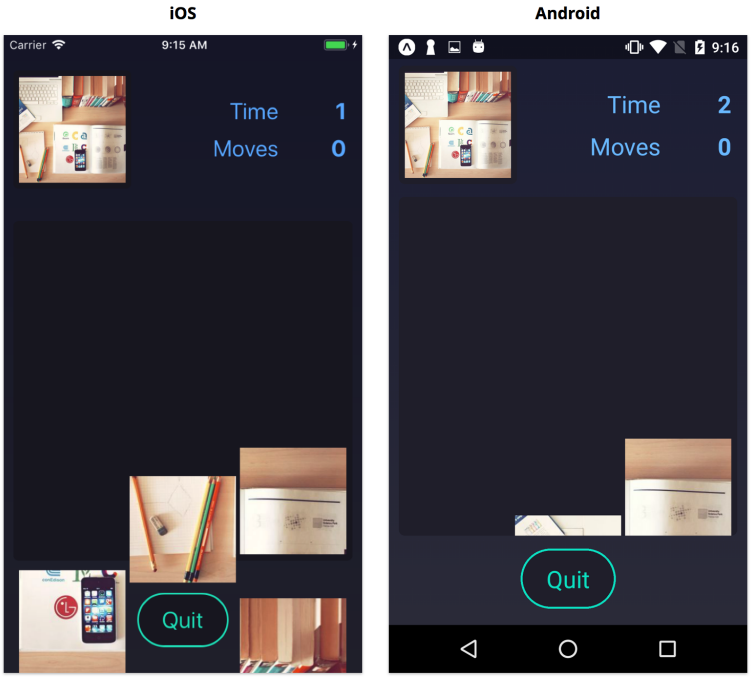
puzzle/components/Board.js

```
  async componentWillReceiveProps(nextProps) {
    const {
      previousMove,
      onTransitionOut,
      puzzle,
      teardown,
    } = nextProps;

    const didMovePiece =
      this.props.puzzle !== puzzle && previousMove !== null;
    const shouldTeardown = !this.props.teardown && teardown;
```

```
    if (didMovePiece) {
      await this.updateSquarePosition(
        puzzle,
        previousMove,
        getIndex(puzzle, previousMove),
      );
    }

    if (shouldTeardown) {
      await this.animateAllSquares(false);

      this.setState({ transitionState: State.DidTransitionOut });

      onTransitionOut();
    }
  }
```

Try it out!

Save `Board.js`. After the app reloads, press the start button to begin the game. To test the animation we just added, you can either complete the puzzle… *or* you can press quit. The pieces should fly offscreen, then the screen should transition out, and finally you'll be taken back to the start screen.



From the start screen, you can begin another game. The state of the game completely resets after each game.

We're Done!

We've built a complete puzzle game with animations and drag-and-drop gestures. Our app performs smoothly and our animations look great on both iOS and Android.

In this chapter, we learned how to use the `PanResponder` in conjunction with the `Animated` API. Using these together, we can build nearly any common gesture you can find in a mobile app.

We covered several ways of ensuring good animation and gesture performance:

- Using `transform` instead of `top` and `left` to avoid costly layout calculations
- Using `useNativeDriver` to reduce the number of messages that must be passed between the native and JavaScript threads

- Using `PureComponent` to prevent unnecessary component re-rendering

In the next chapter, we'll cover how to publish your app on the App Store and Play Store.

Native Modules

What are native modules?

So far in this book we've written all of our apps purely in JavaScript. We've used the built-in React Native components and APIs to interact with the underlying native iOS and Android platforms.

However, sometimes we want to use native functionality that isn't provided out-of-the-box by React Native. In these cases, we can write native components and APIs ourselves, and expose bindings to use them from JavaScript. In React Native, these bindings are called a "bridge."

Common use cases

Native modules are most commonly used for bridging existing native functionality into JavaScript. Native modules are also occasionally used for performance.

Here are a few of the most common cases:

- Accessing native platform features that React Native doesn't support out-of-the-box, e.g. payments APIs
- Exposing components and functionality when adding React Native to an existing native app
- Using existing iOS and Android libraries, e.g. authentication libraries for a 3rd party service
- High-performance algorithms like image processing that are usually low-level and multithreaded
- Extremely high-performance views when running into performance issues with React Native views (this is rare)

When to use native modules

Using native modules should be the exception, rather than the norm. It's generally best to write views, algorithms, and business logic in JavaScript when possible. The JavaScript we write is almost completely cross-platform, and updating to new versions of React Native is usually low effort. Native modules, on the other hand, must be written per platform, and can be time-consuming to update since they depend on both the native platform APIs and React Native's APIs. Additionally, we can't use the convenient Expo preview app once we start working with native code – we have to either initialize a new project with `react-native init` (covered later in this chapter), or we have to eject our existing app using `expo eject`. For either of these approaches we'll then need to build the app using Xcode and Android Studio before we can see it on our phones.

If we're integrating React Native into an existing app (this is known as a "hybrid" app), it's likely we'll use native modules more frequently, since we'll want to expose the existing components and functionality of our app to React Native. In the short term, it's often faster to bridge existing components than to re-write them in React Native. However, in the long term, it can be better to re-write them – by migrating components to React Native, we'll only need to maintain a single implementation, and our team will only need knowledge of a single language/platform.

Native modules on npm

When we decide we need a native module, we should first check if there's an existing open source implementation. We'll likely find an npm package for common use cases such as taking photos, playing videos, and displaying maps.

The GitHub organization react-native-community[81] maintains several of the most popular native modules. These modules are very high quality and maintained by React Native core contributors.

It's very important to read the installation instructions, as setup for native modules can vary. Most native modules on npm come with two sets of instructions, one for automatic setup using `react-native link`, and one for manual setup.

[81] https://github.com/react-native-community

`react-native-link`

Most of the time, installing a native module consists of 2 steps:

1. Install the npm package with: `yarn add foo`
2. Integrate the native code into your app by running `react-native link`

Remember, `yarn` and `npm` work interchangeably, but you should always stick to one or the other. Because we're using yarn in this book, if you see `npm install foo` in a package's installation instructions, make sure to run `yarn install foo` instead!

The command `react-native link` can often integrate native modules automatically. Library authors can configure the various paths and settings used by this command to integrate their native code.

However, `react-native link` only handles the most common cases, so many native modules come with custom setup instructions beyond this. Custom setup instructions usually involve manually modifying iOS and Android native code.

Manual setup

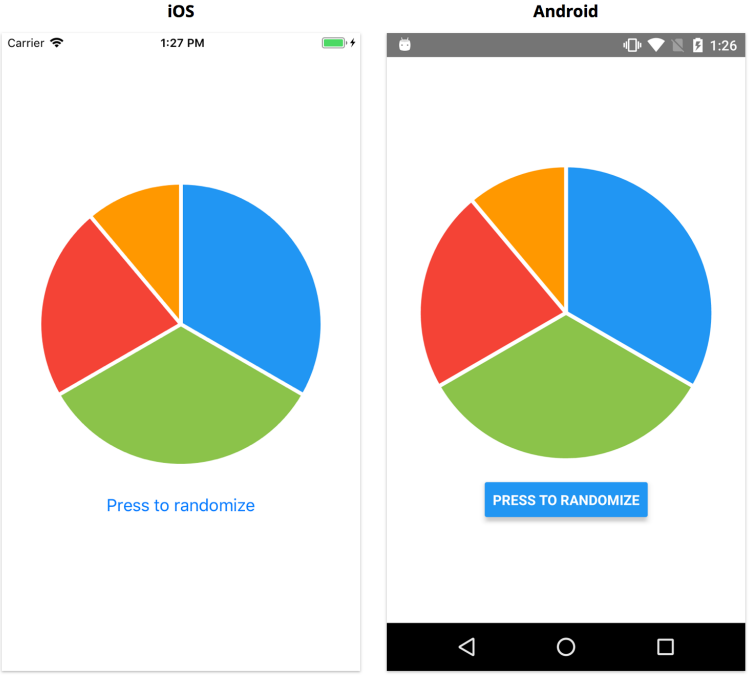
If you're building a hybrid app, it's likely your directory structure and code will differ somewhat from the structure expected by `react-native link`. For this reason, native modules usually include a set of instructions for manually integrating the native code into your app. This generally involves modifying the Xcode and gradle build configurations to compile native libraries that were downloaded by `yarn` into the `node_modules` directory.

The `react-native link` command supports some configuration options by adding an `rnpm: { ... }` object to your project's package.json. However, documentation is currently non-existent. If you choose to try this, the source code for reading configuration options is currently here[82].

[82] https://github.com/facebook/react-native/blob/6942408a474af80560497193f73c9e60bf272263/local-cli/core/ios/index.js#L34

Building a native module

In this chapter, we'll build an app that displays a native pie chart:



There are a variety of graphing libraries available for React Native already, some of which are written in JavaScript and some of which are native modules. In order to explore how native modules work, however, we'll write a native pie chart module from scratch.

The semantics of native iOS and Android code are outside the scope of this book, so we will primarily copy and paste the native code we need. People without any experience writing native code are often able to bridge simple native modules, so we recommend you attempt to follow along even if you don't have any experience with these platforms.

Building this app will consist of the following steps:

1. Create a new app using `react-native init`

2. Write the pie chart component for both iOS and Android
3. Create a single `PieChart.js` that renders the native pie chart component from JavaScript

If you're primarily testing on Android, feel free to skip the Xcode/iOS sections, or vice versa. The project will work correctly on one platform regardless of any native code or development tools for the other platform.

Native development is challenging!

There are *a lot* of things that can go wrong when developing a native app. Although the code we'll write in this chapter is relatively simple (as native apps go), it's likely you'll run into several challenges along the way, especially if you've never done native development before.

The most challenging issues tend to be related to your development environment or build tools. These can be tricky to debug, since they may be somewhat unique to the setup on your computer. When you encounter an error with a development tool or building the app, the best place to start is with a Google search. This will often reveal a Stack Overflow question or GitHub issue where somebody else in the community had the exact same problem. If you don't find anything useful, we recommend opening a GitHub issue on the React Native github repo[83]. This is the most likely way to have your issue resolved in a timely manner. If that still doesn't work, you're welcome to ask us (the authors) for help (instructions on how to do so are in the introduction chapter), but be aware that it's *unlikely we will be able to solve problems related to native app development.*

It's not all bad news though! The React Native community is extremely active, and new native modules are added to npm frequently – writing custom native modules will become less and less common as the ecosystem evolves. These complex challenges with native development are a big reason for React Native's success after all!

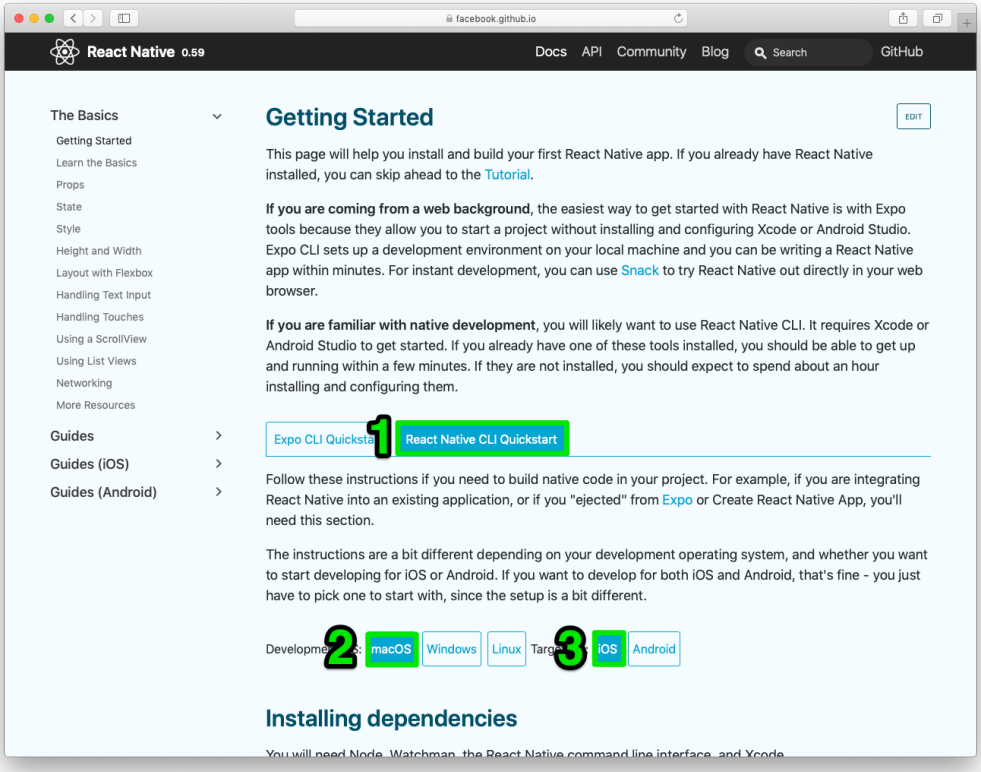
[83] https://github.com/facebook/react-native

Development environment

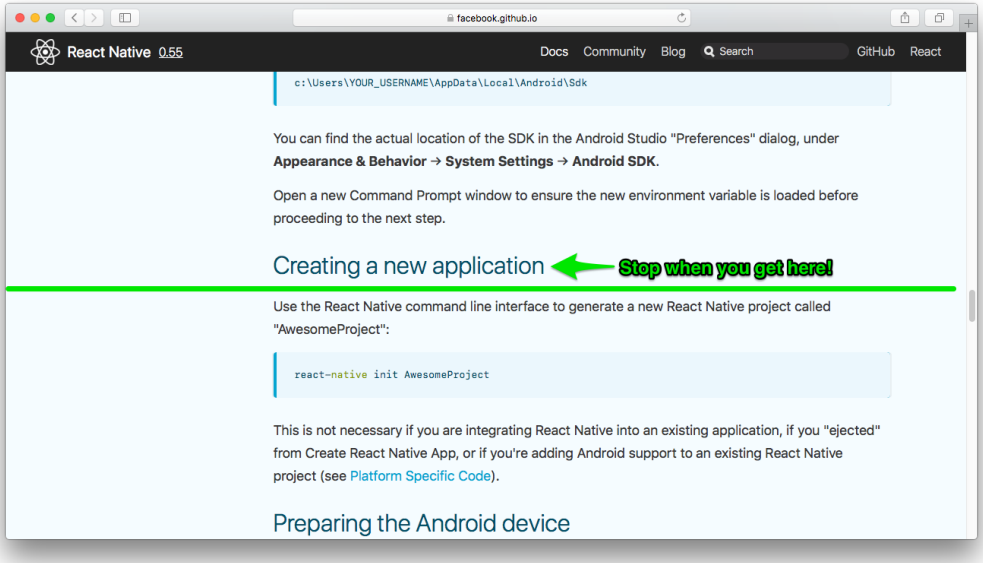
Before we can get started building the pie chart app, you'll need to set up your development environment. If you haven't done native app development before, it's likely you'll need to download some new software. Building for iOS will require a computer running macOS with Xcode installed. Building for Android can be done on any computer with Android Studio installed. We recommend you set up at least one of these tools before continuing with this chapter.

To set up your development environment, follow the instructions on the "Getting Started"[84] page of the React Native docs site. At the top left of the header of this page, you should see a version number – if this is greater than 0.59, switch to 0.59 now by clicking on the version number and selecting the documentation for 0.59 (since that's the version we use in this chapter). After confirming the version, click the "React Native CLI Quickstart" tab at the top of the page, then select the "Development OS" and "Target OS" you plan to test with.

[84] https://facebook.github.io/react-native/docs/getting-started.html



Follow the instructions for the “Development OS” and “Target OS” of your choice, up until the section “Creating a new application.” We’ll create a new application in a slightly different way than these docs demonstrate (although both will give the same result).



If you've previously followed these instructions and installed dependencies for a version of React Native that's different from 0.59, everything will likely still work. The setup doesn't change very often.

Initializing the project

We're going to create a new project using `react-native init`

```
$ react-native init PieChart --version react-native@0.59.8
```

Once this finishes, navigate into the `PieChart` directory.

Project structure

Let's take a look at the files in our project directory now:

```
├── .buckconfig
├── .flowconfig
├── .gitattributes
├── .gitignore
├── .watchmanconfig
├── App.js
├── android
├── app.json
├── babel.config.js
├── index.js
├── ios
├── metro.config.js
├── node_modules
├── package.json
└── yarn.lock
```

Most of the files should look familiar. There are a few new configuration files, but we'll focus mainly on the new `ios` and `android` directories and the `index.js` file.

The `ios` directory contains an Xcode project and the `android` directory contains an Android Studio project. From this point on, we'll need to build the project in either Xcode or Android Studio before we're able to preview it in a simulator or on a device.

You may also build using `react-native run-ios` and `react-native run-android`, which call into the native platform's build tools from the command line. However, if you run into any errors, they'll be easier to diagnose within Xcode or Android Studio.

The `index.js` file is the "entry point" of our app now – in other words, it's the first JavaScript file in our app that gets executed when our app launches. Let's look at this file now.

Here's what `index.js` contains:

PieChart/index.js

```
/**
 * @format
 */

import {AppRegistry} from 'react-native';
import App from './App';
import {name as appName} from './app.json';

AppRegistry.registerComponent(appName, () => App);
```

The call to `AppRegistry.registerComponent` registers a "root component" of our app that will be instantiated by native code. Apps can have multiple root components, each with a unique name, which can be instantiated within native code.

The `@format` annotation at the top of files created by `react-native init` tell code formatters, like `prettier`[85], that the file should be formatted.

For apps created with `expo init`, the `App.js` file is normally the entry point and the `App` component is registered automatically so long as it has `export default` in front of it.

How native modules work

There are 2 kinds of native modules:

- API modules
- UI component modules

API modules expose bindings for native methods to be called from JavaScript. When calling a native method from JavaScript, any values passed are marshalled[86] on the JavaScript side and unmarshalled on the native side. All APIs called from JavaScript

[85] https://prettier.io/
[86] https://en.wikipedia.org/wiki/Marshalling_(computer_science)

are asynchronous, so we will need to use promises, callbacks, or events if we want to handle a response from the native side.

UI component modules expose a new React component that we can render from our JavaScript code. When we render this component in our JavaScript, the native thread will use a "View Manager" to create a new native view. The View Manager handles the lifecycle of the native view, including: instantiating the view, marshalling and unmarshalling the component's props, updating the view with its props, and reusing native views where possible (for performance).

Prop types

On both platforms, we'll want our view to consume the same props. This will allow us to create a single React component that works for both iOS and Android. Our pie chart component will use the following props:

PieChart/PieChart.js

```
12  static propTypes = {
13    data: PropTypes.arrayOf(
14      PropTypes.shape({
15        value: PropTypes.number,
16        color: ColorPropType,
17      }),
18    ).isRequired,
19    strokeWidth: PropTypes.number,
20    strokeColor: ColorPropType,
21    ...ViewPropTypes,
22  };
```

The different segments of the pie chart, the `data` prop, are passed as an array of objects containing a numeric `value` and a `color` string. The segments of the pie chart may optionally be rendered with a colored stroke, configurable with a numeric `strokeWidth` and `strokeColor` string. We'll also allow a `style` prop, just like other built-in React Native components.

We'll now build a UI component native module for each platform. As we build the module, we'll make sure it supports the `data`, `strokeWidth`, and `strokeColor` props. The `style` prop will be handled automatically for us.

Feel free to follow the instructions for just iOS or just Android, and come back to the other platform another time.

iOS

The structure of the `ios` directory looks like this:

```
ios/
├── PieChart
│   ├── AppDelegate.h
│   ├── AppDelegate.m
│   ├── Base.lproj
│   │   └── LaunchScreen.xib
│   ├── Images.xcassets
│   │   ├── AppIcon.appiconset
│   │   │   └── Contents.json
│   │   └── Contents.json
│   ├── Info.plist
│   └── main.m
├── PieChart-tvOS
│   └── Info.plist
├── PieChart-tvOSTests
│   └── Info.plist
├── PieChart.xcodeproj
│   ├── project.pbxproj
│   ├── project.xcworkspace
│   ├── xcshareddata
│   └── xcuserdata
└── PieChartTests
```

```
├── Info.plist
└── PieChartTests.m
```

We'll be opening `PieChart.xcodeproj` in Xcode, and then adding a few new files to the `PieChart` directory from within Xcode. We won't be adding native tests or configuring our app for Apple TV, so we can ignore the `PieChart-tvOS`, `PieChart-tvOSTests`, and `PieChartTests` directories.

Swift or Objective-C?

When working with iOS, we have two choices for which language we want to use: Swift or Objective-C (abbreviated Obj-C). The React Native framework for iOS is written in Obj-C, so the built-in native modules and most of the documentation uses Obj-C. However, Swift is significantly easier to learn and use, so we'll be using Swift. In general we recommend using Swift for new native modules, unless you know that you need Obj-C for some reason. Regardless of which we choose, we'll still need to use Obj-C for one part of the process.

Exporting the native view

There are 4 things we need to do in native code to create a new UI component native module:

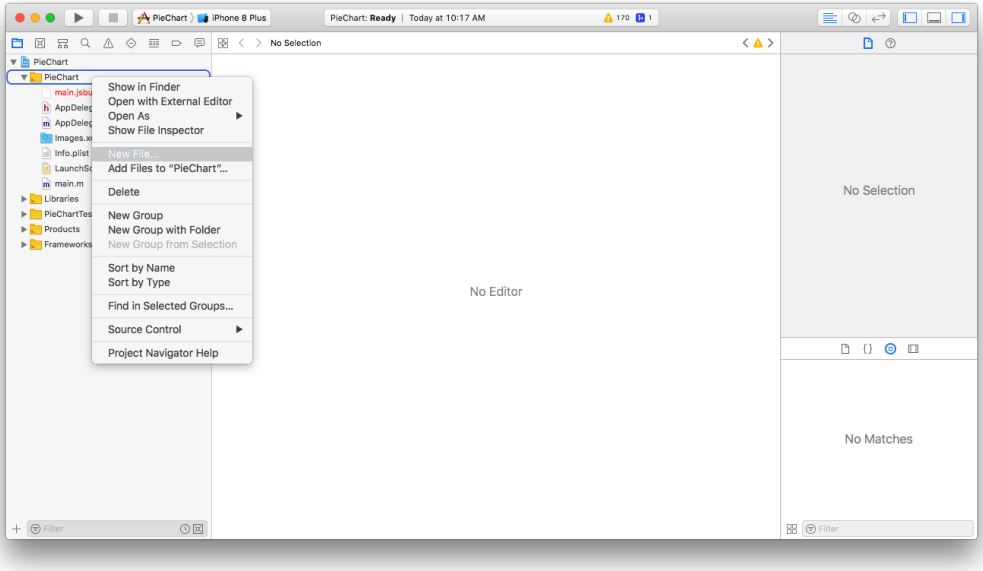
1. Define the view that we want to instantiate from JavaScript. This will be a subclass of `UIView`. In our case, we'll call this class `PieChartView`.
2. Create a bridging header to expose our Swift code to React Native (this is only necessary if we're using Swift). Xcode will help us create this automatically when we create our first Swift file.
3. Define the View Manager that will handle the lifecycle of our component. This will be a subclass of `RTCViewManager`. We'll call our subclass `PieChartManager`.
4. Export our custom View Manager and our component's props to JavaScript using macros. This is done in Obj-C, regardless of whether we're using Swift for our component or not.

Creating files

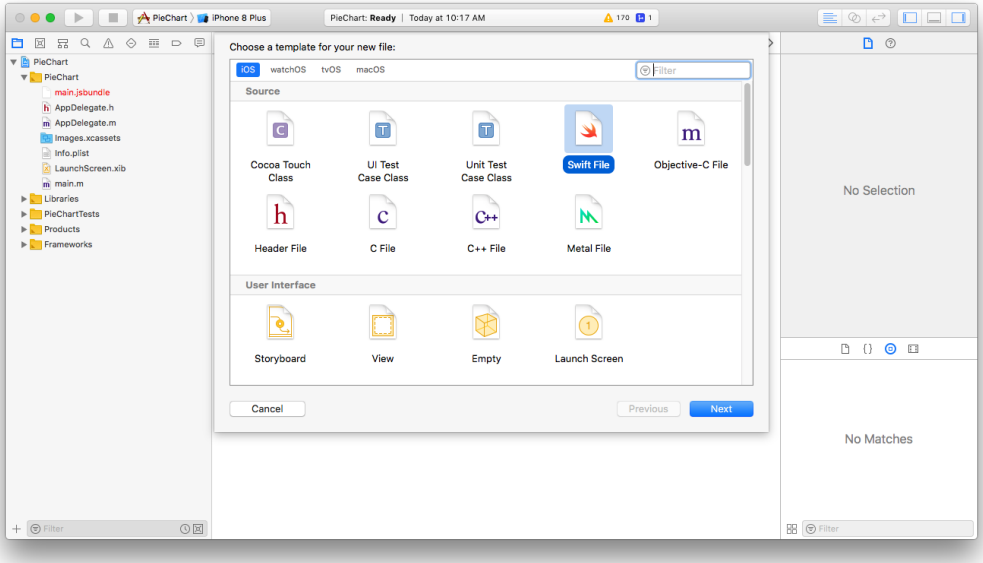
Let's begin by creating all the Swift and Obj-C files we'll need within Xcode. Open `PieChart.xcodeproj` in Xcode now. You can do this by launching Xcode and then choosing `File > Open...` from the menubar.

This project was written using Xcode 10.2. The project may fail to build in older versions of Xcode!

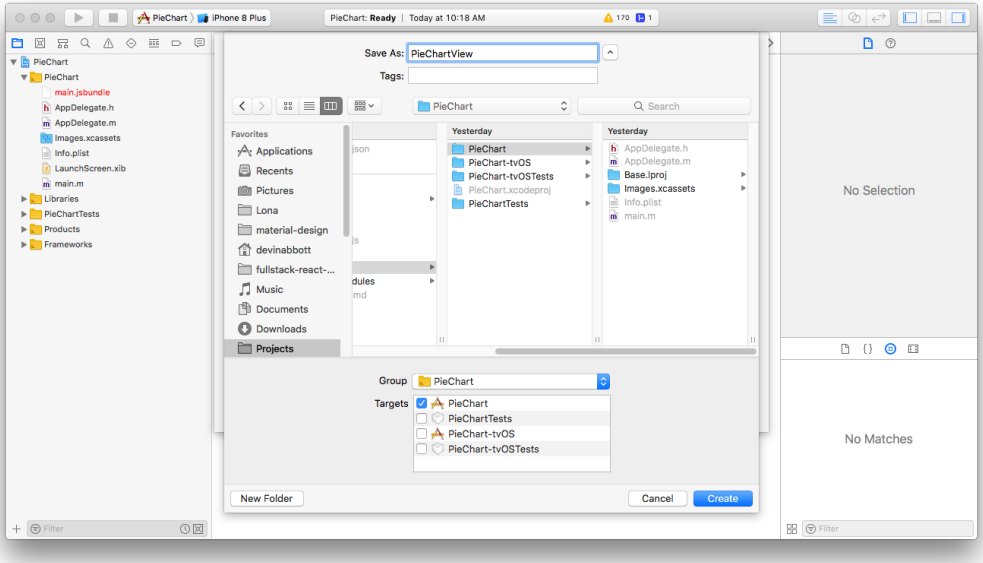
First we'll create our native view class, `PieChartView.swift`. In the project navigator on the left, right click the "PieChart" group (the one with the yellow folder icon) and choose "New File...".



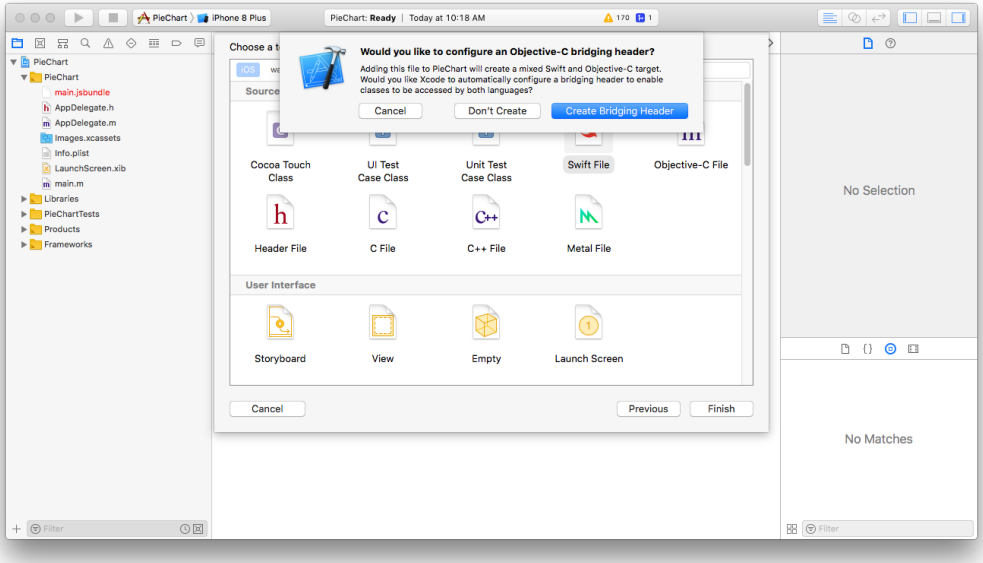
Select the "Swift File" option.



Click “Next” and then save the file as `PieChartView` (the file extension is added automatically) in the `ios/PieChart` directory:

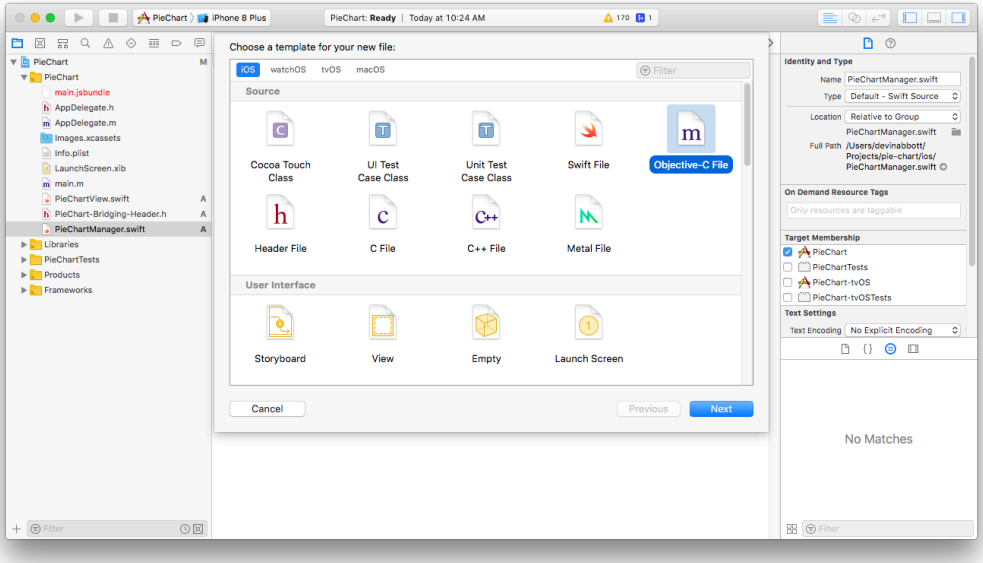


Click “Create.” Upon creating this file, Xcode will prompt us to create a “bridging header” – this is necessary to expose our Swift code to React Native, as React Native is written in Obj-C. Click “Create Bridging Header”:



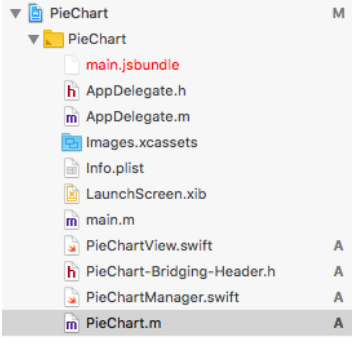
Next, right click the "PieChart" group in the project navigator again and create the file `PieChartManager.swift` following the same process. Xcode won't prompt you to create a bridging header this time, since we already have one.

Last, we'll create an Obj-C file to expose our view to JavaScript. Once again, right click the "PieChart" group and choose "New File...". This time, select "Objective-C File":



Save this file as "PieChart" in the `ios/PieChart` directory.

At this point, the file navigator should show these files:



Now that we've created the files we need, let's fill them out one by one.

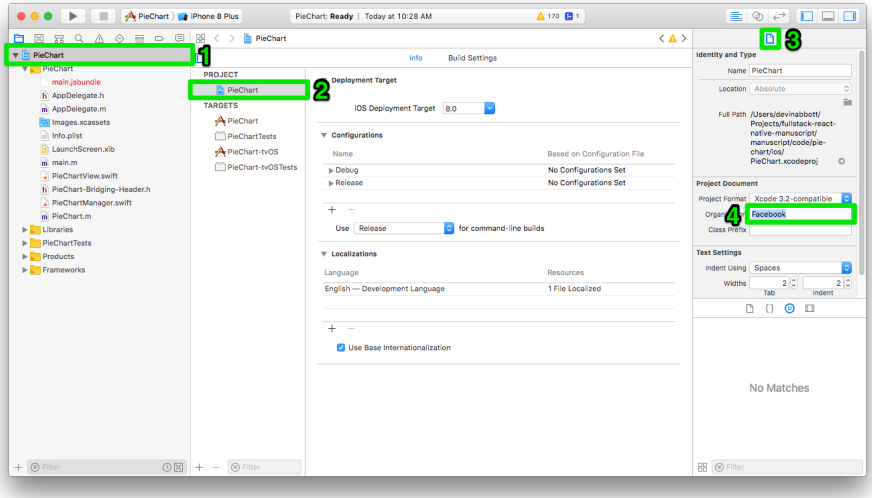
Note that despite how the Xcode file navigator looks, `PieChart-Bridging-Header.h` is actually in the `ios` directory, not the `ios/PieChart` directory. The Xcode file navigator doesn't map directly to the file system. There's no need to move this file though – it will work correctly regardless of where it exists on the file system. In fact, moving files managed by Xcode can be fairly tricky, so for our PieChart app, we recommend against moving any files if possible.

You may notice that new files created in Xcode include a copyright header automatically. The copyright header for projects created with the Expo CLI is set to "Facebook" by default, e.g:

```
//  Copyright © 2018 Facebook. All rights reserved.
```

If you're working on a real project, you'll likely want to change the default value to your name or your organization's name, rather than "Facebook".

The following image demonstrates how to change the organization name used for the copyright header:



Bridging header

We'll be copying code from the sample code directory, `PieChart/ios`, into the files we just created.

Copy the contents of `PieChart-Bridging-Header.h` from the sample code directory into your own `PieChart-Bridging-Header.h`:

PieChart/ios/PieChart-Bridging-Header.h

```
1 //
2 //  Use this file to import your target's public headers that you would\
3  like to expose to Swift.
4 //
5
6 #import "React/RCTViewManager.h"
```

This exposes the `RCTViewManager.h` headers to our Swift code so that we can write a native view in Swift.

PieChartView

We'll be using a subclass of UIView that draws a pie chart based on the `data`, `strokeWidth`, and `strokeColor` props.

Copy the contents of `ios/PieChart/PieChartView.swift` from the sample directory into your own `PieChartView.swift` file. We'll look at two important details of this code.

If you don't fully understand the explanations of the native code, that's fine! This is mainly included for people who do have a little native iOS development experience.

Props must be member variables of the class, exposed to Obj-C using the `@objc` annotation, for example:

```
@objc var strokeWidth: CGFloat = 0.0
```

When a prop updates, we need to re-draw the pie chart. We can do this by overriding the `didSetProps` method of our view:

```
override func didSetProps(_ changedProps: [String]!) {
  setNeedsDisplay()
}
```

PieChartManager

Now that we have our view class, we need to create a manager class to instantiate it. Copy the contents of `PieChartManager.swift` from the sample directory into your own `PieChartManager.swift` file.

This class allows React Native to instantiate our `PieChartView` class as needed when we render it from JavaScript.

Export macros

Last, copy the contents of `PieChart.m` from the sample directory into your own `PieChart.m` file.

PieChart/ios/PieChart/PieChart.m

```
1  //
2  //  PieChart.m
3  //  PieChart
4  //
5  //  Created by Devin Abbott on 6/3/18.
6  //  Copyright © 2018 Fullstack. All rights reserved.
7  //
8
9  #import "React/RCTViewManager.h"
10
11 @interface RCT_EXTERN_MODULE(PieChartManager, RCTViewManager)
```

```
12
13 RCT_EXPORT_VIEW_PROPERTY(data, NSArray)
14 RCT_EXPORT_VIEW_PROPERTY(strokeColor, UIColor)
15 RCT_EXPORT_VIEW_PROPERTY(strokeWidth, CGFloat)
16
17 @end
```

This file uses macros to expose the view manager class and the view's props to React Native.

The `RCT_EXTERN_MODULE` macro exposes our `PieChartManager` class to React Native. We can now consume a native module called `PieChart` (without the `Manager` suffix) from our JavaScript.

The `RCT_EXPORT_VIEW_PROPERTY` macro exposes the member variables on our `PieChartView` class as props to React Native. We also provide the types of these props so they can be marshalled and unmarshalled correctly.

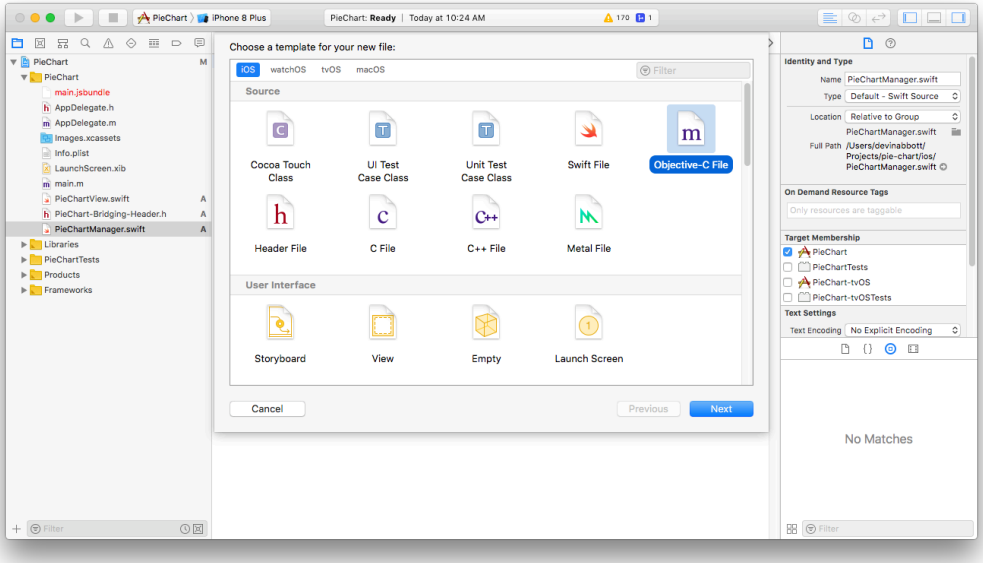
You may see an error `'React/RCTViewManager.h' not found` on the line with the `#import "React/RCTViewManager.h"`. Xcode should find this dependency during the build process, so the error should disappear once you build the app in the next step.

Try building!

We won't be able try our component until we render it from JavaScript, but we can at least confirm that our Xcode project builds successfully.

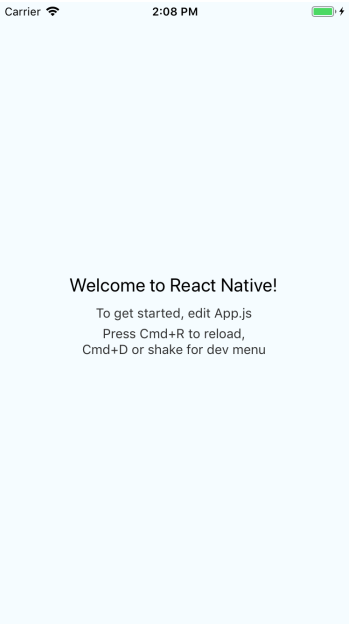
In the top left of Xcode:

1. Choose a simulator to build the project on. It's more difficult to build on a real device, so we recommend using the simulator for this chapter unless you're already set up for building to your device.
2. Click the play button to start the build.



Xcode will open a new terminal and start the packager in the root directory of our app if you don't have a React Native packager process running on your computer. This is for convenience – you may also quit the terminal that Xcode opened and launch a packager process of your own with `yarn start` as usual.

If everything goes well, after a minute you should see a "Build Succeeded" popup from Xcode. The simulator you chose before building should launch (this can take a minute or two) and you should see the default `react-native init` screen (possibly with slight variations).



Wrapping up iOS

We've finished creating a native pie chart component for iOS! The next step will be to consume it from JavaScript. We'll do that in the JavaScript section of this chapter.

At this point, you can either build the Android version of the pie chart, or skip ahead to the JavaScript section (recommended) and come back to Android later.

Android

The structure of the `android` directory (excluding some deeply nested files) looks like this:

```
android/
├── PieChart.iml
├── app
│   ├── BUCK
│   ├── build.gradle
│   ├── proguard-rules.pro
│   └── src
├── build.gradle
├── gradle
│   └── wrapper
├── gradle.properties
├── gradlew
├── gradlew.bat
├── keystores
│   ├── BUCK
│   └── debug.keystore.properties
└── settings.gradle
```

We'll be opening the `android` directory in Android Studio. We'll be adding a few new Java source files to `android/app/src/main/java/com/piechart/`. We can ignore the rest of the files in this directory, which are mainly configuration files.

Java or Kotlin

When working with Android, we have two choices for which language we want to use: Java or Kotlin. The React Native framework for Android is written in Java, so the built-in native modules and most of the documentation uses Java. While Kotlin is more modern and a popular choice for new Android apps, most Android apps today are still written in Java, so we'll be using Java for our pie chart example.

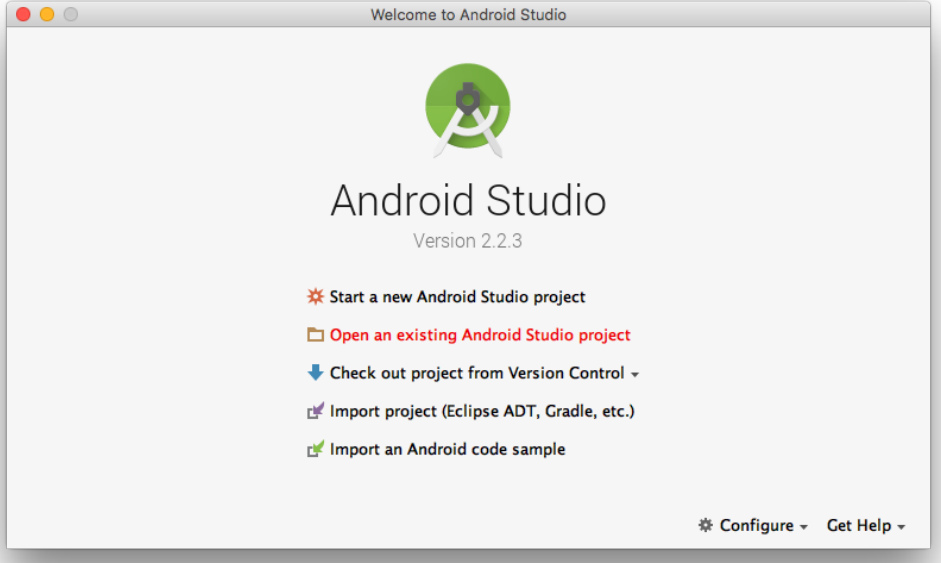
Exporting the native view

There are 4 things we need to do in native code to create a new UI component native module:

1. Define the view that we want to instantiate from JavaScript. This will be a subclass of `android.view.View`. In our case, we'll call this class `PieChartView`.
2. Define the View Manager that will handle the lifecycle of our component. This will be a subclass of `SimpleViewManager<PieChartView>`. We'll call our subclass `PieChartManager`.
3. Define a new "package" called `PieChartPackage`, a subclass of `ReactPackage`, that instantiates our View Manager.
4. Register our `PieChartPackage` at app launch from `MainApplication.java`.

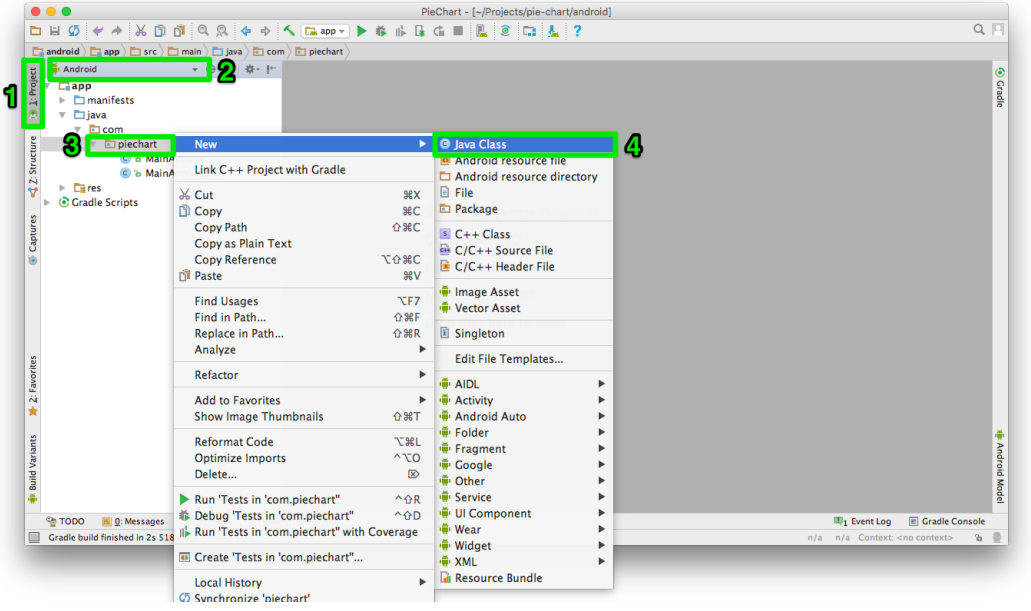
Exporting the native view

Let's begin by creating all the Java files we'll need within Android Studio. Launch Android Studio now, and choose "Open an existing Android Studio project".

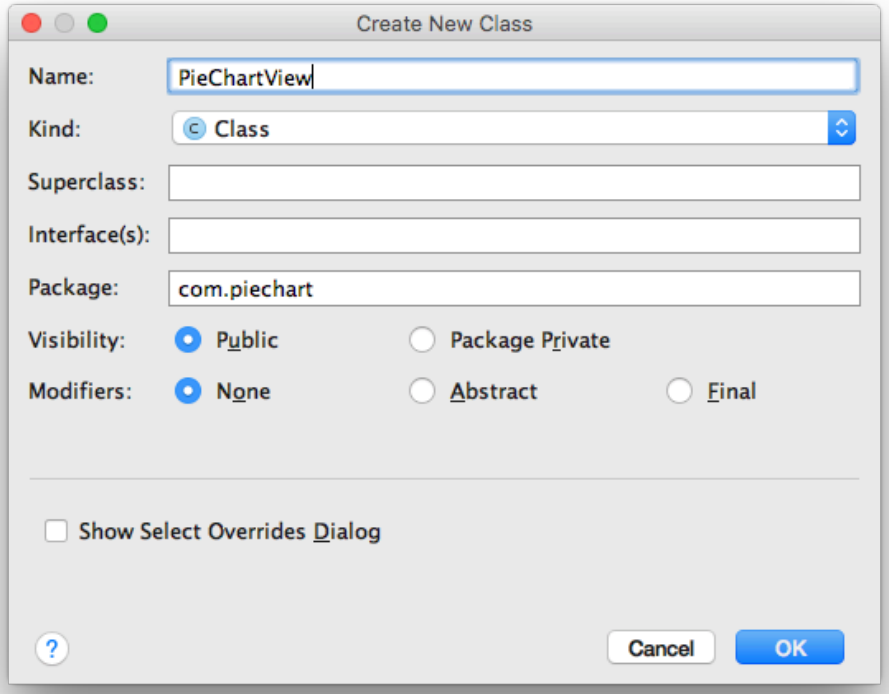


Select the `android` directory within the `PieChart` directory we just created and press "OK." It may take Android Studio a minute or two to configure the project.

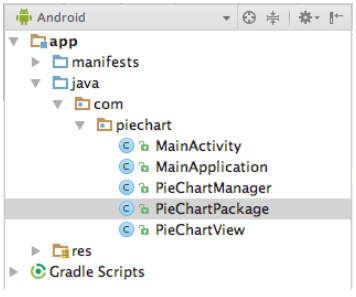
Next we'll create a new Java file, `PieChartView.java`. If you've never used Android studio before, the following diagram depicts the steps to take. First, click the "Project" tab on the left of the window. Second, choose the "Android" option in the dropdown at the top of the file tree. Third, right click the "piechart" directory. Lastly, choose "New > Java Class" from the context menu.



Within the dialog that appears, type `PieChartView` and click "OK."



Repeat this process of creating new files for two more files: `PieChartManager.java` and `PieChartPackage.java`. Once you've finished, the file tree should look like this:



Now that we've created the files we need, let's fill them out one by one.

PieChartView

We'll be using a subclass of `android.view.View` that draws a pie chart based on the `data`, `strokeWidth`, and `strokeColor` props. React Native doesn't interact with view classes directly, so this class could be written any way we want – the member variables of the view could have completely different names and types from our props.

Copy the contents of `PieChartView.java` from the sample directory into your own `PieChartView.java` file.

PieChartManager

Now that we have our view class, we need to create a manager class to instantiate it. Copy the contents of `PieChartManager.java` from the sample directory into your own `PieChartManager.java` file.

This class allows React Native to instantiate our `PieChartView` class as needed when we render it from JavaScript. The `REACT_CLASS` string determines the name of the component within our JavaScript:

```
public static final String REACT_CLASS = "PieChart";
```

In this case, our component will be available as `PieChart`.

Methods of the `PieChartManager` handle updating the `PieChartView` to reflect the latest props. A method can be registered to handle a specific prop by name using the `@ReactProp` annotation:

```
@ReactProp(name = "strokeWidth", defaultFloat = 0f)
public void setStrokeWidth(PieChartView view, float strokeWidth) {
  view.strokeWidth = strokeWidth;

  view.invalidate();
}
```

These annotated methods handle converting common JavaScript types to Java types. For more detail on annotating props, check out this guide in the docs[87].

Our `PieChartView` implementation overrides the `draw` method in order to do custom drawing, so anytime we change a prop, we also call `invalidate()` to trigger a re-draw.

Exporting the package

Now that we have our view manager class, we can create a `ReactPackage` subclass that registers it with React Native. Copy the contents of `PieChartPackage.java` from the sample directory into your own `PieChartPackage.java` file.

This class can register multiple native modules at once, including both API modules and UI component modules. We register our `PieChartManager` using the following:

```
@Override
public List<ViewManager> createViewManagers(ReactApplicationContext rea\
ctContext) {
    return Arrays.<ViewManager>asList(
            new PieChartManager()
    );
}
```

Lastly, we'll register our `PieChartPackage` class within `MainApplication.java`.

The `getPackages` method currently looks like this:

[87] https://facebook.github.io/react-native/docs/native-components-android#3-expose-view-property-setters-using-reactprop-or-reactpropgroup-annotation

```
@Override
protected List<ReactPackage> getPackages() {
  return Arrays.<ReactPackage>asList(
      new MainReactPackage()
  );
}
```

Update it to the following:

```
@Override
protected List<ReactPackage> getPackages() {
  return Arrays.<ReactPackage>asList(
      new MainReactPackage(), new PieChartPackage()
  );
}
```

This registers our `PieChartPackage` with React Native.

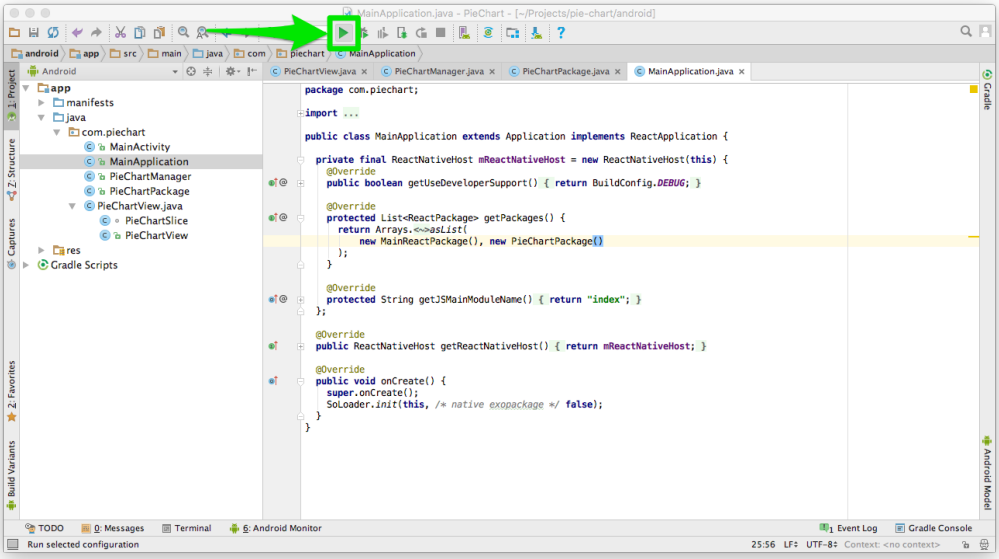
Try building!

We won't be able try our component until we render it from JavaScript, but we can at least confirm that our Android Studio project builds successfully.

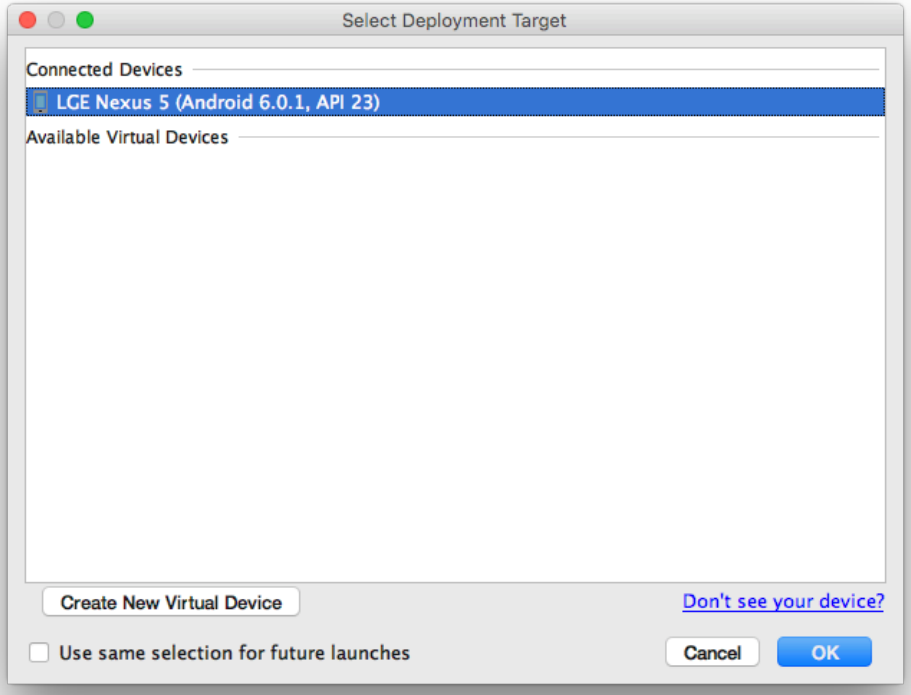
We can either build to a real device or an emulator. It's often quicker and easier to build to a real device if you have one (and a USB cable) handy. If not, now's a good time to set up an emulator. In either case, follow the section titled "Preparing the Android Device"[88] for information on how to set up your real device or emulator. If the website shows the wrong operating system (e.g. macOS when you're running Windows), you may need to set the "Development OS" toggle at the top of this page again. Follow the instructions under "Preparing the Android Device" until you reach "Running your React Native application."

At the top of Android Studio, click the play button:

[88] https://facebook.github.io/react-native/docs/getting-started#preparing-the-android-device



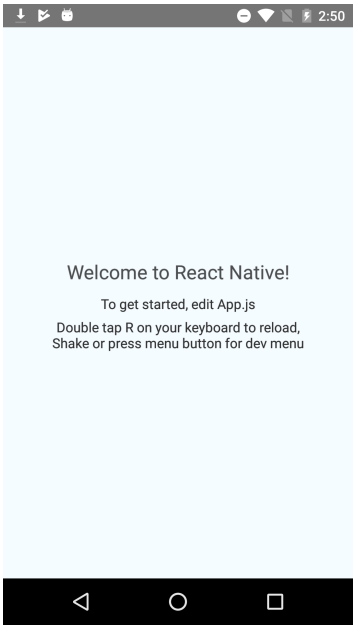
Next, choose a device or emulator to build the project on and press “OK”:



This will build the app, install it on your device, and launch it automatically. Android Studio *doesn't* automatically launch the React Native packager, so once the app launches you should see a red error screen explaining that it can't load the script.

Navigate to the root directory of the `PieChart` app we just created and start the packager with `yarn start` as usual. Once this finishes, press the "RELOAD" button at the bottom of the red screen on your device or emulator.

If everything goes well, you should see the default `react-native init` screen (possibly with slight variations).



JavaScript

Now that we have a native implementation of our pie chart component, we can use it from JavaScript.

Using the native view from JS

In your text editor, create a new file `PieChart.js` in the root of our project directory (at the same level as `App.js`).

In this file, we'll import the native pie chart component, and render it from a new React component. It's best to wrap a native component within another React component so that we have the ability to modify component props before they're passed to the native component, and so that we can control which imperative APIs are available on the component class (although in this case we won't use any).

Let's begin by importing the following at the top of `PieChart.js`:

PieChart/PieChart.js

```
import React from 'react';
import PropTypes from 'prop-types';
import {
  ColorPropType,
  StyleSheet,
  ViewPropTypes,
  requireNativeComponent,
  processColor,
} from 'react-native';
```

Next, we'll define a React component called `PieChart`. This component will wrap the native component which we'll import shortly. In the `PieChart` component, we need to define the prop types and default props in the exact same way that our native component expects. So, we need a `data`, `strokeWidth`, and `strokeColor` prop type. As a reminder, the `data` prop should be an array of objects, where each object contains a numeric `value` and a `color` string.

Even though we didn't specify this explicitly in our native code, our native component also expects every prop type supported by the built-in React Native `View`. This is the default behavior for native components, which allows our native pie chart to work with layout and gestures just like any other React Native core component.

Create the `PieChart` class and `propTypes` now:

PieChart/PieChart.js

```
export default class PieChart extends React.Component {
  static propTypes = {
    data: PropTypes.arrayOf(
      PropTypes.shape({
        value: PropTypes.number,
        color: ColorPropType,
      }),
    ).isRequired,
    strokeWidth: PropTypes.number,
    strokeColor: ColorPropType,
```

```
    ...ViewPropTypes,
  };
```

Note that we use the spread syntax, `...ViewPropTypes`, to add every prop type from `View` to our `PieChart` component.

Next we'll add `defaultProps`:

PieChart/PieChart.js

```
  static defaultProps = {
    data: [],
    strokeWidth: 0,
    strokeColor: 'transparent',
  };
```

`requireNativeComponent`

Before we add the `render` method to our `PieChart` component, we first need to import our *native* pie chart component. We can do this using the:

`requireNativeComponent(viewName, componentInterface)` API.

In this case, the `viewName` will be `"PieChart"` (since that's how we exported it from native code), and the `componentInterface` will be the `PieChart` component we just made. The `requireNativeComponent` API will use the `propTypes` of our `PieChart` (the `componentInterface`) to ensure that props passed from JavaScript to native code have the correct names and types.

Let's add the following line *below* our `PieChart` React component definition:

PieChart/PieChart.js

```
const NativePieChart = requireNativeComponent('PieChart', PieChart);
```

We'll be rendering `NativePieChart` from within the `render` method of our `PieChart` component.

Even though we're declaring `NativePieChart` below the `PieChart` class, we'll still be able to use it from within the `render` method. This works the same way as declaring `styles` below the component class.

One last thing to do before writing our `render` method: we want to set the background of our native pie chart component to `"transparent"`, since native components have a black background by default. Let's add a style that handles this for us at the bottom of the file:

PieChart/PieChart.js

```
const styles = StyleSheet.create({
  container: {
    backgroundColor: 'transparent',
  },
});
```

Rendering

Now we can write the `render` method of our `PieChart` class. Within the `render` method, we'll render a `NativePieChart` component, propagating all of the props passed to `PieChart` into the `NativePieChart`.

There are two props that we'll modify before propagating them to the `NativePieChart` component:

- `data` - we need to call `processColor` on each `color` within the objects in the `data` array. The `processColor` function converts colors into a format that our native code can understand. React Native normally handles this conversion automatically (e.g. for our `strokeColor` prop), but since our colors are nested within objects/arrays, we must do it ourselves for the `data` array. In order to do this, we'll map each object in the data array to a new object containing the converted color.
- `style` - we want to apply our default `styles.container` style before any other styles in order to clear the default background color.

Let's add the render method now:

PieChart/PieChart.js

```
render() {
  const { style, data, ...rest } = this.props;

  const processedData = data.map(item => ({
    value: item.value,
    color: processColor(item.color),
  }));

  return (
    <NativePieChart
      {...rest}
      style={[styles.container, style]}
      data={processedData}
    />
  );
}
```

Save `PieChart.js`. That wraps up our `PieChart` component! Now it's time to render this component from `App`.

App

Open `App.js`. In this component we'll render the `PieChart` with an initial set of data, and we'll include a button that randomizes the data.

You may either leave or delete the comment at the top of the file containing the `@format` and `@flow` annotations – we won't be using these.

The `@flow` annotation (e.g. in App.js) indicates that the file uses the `Flow`[89] static typechecker. Facebook uses this tool for many of their open source projects, including React Native. For the application code we write, we don't need to use it (most people don't outside of Facebook).

We'll begin by updating the imports at the top of the file:

[89] https://flow.org/

PieChart/App.js

```
import React from 'react';
import {
  AppRegistry,
  StyleSheet,
  Text,
  View,
  Button,
} from 'react-native';

import PieChart from './PieChart';
```

Next, let's add a style called `chart` in the `styles` object at the bottom of this file. This style will render our pie chart as a 300x300 square with a margin below it. Update the `styles` object now:

PieChart/App.js

```
const styles = StyleSheet.create({
  container: {
    flex: 1,
    backgroundColor: '#fff',
    alignItems: 'center',
    justifyContent: 'center',
  },
  chart: {
    width: 300,
    height: 300,
    marginBottom: 20,
  },
});
```

Now let's move on to the `App` component. We'll add a component `state` object containing some initial `data` to render in the pie chart:

PieChart/App.js

```
  state = {
    data: [
      { value: 12, color: '#2196F3' },
      { value: 12, color: '#8BC34A' },
      { value: 8, color: '#f44336' },
      { value: 4, color: '#FF9800' },
    ],
  };
```

We'll also add a `randomize` function to this class which randomizes the pie chart's `data`:

PieChart/App.js

```
  randomize = () => {
    const { data } = this.state;

    this.setState({
      data: data.map(slice => ({
        value: Math.random() + 0.1,
        color: slice.color,
      })),
    });
  };
```

Finally, we can update the `render` method. Delete the current placeholder contents within the `render` method. Then, render a `PieChart` component using the `styles` and `data` we just defined, along with a `Button` below it that calls `this.randomize` when pressed.

PieChart/App.js

```
  render() {
    const { data } = this.state;

    return (
      <View style={styles.container}>
        <PieChart
          style={styles.chart}
          strokeColor={'white'}
          strokeWidth={4}
          data={data}
        />
        <Button title="Press to randomize" onPress={this.randomize} />
      </View>
    );
  }
```

Save `App.js`.

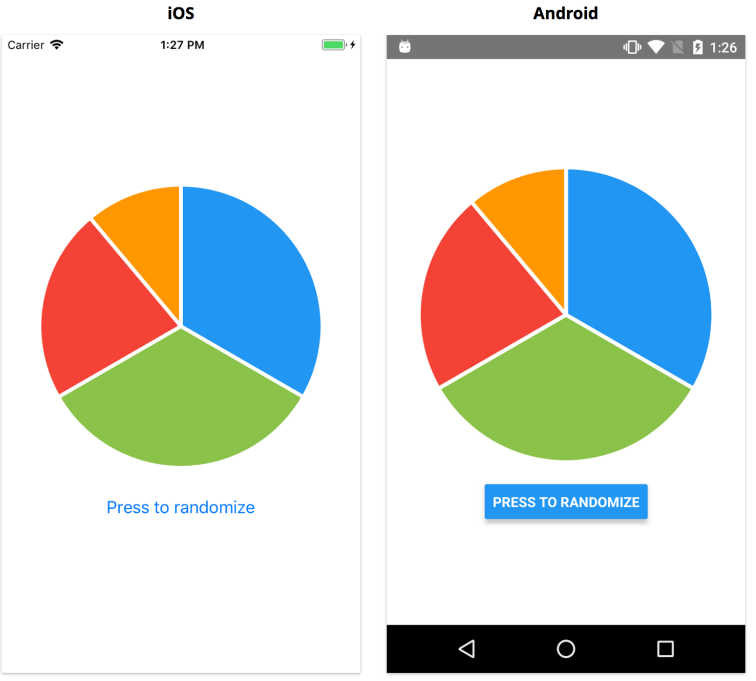
Try it out!

You'll likely need to manually reload the app on your simulator or device, since live reload and hot reload are disabled by default in apps created using `react-native init`.

To reload:

- On a physical device, shake the device until the developer menu appears, then tap "Reload".
- On an iOS simulator, press Cmd+R.
- On an Android emulator, press R twice.

Once the app has reloaded, you should see the pie chart on the screen!



Try tapping the "Press to randomize" button a few times to make sure the native component updates correctly whenever props change.

Wrapping up

We just created a native module for both iOS and Android, and bridged it into React Native. Although bridging a native module is more complex than creating a JavaScript API or UI component, it can be necessary in order to leverage native functionality.

As the React Native community has evolved, many native modules have been published on npm. Creating native modules manually like we did in this chapter is already significantly less common than it was several years ago. In the future, more and more apps will likely be built without writing any native code. However, knowing how to bridge a native module will always be an important skill for a React Native developer, since the need might arise throughout the lifetime of a project.

In the next chapter, we'll cover how to publish our apps to the App Store and Play

Store.

Building and publishing

After spending some time completing a mobile application, the next natural step is to share your work with the world! If we want any user to be able to access our application at any time, we need to **build and publish** it to an app store. By doing so, we let users discover and download our application to their device.

How to read this chapter

This chapter serves as a reference for when you need to deploy and distribute a React Native application. Unlike other chapters, you won't be following along with an example application. Feel free to read it now to get an idea of the process and return later when you're ready to publish an application of your own.

Shipping an application to an app store is generally a two-step process:

1. Create a native build of our application. This involves generating an IPA (iOS App Store Package) file for iOS and an APK (Android Package Kit) file for Android.
2. Publish the build to an app store. App Store Connect[90] and Google Play Console[91] are the two platforms used to publish and distribute an iOS and Android application respectively.

We'll start with **Building**. There are two different approaches to creating a build. We'll weigh their advantages and disadvantages.

After this section, we suggest you head directly to the section covering the operating system that you plan on publishing with: **iOS** or **Android**.

[90] https://developer.apple.com/app-store-connect/
[91] https://developer.android.com/distribute/console/

Building

We explored how to add native components to a React Native application in the "Native Modules" chapter. While doing so, we described how to set up the necessary integrated development environments (IDEs) needed for writing native code. To develop for iOS, Xcode[92] is the required IDE and can only be installed on a Mac computer. Android Studio[93] is the official IDE used for Android development.

In order to submit to an App Store, we first need to create a build of our application that we can publish. If we were building mobile applications without React Native, we would use the same IDEs that we write native code with to create builds of our application. With applications built with the Expo CLI, we can create standalone builds in two different ways:

1. Using the Expo CLI directly
2. Ejecting and creating builds manually through Xcode or Android Studio

Both approaches will allow us to generate iOS and Android builds that we can deploy to app stores. Each approach has its advantages and disadvantages, which we will cover in a little bit.

In the next section, we'll explore how Expo allows us to create standalone builds using one of its tools. After that, we'll review the pros and cons for using this approach as well as the trade-offs for building manually using the IDEs.

Building with Expo

In order to build with the Expo CLI, you need to have an Expo account. You can create one at https://expo.io/signup[94]. Once your account is set up, you can sign in directly through the command line:

[92] https://developer.apple.com/xcode/
[93] https://developer.android.com/studio/
[94] https://expo.io/signup

```
expo login
```

The `app.json` file is automatically generated in the root directory when creating a new project with Expo and allows us to modify a number of build configurations. Although it populates with many fields by default, only a number of attributes are required for a native build.

```
{
  "expo": {
    "name": "Weather",
    "slug": "weather",
    "sdkVersion": "33.0.0",
    "icon": "./path/app-icon.png",
    "version": "1.0.0",
    "ios": {
      "bundleIdentifier": "com.companyname.appname"
    },
    "android": {
      "package": "com.companyname.appname"
    }
  }
}
```

- `name`: The name of the application that shows on the device home screen for applications installed through an App Store.
- `slug`: The URL name for published Expo applications. For this configuration, the URL will look like `expo.io/user_name/weather`.
- `sdkVersion`: The Expo sdkVersion that the application is running with. This needs to match with the installed version in `package.json`.
- `icon`: The icon of the application that shows on the device home screen.
- `version`: The version of your current build.
- `ios`/`android`: iOS and Android build-specific configurations. The iOS `bundleIdentifier` and Android `package` fields are both unique strings that identify the application and follow a reverse domain naming convention. It is important to make sure a proper name is chosen for both fields, as they cannot be changed once the application is published to an App Store.

Although these are the only fields that are required to create native iOS and Android builds, there are many other configurations that we can add including defining a splash screen[95], modifying the app status bar[96] and using appropriate and platform specific app icons[97].

Expo provides an extensive guide[98] for best practices when creating builds to publish to App Stores. Further, Expo provides a full list of possible configurations[99].

Pros and cons of building with Expo

Creating builds with Expo is only possible if we do not plan on including any custom native code whatsoever. If we need to include any native dependencies in our application, we have to eject and create our builds manually using Xcode and Android Studio. If you have already ejected, then skip right ahead to the "Building Manually" section of this chapter. Otherwise, we highly recommend to use Expo as it is a much simpler and quicker build process.

The Expo platform supplies a CLI to automate the process of creating a native iOS or Android build of our application. When building for both iOS and Android, signing files are required to identify the author of the application. Expo can automatically generate these files for you. This method allows us to create iOS builds without using Xcode and without owning a Mac computer. However, Xcode is still required to publish the build to the iOS App Store.

Another significant advantage of using this approach is over-the-air (OTA) updates. By default, applications published with Expo will always check for updates when launched. If a new version of the app has been published with Expo, the updated build will be fetched and loaded automatically. With this, we can release fixes and updates to our application without going through the process of publishing a new version to the App Store. We'll cover this feature, along with its limitations, in more detail at the end of this chapter.

[95] https://docs.expo.io/versions/latest/guides/splash-screens.html
[96] https://docs.expo.io/versions/latest/guides/configuring-statusbar.html
[97] https://docs.expo.io/versions/latest/guides/app-icons.html
[98] https://docs.expo.io/versions/latest/guides/app-stores.html
[99] https://docs.expo.io/versions/latest/guides/configuration.html

A drawback of this approach is the limited control it allows over the build process. The final bundled build will include every API provided by Expo, regardless of whether we use them or not. This can result in significantly large build sizes even if the code that makes up our application is relatively small.

Pros and cons of building manually

We can create builds of our application using the IDE for each platform, Xcode and Android Studio. The primary advantage of this approach is the capability to add native iOS and Android code to our application. Building manually also allows us to take full control over the build process, and this includes modifying any signing steps and adjusting the final build size ourselves.

The downside is that in order to use an IDE to build our app, we have to eject from Expo. This means that we will have to own a Mac computer to create an iOS build. And as mentioned in the previous section, the process of creating builds manually is much more complicated than using Expo. We recommend taking this approach only if you need to include native code for your application and own a Mac computer (if you wish to build for iOS).

As we covered in the last chapter, we have two different options for ejecting. We can either eject to a regular React Native project, or detach to ExpoKit. Ejecting to regular React Native means we also lose access to APIs provided by Expo. Further, we no longer benefit from the platform's built-in OTA updates. To push new updates to our users without deploying a new build version, we'd need to use a tool like Microsoft's CodePush[100]. However, ExpoKit allows us to build with the IDEs while retaining access to Expo APIs (and OTA updates).

Reference Guide

Now that we've outlined our options, the rest of this chapter will be a reference guide that you can refer to when you need to build and publish a React Native application. You can skip directly to the operating system that you are currently working with.

[100] https://github.com/Microsoft/react-native-code-push

iOS

As we mentioned previously, you can skip directly to the appropriate build method depending on the state of your application:

- If you have not ejected your application and do not plan on adding any native dependencies, you can read the next section and skip the section that explains how to use Xcode to create a build.
- If you have an ejected application, skip the following section and head directly to "Creating an iOS build with Xcode."

After using one of the two strategies to create a build, you can head to the "Testing the final build" section to learn how to test your final build before continuing to read how to publish to the App Store.

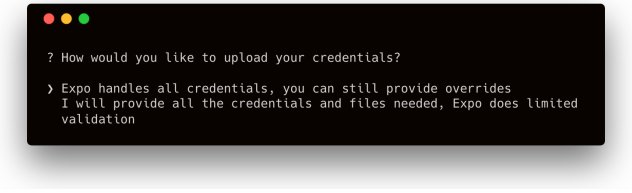
Creating an iOS build with Expo

In order to create builds for iOS applications, you need to enroll in the Apple Developer Program[101]. You can either enroll as an individual or an organization. As an individual, apps distributed in the App Store are tied to your personal name. As an organization, apps are tied to a legal entity's name.

Once we have a developer account set up, we can build a native iOS bundle through Expo with the following command:

```
1  expo build:ios
```

We are then asked how we would like to handle our credentials:

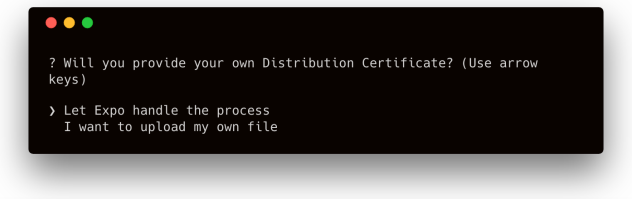


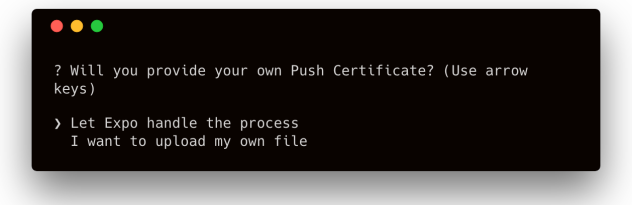
[101] https://developer.apple.com/programs/enroll/

The credentials here refer to signing certificates and a provisioning profile needed to submit applications to the App Store. We'll go with the simpler option of letting Expo handle all of the credentials here, but we will explore what each of these mean in detail in the next section.

Once we have selected the option for Expo to take care of managing our files, we'll need to submit the ID and password for our Apple Developer Account:

Although we specified we want Expo to handle all credentials, we still have the option to provide overrides for specific certificates. Expo prompts us about these next. We want Expo to handle both:





Next, the build process will begin and a URL is provided

(e.g. `https://expo.io/builds/unique-id`).

This URL provides access to the current status of the build and you can follow along by reading its logs.

Clearing Credentials

Expo will always check if a certificate and provisioning profile exist before asking whether it should handle creating new files or allow you to provide them. If you wish to clear the already available credentials, you can run `expo build:ios --clear-credentials`.

The build process can take a few minutes to complete. Once completed, another URL will be provided that contains the generated `.ipa` build file. Pasting this link into your browser's address bar will begin downloading it to your machine.

Creating an iOS build with Xcode

As we mentioned earlier in this chapter, an account with the Apple Developer Program is necessary in order to create a build ready for distribution. You'll need to enroll[102] if you haven't already.

Once enrolled, the first thing we'll need to do is code sign our application. **Code signing** is the process of using a digital signature to identify the application author's identity. Signatures are used to ensure that updates to an application are published by the same author.

With Xcode, we have two options for code signing an application:

1. Manually, where we provide all the resources ourselves
2. Automatically, where Xcode takes care of creating all the necessary signing credentials

Automatic code signing is recommended in the Xcode documentation as it simplifies the process of creating all the required assets needed for signing. Xcode takes care of creating all the needed credentials and we only have to provide our developer account without doing more additional work. With this approach, Xcode will:

[102] https://developer.apple.com/programs/enroll/

- Create the necessary signing certificates
- Create an App ID
- Handle all the provisioning profiles needed

Manually code signing an application means that we will have to create all the needed assets in the Apple Developer Console and assign them to our application ourselves. This approach gives us some more control over which provisioning profiles and signing certificates we would like to use.

If you don't need to use a particular profile or certificate for your application, you should use the recommended approach of automatic code signing. We'll cover this first. After reading, feel free to skip the portion of this chapter where we cover how to manually code sign your application.

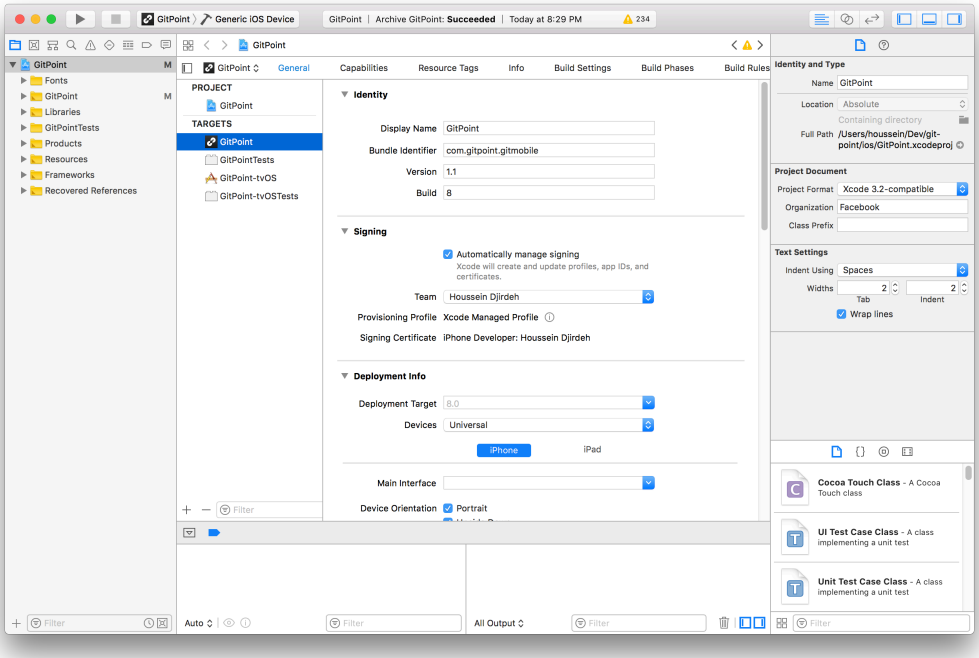
If you are interested in learning more about how provisioning profiles and signing certificates work, or you would like to manually handle these credentials yourself, then you can head directly to "Manual Code Signing".

> Xcode version 9.1 is used in this chapter. There may be slight inconsistencies to the UI displayed in the screenshots if you happen to be using a later version of the software. However, the general procedure should remain the same.

Automatic Code Signing

To access a React Native application using Xcode, we can open the `/ios/AppName.xcodeproj` file in our project. An Xcode project file (`.xcodeproj`) contains all the source files and resources needed for building and managing a project with the platform.

Once the file is opened with Xcode, you should see your application loaded as the main target. This is what the default dashboard looks like for an open application:



The bundle identifier in the `Identity` section of the `General` tab is a required field and is a unique string that identifies your application. Once a build of your application is uploaded for submission, this field cannot be changed. The version and build number fields also need to be completed and will be used by App Store Connect to identify different versions of your application.

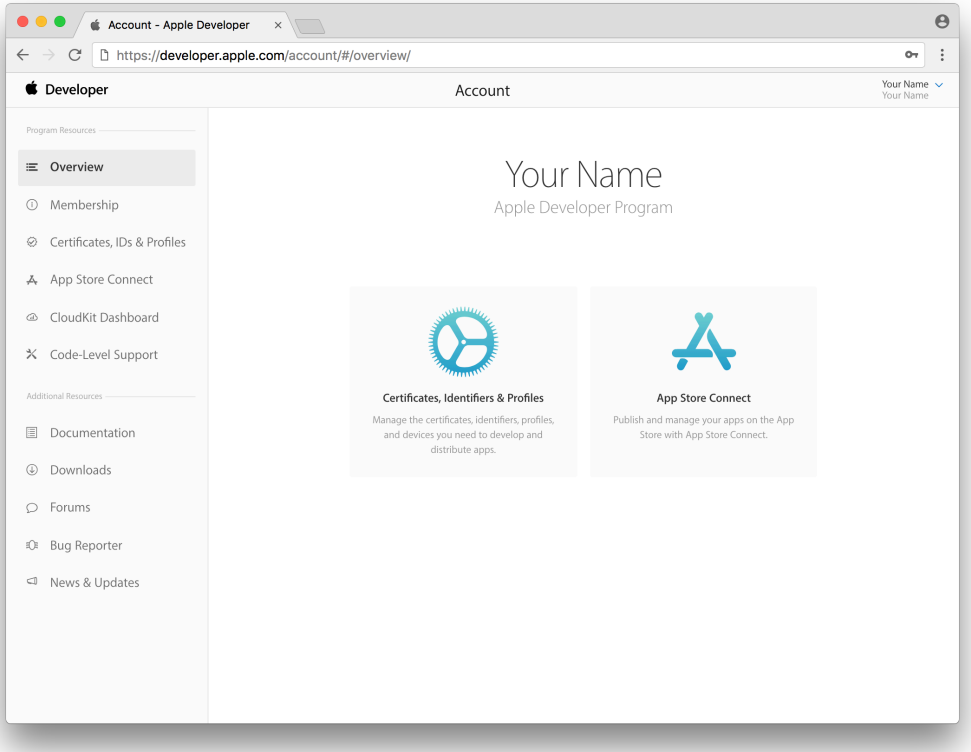
In the `Signing` section of the screen, there is a checkbox for `Automatically manage signing`. After checking this field, a "Team" drop-down is displayed asking for a development team that can be used to associate all the created signing credentials. In order to see your team as one of the drop-down options, you must add an Apple Developer Account to Xcode. You can add this account by opening `Xcode  Preferences` in the main menu.

Once a development team is selected, you should see a signing certificate assigned to your developer account. Xcode takes care of creating this certificate along with a provisioning profile and assigns it to your team. With a certificate set up, you can now head directly to the "Creating a build archive" section to create a build of your

application.

Manual Code Signing

To begin the process of manually code signing, we'll need to sign in to the Apple Developer Portal[103].



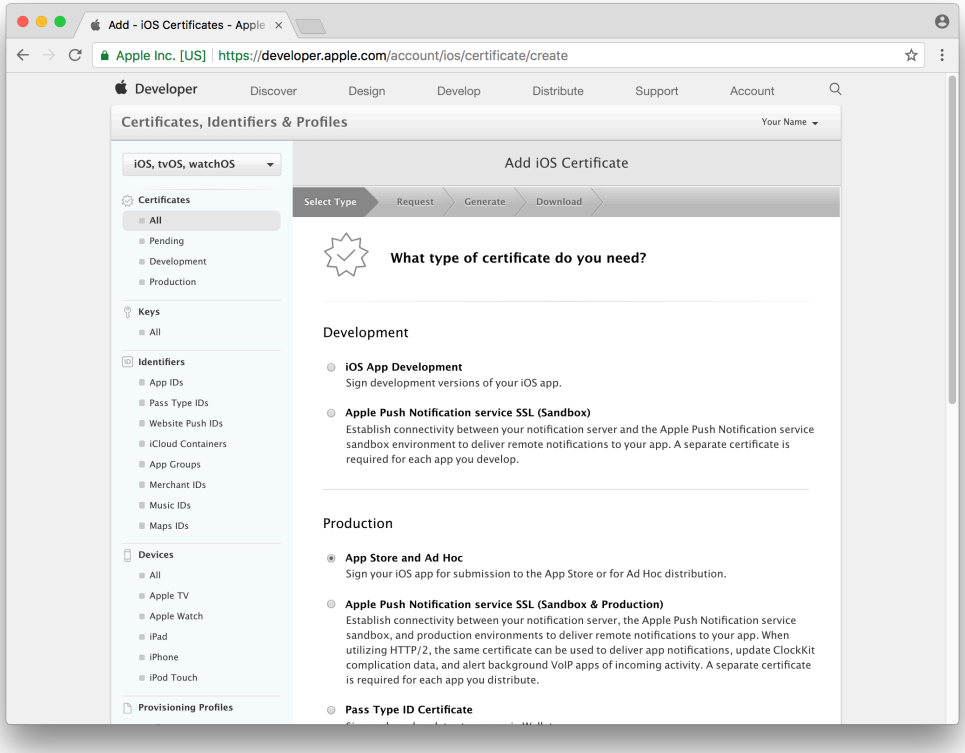
The Apple Developer Portal provides links to resources, guides and documentation. There are two important tools provided by the platform that we will be exploring:

- **Certificates, Identifiers & Profiles** is where we set up signing certificates and profiles for our application to identify them.

[103] https://developer.apple.com/account/

- **App Store Connect** is a collection of tools that allow us to manage and submit application builds to the App Store. We will cover how to use this to publish an application in the next section.

Let's navigate to `Certificates, Identifiers & Profiles` and begin by creating an appropriate signing certificate. Once we are at the certificates[104] screen, clicking the + icon on the right hand of the screen will allow you to create a new certificate. Make sure `iOS, tvOS, watchOS` is selected in the dropdown in the left navbar.



Signing certificates are digital signatures used to perform actions while ensuring the application is from the same source and has not been altered with. There are two certificate types relevant to building and distributing an iOS application:

[104] https://developer.apple.com/account/ios/certificate/

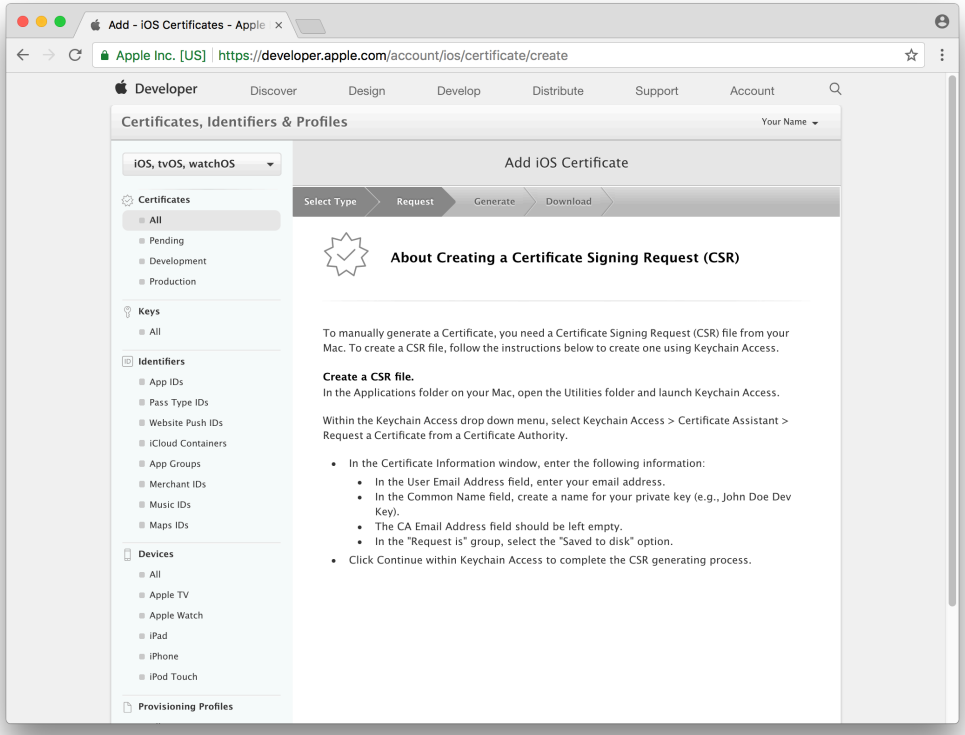
- **Development (iOS App Development)**: Used for the development of an iOS application and limits the number of devices that the application be installed on
- **Distribution (App Store and Ad Hoc)**: Used for the distribution of iOS applications to App Stores or for Ad Hoc distribution

If you need to continue development of a React Native application after ejecting from the Expo CLI and would like to handle code signing manually, you will need to create an iOS App Development certificate and register your device. Since this chapter focuses on distributing an application, we'll select `App Store and Ad Hoc` and click continue.

These are many more certificate types available for other use cases (such as enabling push notifications or building and distributing a macOS app). You can see a full list of them in the Xcode docs[105].

The next screen provides instructions to create a Certificate Signing Request (CSR) file from a Mac computer.

[105] https://help.apple.com/xcode/mac/current/#/dev80c6204ec



A CSR file is a formatted and encrypted file that contains information that identifies a particular source and is used to issue a certificate. You can follow the instructions provided to save a CSR file somewhere on your computer. Once that's done, click continue to proceed and upload the file. Once uploaded, you should be able to download the certificate by clicking `Download`. Double-clicking the certificate file (`.cer` format) will save it in your Keychain.

Keychain Access[106] is a Mac application that can store sensitive account information such as passwords and certificates.

Let's move on to creating an app identifier. This is also known as the **App ID** and is a unique string that identifies a single application (or multiple applications) connected

[106] https://support.apple.com/en-ca/guide/keychain-access/what-is-keychain-access-kyca1083/mac

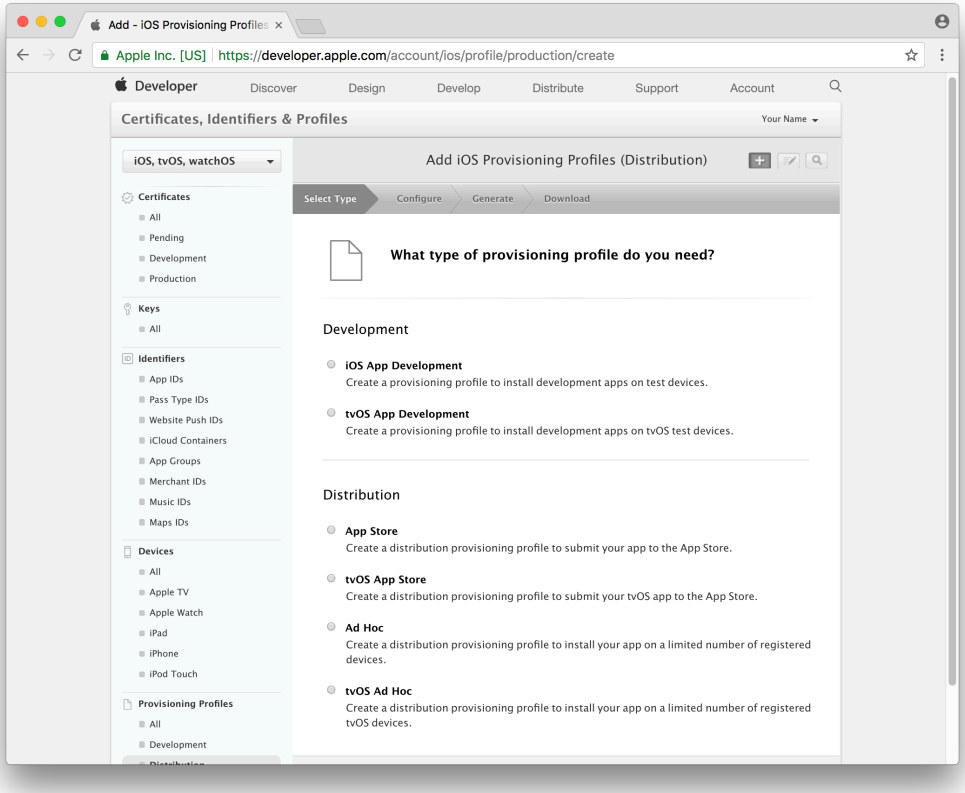
to a development team. We can do this by navigating to the iOS App IDs[107] screen by clicking `Identifiers/App IDs` in the side menu. To register a new App ID, we need to fill out a few fields:

- App ID Description: Any description of your application can be used here, but this is usually the same as the name of the app.
- App ID Prefix: This is your Team ID by default.
- App ID Suffix: By changing the suffix of our App ID, we can choose between its two different types: * An **Explicit App ID** is used for a single application and must be unique. A reverse domain naming convention is commonly used (`com.companyname.appname`). This option needs to be selected in order to include most application services such as in-app purchases and push notifications. You can see a list of all services that can be enabled/disabled at the bottom of the screen. * A **Wildcard App ID** can allow a single identifier and provisioning profile to be used for multiple apps. Many Apple services cannot be included with this type of ID. Since App IDs cannot be changed for an application submitted to the App Store, it is important to ensure that this option is only selected if no such services are included and will not be in the future. An asterisk must be the last character of the ID (`com.companyname.*`) here.
- App Services: In here, you can select any Apple services to include in your application.

Once a certificate and identifier is created, a **provisioning profile** needs to be set up for the application in order to allow it to be downloaded on physical devices. A provisioning profile is the combination of an application's unique bundle identifier and a signing certificate. Without a profile, we cannot run an app on a mobile device.

A **distribution** provisioning profile is needed when an application is ready to be distributed to multiple users. To create a distribution provisioning profile, we can click the Provisioning Profiles –> Distribution[108] list item in the side menu and then + on the right hand side of the screen.

[107] https://developer.apple.com/account/ios/identifier/bundle
[108] https://developer.apple.com/account/ios/profile/production/create



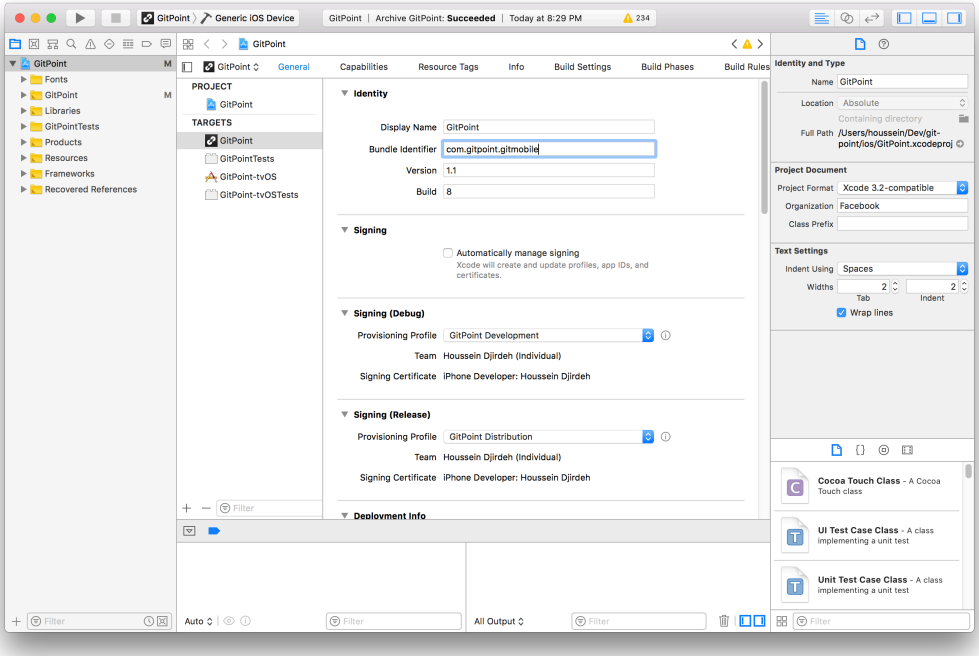
Of the many possible options, there are two specific types of distribution profiles relevant to iOS applications:

- **App Store**: Used to submit an application to the App Store.
- **Ad Hoc**: Used to distribute applications to multiple testers. Unlike a development provisioning profile, an Ad Hoc profile can not used to debug applications.

Select *App Store* to create the profile you need to submit an application to the App Store. In the next few screens, you will need to select the App ID you just created and the certificates you wish to include in the profile. Once completed, you can name your provisioning profile and download it to your machine.

While creating a build of an application, a **development** provisioning profile uses a development signing certificate to connect developers and devices to an authorized team. This allows for multiple developers to debug on more than one device. The process of selecting an App ID and certificate is the same, but each device's unique device identifier (UDID) needs to be explicitly added to the same profile. This can be done in the Apple Developer Console[109].

The final step here is to manually assign our created distribution certificate to our project in Xcode. We can open the `/ios/AppName.xcodeproj` file to do this.



The bundle identifier field must be the same as the `AppID` you created earlier in the developer console, so you'll need to make sure that it matches in order to create a successful build.

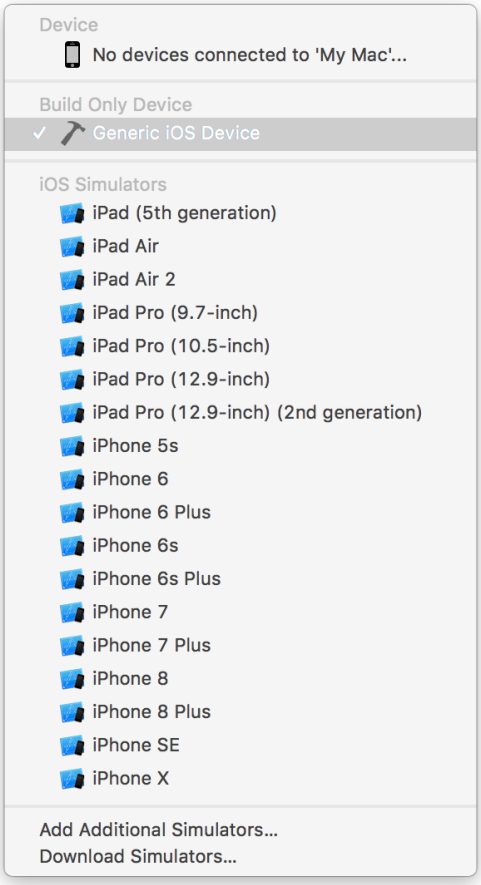
To manually take care of assigning a provisioning profile to our application, disable

[109] https://developer.apple.com/account/ios/profile/

the `Automatically manage signing` checkbox. Two newer sections, `Signing (Debug)` and `Signing (Release)`, will show up underneath. Select the `Provisioning Profile` dropdown for our signing release and click `Download Profile` to download the distribution profile directly from the Apple Developer Console. We can do the same for the debug section if we have a development profile created as well.

Creating a build archive

Once all the credentials needed for code signing have been set up, we can create a build archive of our application. We can begin by changing our device target at the top of the screen to `Generic iOS Device`.



For an ejected Expo application, we can run our application on different simulators using the `react-native run-ios --simulator="iPhone 8"` command. We can also use this device target menu on Xcode to do the same thing (as well as preview our application on a physical device plugged in to our computer).

The `Generic iOS Device` target is only used to create an iOS device build. With this target selected, we can select `Product  Archive` to create a build archive. After a few minutes, a window showing all past archives will pop up. Clicking `Export` on the right hand side and selecting `App Store` as our method for distribution will allow us

to export an `.ipa` file of our application. Instead of doing this however, we can also submit directly to App Store Connect by clicking `Upload to App Store`. We'll cover the flow of this process in the next section.

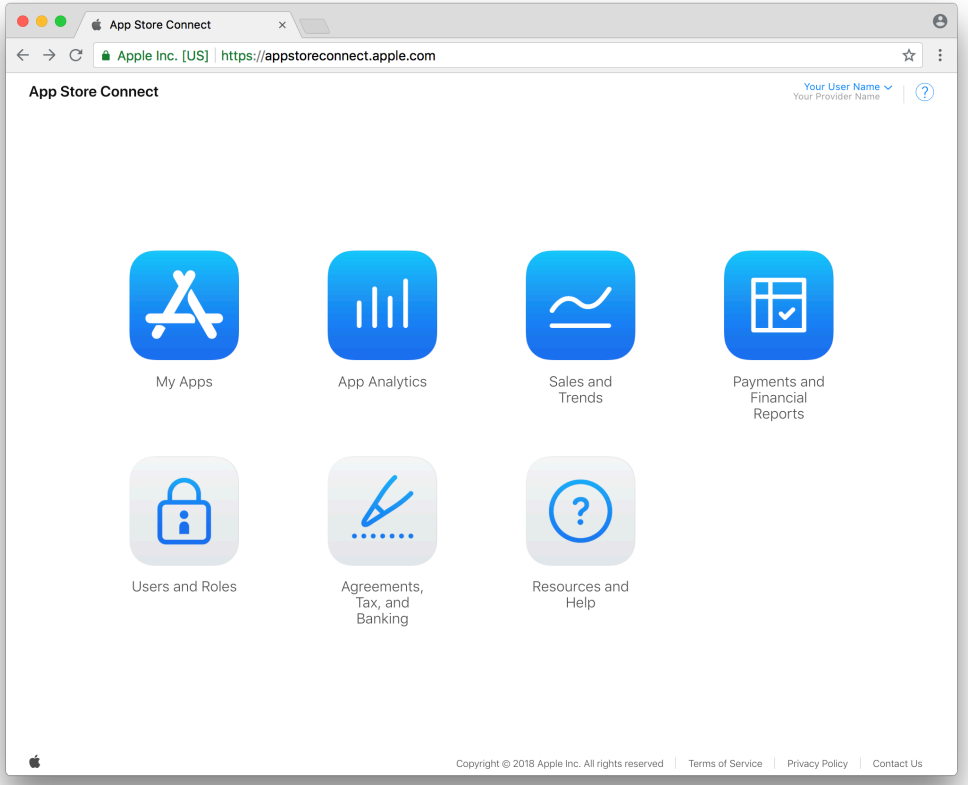
Testing the final build

Since we signed the iOS build we created earlier in this chapter with an App Store distribution certificate, it cannot be downloaded and run on a personal simulator/device for testing purposes through Xcode. To allow for this, we can use TestFlight[110]. TestFlight is an Apple platform that allows others to download and test a production build on their devices. Instructions for using TestFlight to invite users to test your production build can be found on the TestFlight website[111].

Publishing to the iOS App Store

Submitting and managing application builds for iOS can be done in App Store Connect[112]. You can sign in with your developer account.

[110] https://developer.apple.com/testflight/
[111] https://itunespartner.apple.com/en/apps/videos#testflight-beta-testing
[112] https://developer.apple.com/app-store-connect/



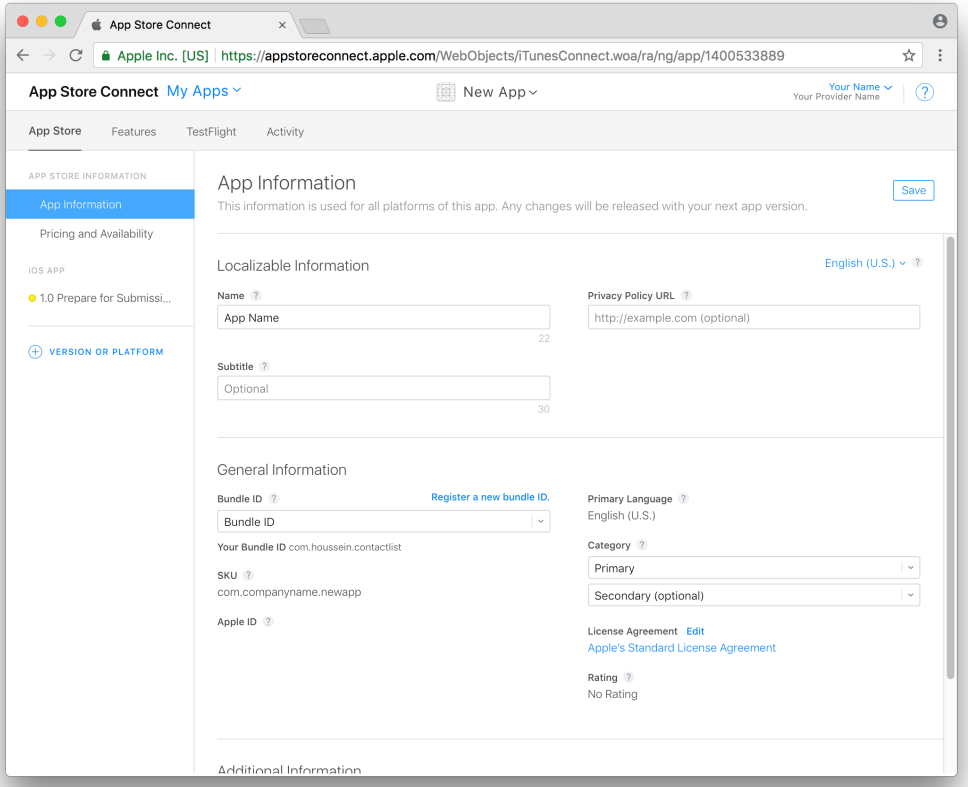
App Store Connect provides a collection of tools that developers can use to manage their applications, view user analytics, study trends and patterns as well as view financial results. Let's navigate to `My Apps` to view a dashboard of all the applications tied to your developer account. Nothing will show here if you haven't submitted an application before.

Click the + icon on the top left to add a new application. We'll need to fill out a form with a few fields:

- Platform: Select whether you're creating a new iOS or tvOS application.
- Name: This is the display name of your application in the App Store.
- Primary Language: The main language your application is localized for.

- Bundle ID: The unique identifier for your application. If you let Xcode automatically code sign your application or Expo handle creating credentials for you, you should see the ID for your application in the dropdown. If you don't see it, you may have to create your App ID manually in the Developer Portal[113].
- SKU: This is the Stock Keeping Unit[114], an identifier commonly used for inventory and financial tracking. It also needs to be unique to each application, and you can use the same string as your bundle ID if you like.

Clicking `Create` will create our application on the platform.



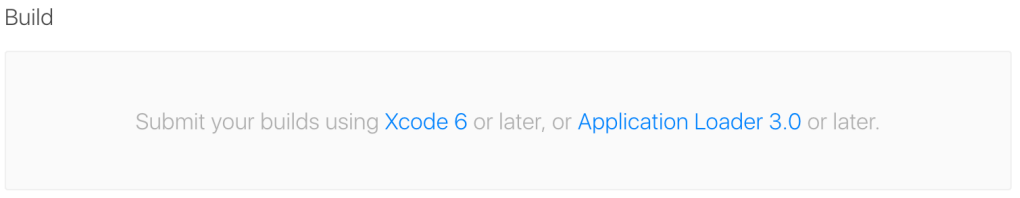
[113] https://developer.apple.com/account/ios/identifier/bundle
[114] https://www.investopedia.com/terms/s/stock-keeping-unit-sku.asp

We can add more general information here such as the application's subtitle, privacy policy link, and categories. On the left side of the screen, you'll notice that the current status of our application's submission process is `1.0 Prepare for Submission`. 1.0 refers to the version of the application, and this number will change once we upload newer build versions. Clicking the link in the side menu will navigate to another form that allows us to provide *version-specific* information of our application. This includes:

- iPhone and iPad application previews and screenshots
- Promotional text
- Keywords
- App description
- App Store Icon
- App review information

All of this information can be modified at any time by submitting updated builds of an application.

In the `Build` section of the screen, you'll see a message letting you know that you can submit builds directly using Xcode.



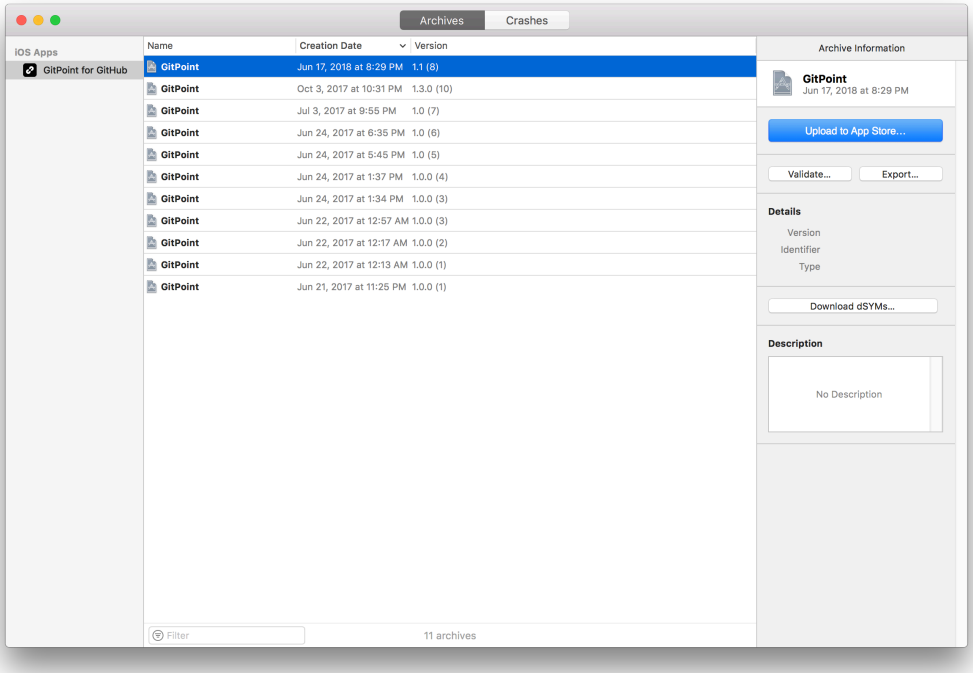
Every iOS application that is published to the App Store goes through an extensive review process before being accepted. To improve your chance of being accepted, there are a few resources you can consider before submitting an application:

- Apple's Review Guidelines[115]
- Xcode's docs on App Store distribution[116]

[115] https://developer.apple.com/app-store/review/guidelines
[116] https://help.apple.com/xcode/mac/current/#/dev91fe7130a

- Expo's docs on app stores[117]

In Xcode's `Window ▯ Organizer` screen, you can see a list of previously created build archives of your application. This is what the screen looks like when you have multiple builds:



Before we upload our build archive to the App Store, we can validate it to ensure that our build files pass all the validation checks performed by App Store Connect. We can do this by clicking the `Validate` button in the menu on the right. If any necessary configurations or assets are missing, Xcode will give us an error here.

If our build archive is validated successfully, we can move on to clicking `Upload to App Store`. After selecting the correct development team, we'll see an `Upload Successful` message if there were no issues with the archive.

It can take a few minutes for the build archive to show up in App Store Connect.

[117] https://docs.expo.io/versions/v27.0.0/distribution/app-stores.html

Once it does, you should see it in the `Activity` tab of the application. Moreover, the `Build` section of our submission will now show a different message - `Select a build before you submit your app.` Clicking the link will display a list of available builds.

After the build shows up on App Store Connect, it may still need to finish processing which can take a little more time. At this point, you'll see a `(Processing)` message next to your build and you'll only be able to select it for submission once it completes.

Once you select your build and complete all the necessary information for your application, you can submit it using the `Submit for Review` button. According to Apple's support documentation[118], review times vary. Half of all applications submitted are reviewed within 24 hours and over 90% are reviewed within 48 hours. The status of the application in App Store Connect will be `In Review` until it is completed.

If your application requires any form of authentication in order to be used, you should also provide sign-in information for a dummy account in App Store Connect's submission form. Without this information, an application may not be able to be reviewed.

Android

As we mentioned previously, you can skip directly to the build approach that is more relevant for your application:

- If you have not ejected your application from Expo, you can read the next section and skip the section that explains how to create a build manually
- If you have an ejected application, skip the following section entirely and head directly to "Creating an Android build manually"

After using the appropriate strategy to create a build, we'll discuss how to publish your application in the "Publishing to the Play Store" section.

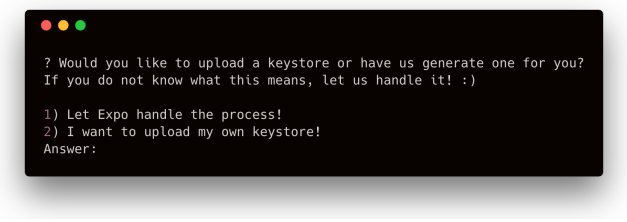
[118] https://developer.apple.com/support/app-review/#app-review-status

Creating an Android build with Expo

We can start a build process for Android with the following command:

```
exp build:android
```

We are then asked if we would like Expo to take care of creating a keystore or uploading it ourselves:



A keystore is a file that contains private keys used to authenticate oneself. We'll explore this in more detail when we build an Android application manually later in this chapter, so we'll go with the option of letting Expo take care of it here.

Next, the build process begins and can take a few minutes to complete. As with the iOS build process, a URL (`https://expo.io/builds/unique-id`) is provided that shows real-time logs from Android Studio. Once the build process is finished, we're provided a URL that contains the final `.apk` build file. We can download the file by pasting the link into our browser's address bar.

Clearing Credentials

A keystore file is used to represent the application owner's identity, so keeping it secure is extremely important. Moreover, we cannot submit updates to our application and publish new versions if we lose our keystore file. We can clear a previously generated keystore used by Expo with `expo build:android --clear-credentials` but it is important to make sure we have fetched and stored a local version of the keystore file first. We can do that with `expo fetch:android:keystore`.

Testing the final build after automatic signing

There are two different ways to test the final build of your application:

1. On an emulator.You can drag and drop the final build `.apk` to have it boot up automatically.
2. On a physical device. You will have to first install Android Platform Tools[119] to your computer. This includes Android Debug Bridge (adb), a command-line interface that allows you to control an Android device connected to your machine. Once installed, you can run `adb install apk-file-name.apk` with your device plugged in.

After setting up and testing your final application's build file, you can head directly to the "Publishing to the Play Store" section to learn how to publish your application as well as distribute testing versions through different channels.

Creating an Android build manually

In order to code sign an Android application with a certificate, the build process requires a **keystore** that contains an app signing key. This is done to ensure the source has not changed if any updates are done to the application. There are two different ways to create an Android keystore for an ejected React Native application:

1. Using Java Keytool
2. Using Android Studio

Using Java's Keytool application can be quicker and is the approach mentioned in the React Native documentation. For that reason, we'll explain the process of using it here. However, instructions to create a keystore using Android Studio can also be found in the Android Studio docs[120] if you prefer that approach.

Keytool[121] is a command-line tool already included in the Java Development Kit that simplifies the management of keys and certificates. It can be used to create a keystore containing an app signing key used to sign an Android build.

[119] https://developer.android.com/studio/releases/platform-tools
[120] https://developer.android.com/studio/publish/app-signing#generate-key
[121] https://docs.oracle.com/javase/8/docs/technotes/tools/unix/keytool.html

The Java Development Kit (JDK) is a development environment to run and develop applications built with Java. It is required to build Android applications with React Native and you should already have it installed after ejecting and following the instructions[122] to build native Android code.

For Unix-like operating systems such as macOS and Linux, the keytool directory is added directly to the `$PATH` variable of our system. This means we can run the command in any directory as an executable. If you are using a Windows machine, you can only run keytool commands in `C:\Program Files\Java\jdk1.x.x_xxx\bin` where `1.x.x_xxx` is the version of JDK installed on your machine.

We can generate a keystore with a single key using the following command in our terminal:

```
$ keytool -genkey -v -keystore android-release.keystore -alias android-\
release-alias -keyalg RSA -keysize 2048 -validity 10000
```

The command contains a number of settings that would apply to our generated keystore:

- `-keystore`: The name of the keystore file. In here, the file would be named `android-release.keystore`.
- `-alias`: The keystore alias is its unique identifier and is used to code sign the application. Our alias here is `android-release-alias`.
- `-keyalg`: Defines the algorithm used to create a public-private key pair in our keystore. `RSA` is commonly used, but you can find out about all the possible options in more detail by referring to Java's cryptography architecture guide[123].
- `-keysize`: Specifies the size of the created key. In short, key size is used in cryptography to define the number of bits in a key used in an algorithm. In here, we've specified 2048 bits (which represents 256 bytes).
- `-validity`: The length of time our key will be valid in days. We've set our validity to 10000 days here.

[122] https://facebook.github.io/react-native/docs/getting-started.html#java-development-kit
[123] https://docs.oracle.com/javase/8/docs/technotes/guides/security/crypto/CryptoSpec.html#AppA

These parameters are all we need to generate a working keystore for our application. You can see a full list of possible configurations by typing `keytool usage:` to your terminal.

Running the command will then prompt for passwords for the keystore and signing key, as well as the Distinguished Name fields for your key. Once provided, an `android-release.keystore` file will be created in the current directory.

Due to the fact that a keystore represents an application owner's identity, it is extremely important to remember to keep a keystore file secure. If the file is lost, updates to an application in the Play Store cannot be performed and a new app will have to be created and submitted. If the file is compromised or stolen, an attacker can publish a newer version of your application with malicious code. It's considered best practice to avoid committing a keystore to your version control system, like Git.

We need to place our keystore file in the `android/app` directory of our project. Once that is done, we can configure the Gradle build process by adding our keystore and key information. Properties that modify the build process can be added to the `android/app/.gradle/gradle.properties` file. Let's add the following to the bottom of the file:

```
APP_RELEASE_KEYSTORE_FILE=android-release.keystore
APP_RELEASE_KEYSTORE_PASSWORD=YOUR_KEYSTORE_PASSWORD_GOES_HERE
APP_RELEASE_KEY_ALIAS=android-release-alias
APP_RELEASE_KEY_PASSWORD=YOUR_SIGNING_KEY_PASSWORD_GOES_HERE
```

Gradle[124] is an extensible and configurable build system used by Android to automate and manage the entire build process. Instead of configuring Gradle to sign our application, we also have the option of signing it manually[125] using the apksigner[126] tool provided by Android Studio.

Since these properties will need to be referenced in our build file, you can choose any key name for each of these key:value pairs.

[124] https://gradle.org/
[125] https://developer.android.com/studio/publish/app-signing#sign-manually
[126] https://developer.android.com/studio/command-line/apksigner

In the above example, we added the username and password of both the signing key and keystore in plain text to the Gradle properties file. This can be dangerous if you are working on a project with multiple team members or if you submit your project to an open source platform.

In these conditions, there are a few options that can be performed to keep this sensitive information outside of this file:

1. Create a separate `keystore.properties` file to contain this information which can be accessed in the application's build file. Instructions to set this up can be found in the Android Studio docs[127]. The properties file should not be committed to version control and can be added to the `.gitignore` file of the project so it is ignored by Git.
2. For macOS users, the credentials can be stored in Keychain Access and loaded directly in the build file. Instructions can be found on this page: https://pilloxa.gitlab.io/posts/safer-passwords-in-gradle/[128].

Once our signing credentials are added to our Gradle properties, we can access them in our build file to complete the signing process. We can apply configurations to the build process by adding them to the `android/app/build.gradle` file. Default configurations are added to this file as soon as we create a new Android project.

Let's add a signing configuration to the `android` block within this file underneath our default configurations:

```
android {
    // ...
    defaultConfig {
        // ...
     }
    signingConfigs {
        release {
            if (
              project.hasProperty('APP_RELEASE_KEYSTORE_FILE')
```

[127] https://developer.android.com/studio/publish/app-signing#generate-key
[128] https://pilloxa.gitlab.io/posts/safer-passwords-in-gradle/

```
            ) {
                storeFile file(APP_RELEASE_KEYSTORE_FILE)
                storePassword APP_RELEASE_KEYSTORE_PASSWORD
                keyAlias APP_RELEASE_KEY_ALIAS
                keyPassword APP_RELEASE_KEY_PASSWORD
            }
        }
    }
    buildTypes {
        release {
            //. ..
            signingConfig signingConfigs.release
        }
    }
}
```

We'll now need to assign our newly created configurations as the release `signingConfig` of the build process:

```
android {
    // ...
    defaultConfig {
        // ...
     }
    signingConfigs {
        // ...
    }
    buildTypes {
        release {
            // ...
            signingConfig signingConfigs.release
        }
    }
}
```

And that completes our signing process! We can now navigate to the `android/` directory and bundle our application into a build:

```
cd android
./gradlew assembleRelease
```

Starting any Gradle build is done with the Gradle Wrapper[129], a command-line tool we can use at the root of any Android project with `/gradlew task-name`. The `assembleRelease` command will bundle (or assemble) all the core JavaScript code into the final build. This file can be found as a `app-release.apk` file in the `android/app/build/outputs/apk/` directory.

Instead of adding signing information to our Gradle properties, we can also manually sign an application using Android Studio[130] or configure the build process[131] to automatically sign any application. Both of these approaches will have the same end result.

Testing the final build after manually signing

With an Android emulator running or a physical device connected to our machine, we can install a production build of our application with the following command:

```
react-native run-android --variant=release
```

Aside from this, we can also publish alpha and beta versions of our app to a closed or open group of testers before submitting it to the Play Store. This is covered in more detail in the next section.

Publishing to the Play Store

In order to publish and manage Android applications with Google Play Console[132], we'll need to create a Google Developer account[133] which requires a one-time payment.

[129] https://docs.gradle.org/current/userguide/gradle_wrapper.html
[130] (https://developer.android.com/studio/publish/app-signing#release-mode)
[131] https://developer.android.com/studio/publish/app-signing#sign-auto
[132] https://developer.android.com/distribute/console/
[133] https://play.google.com/apps/publish/signup

Once we launch the console, we can click `Create Application` to begin the process of submitting an application to the Play Store.

The first few fields we need to fill out are the application's default language and title.

Once completed, we land on the `Store listing` page. This page allows us to specify the content in our app's listing in the Play Store. Parameters include:

- App description
- Graphic assets such as screenshots, icons and banners
- Application type and relevant category
- Privacy policy link

The left-side menu contains links to other areas of our application such as setting up the price of a paid application, its places of distribution, and its content rating.

The Android doc's Launch Checklist[134] is a great resource on a number of best practices.

The `App Releases` link in the menu is where we can manage uploading the APK builds of our application. We can roll out new builds in a number of different channels:

- **Internal test**: Used to quickly publish builds for internal testing with a small number of testers.
- **Closed (alpha)**: Used to publish builds for closed testing. This is useful to test your application with a larger number of privately invited testers.
- **Open (beta)**: Used to publish builds for open testing. Anybody can join this testing program and provide private feedback to the author of the application.
- **Production**: Used to publish final production builds to the Google Play Store.

[134] https://developer.android.com/distribute/best-practices/launch/launch-checklist

With any of these build tracks, we can upload an APK file by clicking `Manage` and then `Create Release`. In here, we have the option of using App Signing by Google Play instead of managing our signing keys manually. Enabling this feature will mean that the signing key within the keystore used for your application will be handled as an upload key. If we opt-in to this feature, we will have to publish a new application if our key is lost or compromised.

There are a few more noteworthy parameters we need to specify. The first is the release name. This is not visible to users and is used to distinguish separate releases in the Play Store. It is recommended to use the version of the APK here or an internal code name relevant to this release.

The second is release notes. We use release notes to explain modifications to the app in this release. After this, we can upload the final signed `.apk` build file (`app-release.apk` in the `android/app/build/outputs/apk/` directory) and review our submission before rolling it out! If you decided to roll out a production build, the application should show up in the Play Store in a few hours.

Handling Updates

Expo supports **over-the-air (OTA) updates** by default. Every standalone application built with Expo will know how to reference updates to an application based on its URL (`expo.io/user_name/APP_NAME`). Once an Expo-built application is published to the iOS App Store or Google Play Store and installed on a user's mobile device, we can distribute any updates to the application using the following command:

```
expo publish
```

This command allows us to publish directly with Expo. When the app is re-launched on a user's device, the new version of the application will be automatically downloaded and displayed. With this, we can publish newer updates without distributing new build versions to app stores.

Publishing with Expo can also allow Android users to test and demo their application without having to go through the Play Store submission process. You can refer to the Appendix to get a better idea of how this works.

OTA updates only work when JavaScript code is modified. We cannot use this feature if we eject to a regular React Native project. In this scenario, we can use a similar third-party tool like Microsoft's CodePush[135]. This will allow us to still benefit from publishing changes to our JavaScript bundle without deploying to an app store. However, we need to be careful to not publish newer JavaScript code over-the-air that bridges functionality to native modules.

In order to comply with Apple's review process, it is important to make sure that only specific fixes/modifications that are in-line with the general direction of the application are included in OTA updates. Section 3.3.2 in the Apple Developer Program License Agreement[136] states that only code that does not change the initial purpose of the application and does not bypass any iOS security features are permitted.

Summary

We began the journey of learning React Native by building a weather app in the first chapter of this book. With each subsequent chapter, we learned about important React fundamentals, explored all of the core components and APIs provided by the framework, and covered advanced topics such as animations and gesture controls. We spent an entire chapter learning how to apply different navigation patterns to an application and even investigated how to build custom native modules and bridge to them ourselves. If you've reached this point of the book, you have all the tools you need to both build and publish a fully functional and powerful React Native application. Give yourself a pat on the back!

As the authors, we hope you enjoyed reading this book as much as we enjoyed writing it!

[135] https://github.com/Microsoft/react-native-code-push

[136] https://developer.apple.com/services-account/download?path=/Documentation/License_Agreements__Apple_Developer_Program/Apple_Developer_Program_License_Agreement_20180604.pdf

Appendix

JavaScript Versions

JavaScript is the language of the web. It runs on many different browsers, like Google Chrome, Firefox, Safari, Microsoft Edge, and Internet Explorer. React Native takes this one step further and allows us to write JavaScript to communicate with native iOS and Android components.

Its widespread adoption as the internet's client-side scripting language led to the formation of a standards body which manages its specification. The specification is called ECMAScript or ES.

The 5th edition of the specification is called ES5. You can think of ES5 as a version of the JavaScript programming language. The 6th edition, ES2015, was finalized in 2015 and is a significant update. It contains a whole host of new features for JavaScript. JavaScript written in ES2015 is tangibly different than JavaScript written in ES5.

ES2016, a much smaller update that builds on ES2015, was ratified in June 2016.

ES2015 is sometimes referred to as ES6. ES2016, in turn, is often referred to as ES7.

ES2015

Arrow functions

There are three ways to write arrow function bodies. For the examples below, let's say we have an array of city objects:

```
const cities = [
  { name: 'Cairo', pop: 7764700 },
  { name: 'Lagos', pop: 8029200 },
];
```

If we write an arrow function that spans multiple lines, we must use braces to delimit the function body like this:

```
const formattedPopulations = cities.map((city) => {
  const popMM = (city.pop / 1000000).toFixed(2);
  return popMM + ' million';
});
console.log(formattedPopulations);
// -> [ "7.76 million", "8.03 million" ]
```

Note that we must also explicitly specify a `return` for the function.

However, if we write a function body that is only a single line (or single expression) we can use parentheses to delimit it:

```
const formattedPopulations2 = cities.map((city) => (
  (city.pop / 1000000).toFixed(2) + ' million'
));
```

Notably, we don't use `return` as it's implied.

Furthermore, if your function body is terse you can write it like so:

```
const pops = cities.map(city => city.pop);
console.log(pops);
// [ 7764700, 8029200 ]
```

The terseness of arrow functions is one of two reasons that we use them. Compare the one-liner above to this:

```
const popsNoArrow = cities.map(function(city) { return city.pop });
```

Of greater benefit, though, is how arrow functions bind the `this` object.

The traditional JavaScript function declaration syntax (`function () {}`) will bind `this` in anonymous functions to the global object. To illustrate the confusion this causes, consider the following example:

```
function printSong() {
  console.log("Oops - The Global Object");
}

const jukebox = {
  songs: [
    {
      title: "Wanna Be Startin' Somethin'",
      artist: "Michael Jackson",
    },
    {
      title: "Superstar",
      artist: "Madonna",
    },
  ],
  printSong: function (song) {
    console.log(song.title + " - " + song.artist);
  },
  printSongs: function () {
    // `this` bound to the object (OK)
    this.songs.forEach(function(song) {
      // `this` bound to global object (bad)
      this.printSong(song);
    });
  },
}

jukebox.printSongs();
```

```
// > "Oops - The Global Object"
// > "Oops - The Global Object"
```

The method `printSongs()` iterates over `this.songs` with `forEach()`. In this context, `this` is bound to the object (`jukebox`) as expected. However, the anonymous function passed to `forEach()` binds its internal `this` to the global object. As such, `this.printSong(song)` calls the function declared at the top of the example, *not* the method on `jukebox`.

JavaScript developers have traditionally used workarounds for this behavior, but arrow functions solve the problem by **capturing the `this` value of the enclosing context**. Using an arrow function for `printSongs()` has the expected result:

```
function printSong() {
  console.log("Oops - The Global Object");
}

const jukebox = {
  songs: [
    {
      title: "Wanna Be Startin' Somethin'",
      artist: "Michael Jackson",
    },
    {
      title: "Superstar",
      artist: "Madonna",
    },
  ],
  printSong: function (song) {
    console.log(song.title + " - " + song.artist);
  },
  printSongs: function () {
    this.songs.forEach((song) => {
      // `this` bound to same `this` as `printSongs()` (`jukebox`)
      this.printSong(song);
    });
```

```
  },
}

jukebox.printSongs();
// > "Wanna Be Startin' Somethin' - Michael Jackson"
// > "Superstar - Madonna"
```

For this reason, throughout the book we use arrow functions for all anonymous functions.

Classes

JavaScript is a prototype-based language where classes, which is common in many object-oriented languages, were not used. However, ES2015 introduced a class declaration syntax. For example:

```
class Ball {
  constructor(color) {
    this.color = color;
  }

  details() {
    return 'This ball is ' + this.color + '!';
  }
}

class SoccerBall extends Ball {
  kick() {
    return 'This ' + this.color + 'soccer ball is kicked!';
  }
}
```

This isn't a brand new JavaScript model, but only a simpler way to define object oriented structures instead of using *prototypal-based inheritance*. For context, let's take a look at how this would probably look like without using a class definition:

```
function Ball(color) {
  this.color = color;
}

Ball.prototype.details = function details() {
  return 'This ball is ' + this.color + '!';
};

function SoccerBall(color) {
  Ball.call(this, color);
}

SoccerBall.prototype = Object.create(Ball.prototype);
SoccerBall.prototype.constructor = Ball;

SoccerBall.prototype.kick = function () {
  return 'This ' + this.color + 'soccer ball is kicked!';
}
```

We won't be going into more detail explaining object oriented paradigms and structures in JavaScript, but it's important to realize that creating objects with properties can be simpler with *classes*. The important thing to note here is that we use this exact same model to create our React Native components.

If you'd like to learn more about ES6 classes, refer to the docs on MDN[137].

Shorthand property names

In ES5, all objects were required to have explicit key and value declarations:

[137] https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Classes

```
const getState = () => {};
const dispatch = () => {};

const explicit = {
  getState: getState,
  dispatch: dispatch,
};
```

In ES2015, you can use this terser syntax whenever the property name and variable name are the same:

```
const getState = () => {};
const dispatch = () => {};

const implicit = {
  getState,
  dispatch,
};
```

Lots of open source libraries use this syntax, so it's good to be familiar with it. But whether you use it in your own code is a matter of stylistic preference.

Destructuring Assignments

For arrays

In ES5, extracting and assigning multiple elements from an array looked like this:

```
var fruits = [ 'apples', 'bananas', 'oranges' ];
var fruit1 = fruits[0];
var fruit2 = fruits[1];
```

In ES6, we can use the destructuring syntax to accomplish the same task like this:

```
const [ veg1, veg2 ] = [ 'asparagus', 'broccoli', 'onion' ];
console.log(veg1); // -> 'asparagus'
console.log(veg2); // -> 'broccoli'
```

The variables in the array on the left are "matched" and assigned to the corresponding elements in the array on the right. Note that `'onion'` is ignored and has no variable bound to it.

For objects

We can do something similar for extracting object properties into variables:

```
const smoothie = {
  fats: [ 'avocado', 'peanut butter', 'greek yogurt' ],
  liquids: [ 'almond milk' ],
  greens: [ 'spinach' ],
  fruits: [ 'blueberry', 'banana' ],
};

const { liquids, fruits } = smoothie;

console.log(liquids); // -> [ 'almond milk' ]
console.log(fruits); // -> [ 'blueberry', 'banana' ]
```

Parameter context matching

We can use these same principles to bind arguments inside a function to properties of an object supplied as an argument:

```
const containsSpinach = ({ greens }) => {
  if (greens.find(g => g === 'spinach')) {
    return true;
  } else {
    return false;
  }
};

containsSpinach(smoothie); // -> true
```

We can also do this with functional React components.

ReactElement

React Native allows us to build applications with a fake representation of the native views rendered in our mobile device. A `ReactElement` is a representation of a rendered element.

Consider this JavaScript syntax:

```
React.createElement(Text, { style: { color: 'red' }},
  'Hello, friend! I am a basic React Native component.'
)
```

Which can be represented in JSX as:

```
<Text style={{ color: 'red' }}>
  Hello, friend! I am a basic React Native component.
</Text>
```

The code readability is slightly improved in the latter example. This is exacerbated in a nested tree structure:

```
React.createElement(View, {},
  React.createElement(Text, { style: { color: 'red' }},
    'Hello, friend! I am a basic React Native component.'
  )
)
```

In JSX:

```
<View>
  <Text style={{ color: 'red' }}>
    Hello, friend! I am a basic React Native component.
  </Text>
</View>
```

Overall, JSX presents a light abstraction over the JavaScript version, yet the legibility benefits are huge. Readability boosts our app's longevity and makes it easier to onboard new developers.

Handling Events in React Native

Using `bind` statements within a `render()` method and property initializers aren't the only ways to handle events. We can also take care of binding our event handlers in a **class constructor**:

```
export default class SearchInput extends React.Component {
  constructor() {
    super();

    this.handleChangeText = this.handleChangeText.bind(this);
  }

  handleChangeText(newLocation) {
    // We need to do something with newLocation
  }
```

```
  render() {
    const { placeholder } = this.props;

    return (
      <TextInput
        placeholder={placeholder}
        placeholderTextColor="white"
        style={styles.textInput}
        clearButtonMode="always"
        onChangeText={this.handleChangeText}
      />
    );
  }
}
```

Instead of using a `constructor` to bind our method, we can also also leverage ES6 arrow syntax to achieve the same effect:

```
export default class SearchInput extends React.Component {
  handleChangeText(newLocation) {
    // We need to do something with newLocation
  }

  render() {
    const { placeholder } = this.props;

    return (
      <TextInput
        placeholder={placeholder}
        placeholderTextColor="white"
        style={styles.textInput}
        clearButtonMode="always"
        onChangeText={text => this.handleChangeText(text)}
      />
    );
```

```
  }
}
```

Notice how this simplifies our syntax where we don't need to continously set up `bind` for each of our event handlers. We're specifically using *ES6 arrow syntax* to pass in the callback:

```
onChangeText={text => this.handleChangeText(text)}
```

In most cases this is just fine, but it's important to realize that this callback will instantiate every time `TextInput` here is rendered. This will also be the case if we use `bind` statements within our component JSX like we did previously. In most applications, this is unlikely to pose any noticeable performance issues due to additional re-rendering. However, binding our member methods within the `constructor` actually prevents this from happening.

This is where using **property initializers** can come in handy:

```
export default class SearchInput extends React.Component {
  handleChangeText = newLocation => {
    // We need to do something with newLocation
  }

  render() {
    const { placeholder } = this.props;

    return (
      <TextInput
        placeholder={placeholder}
        placeholderTextColor="white"
        style={styles.textInput}
        clearButtonMode="always"
        onChangeText={this.handleChangeText}
      />
    );
  }
}
```

By using this pattern, we can remove some boilerplate within our constructor method as well as handle events in a cleaner fashion *without* causing additional re-renders.

Higher-Order Components

A Higher-Order Component (or HOC, for short) sounds complex, but the idea is simple: we want a way to add common functionality (e.g data fetching or drag-and-drop) to many different components. To do this, we write a function that takes an existing component and *wraps* it in an *enhanced* component. Instead of changing the code of original component, a higher-order component allows us to change the functionality by controlling how and when we show the original component.

In code, a HOC is conceptually straightforward as well. To create a HOC, we'll create a function that accepts a component to wrap:

```
const Enhance = OriginalComponent => {
  return props => <OriginalComponent {...props} />;
};
```

It looks like there is a lot going on in the `Enhance` function, but it's pretty simple. The function accepts an `OriginalComponent` argument and returns a stateless component function.

JSX spread syntax

We cover spread syntax, `{...props}`, in the "React Fundamentals" chapter, but we haven't mentioned we can also use it for component props. Instead of having to know all of the key-value pairs in the `props`, the spread syntax takes each of the props and sets them as key-value pairs automatically.

For instance, if we have a `props` object that has two keys:

```
const props = {msg: "Hello", recipient: "World"}
```

In spread-syntax, JSX will make the resulting examples equivalent:

```
<Component {...props} />
<Component msg={"Hello"} recipient={"World"} />
```

The HOC can also return a class component:

```
const Enhance = OriginalComponent => {
  return class extends React.Component {
    render() {
      return <OriginalComponent {...this.props} />;
    }
  };
};
```

Providing a class name is optional. It's generally a good idea to provide a meaningful name specific to the purpose of the HOC, but in this case we don't know what the example HOC does so we omitted the class name.

Notice that we can return *whatever* we want in our HOC as the `render()` value. To display the original component, we just have to return it as a React component in JSX (as we do above). We could instead modify the props of the original component before rendering it, or we could display a completely different component based on the `state` of our enhanced component.

To apply our HOC to existing components, we can call it with the original component to get the enhanced component.

```
const EnhancedComponent = Enhance(OriginalComponent);
```

We can then use it anywhere we could use the original:

```
...

render() {
  return <EnhancedComponent />
}

...
```

Publishing with Expo

Instead of ejecting an application built with the Expo CLI and going through the process of building and publishing standalone native builds manually, we also have the option to publish with Expo. This can be done using the following command:

```
exp publish
```

Expo will take a few minutes compiling JavaScript bundles in production mode before deploying it to the platform. Once completed, a URL will be provided that looks like `https://exp.host/@fullstackio/contact-list`. You can send this link to any user who can open your application directly through the Expo Client app.

One benefit of this approach is that users can access our application without us having to set up standalone builds. This means we don't have to take the steps to create and deploy native iOS/Android builds to the app stores. The only requirement is that users have the Expo Client application installed on their device. Every sample application in this book has been published with Expo.

A disadvantage of relying on Expo Client for application distribution is that it only works for users with Android devices. Users with iOS devices are significantly limited in accessing unauthorized applications. They need to be logged in to the same Expo account that has published the project in order to open and preview the application through the Client app. Only Android users have the capability to open any Expo application published to the platform using their Client app. This means that we *only* have the option of deploying a native build to the iOS App Store to allow other iOS users to test and view our React Native application.

Changelog

This document highlights the changes for each version of Fullstack React Native.

Be sure to check there to ensure that you have the latest revision.

Revision 9 - `2019-09-23`

Release notes: Updated Expo SDK to v33

Revision 8 - `2019-06-12`

- Updated react-navigation to v3

Revision 7 - `2019-02-27`

- Fixed incorrect npm package version

Revision 6 - `2018-12-19`

- The tool we use to create new projects, `create-react-native-app` has been renamed/merged with `expo-cli`. We've updated the book to use this new command.
- The native modules chapter now uses the `react-native init` command for initializing a project that will use native code.
- All chapters have been updated to React Native 57 and Expo SDK 31
- We improved the Navigation chapter, using a mock API for better stability
- We handle newer iPhone sizes in the Core APIs chapter (edited)

Revision 5 - `2018-07-26`

Revision 5 - Adds Native Modules chapters to the book

Revision 4 - 2018-07-20

Revision 4 - Adds Publishing & Gestures chapters to the book

Revision 3 - 2018-05-10

Revision 3 - Adds Animation chapter to the book

Revision 2 - 2018-02-28

Adds Navigation chapter to the book

Revision 1 - 2017-12-06

Initial version of the book