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THE ULTIMATE REACT COURSE

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SLIDES FOR THEORY LECTURES

(DON'T SKIP THEM, THEY ARE SUPER IMPORTANT 🤓)

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WELCOME, WELCOME, WELCOME!

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SECTION

WELCOME, WELCOME, WELCOME!

LECTURE

WATCH BEFORE YOU START!

SOME QUICK **CONSIDERATIONS** BEFORE WE START... 🚀

✌️ **This course is for everyone!** So please don't write a bad review right away if the course is too easy, or too hard, or progressing too slow, or too fast for you

✌️ To make the course perfect for **YOU**: **rewatch** lectures, jump to **other sections**, watch the course with **slower** or **faster** speed, or ask **questions**

Please don't be that person. Everyone is different... Unless the course is truly terrible (it's not 😛)

SOME QUICK **CONSIDERATIONS** BEFORE WE START... 🚀

😱 **You don't need to watch the entire course in order to learn React!** If you are in a hurry, can cut the course length in **HALF** by skipping optional sections and practice parts

A First Look at React	7 lectures • 1hr 8min
[Optional] Review of Essential JavaScript for React	14 lectures • 1hr 51min
Working With Components, Props, and JSX	23 lectures • 2hr 53min
State, Events, and Forms: Interactive Components	20 lectures • 2hr 54min
Thinking In React: State Management	16 lectures • 2hr 41min
[Optional] Practice Project: Eat-'N-Split	8 lectures • 1hr 28min
Thinking in React: Components, Composition, and Reusability	16 lectures • 2hr 38min
How React Works Behind the Scenes	17 lectures • 2hr 36min
Effects and Data Fetching	18 lectures • 3hr 12min
Custom Hooks, Refs, and More State	14 lectures • 2hr 1min
[Optional] React Before Hooks: Class-Based React	9 lectures • 1hr 21min

SOME QUICK **CONSIDERATIONS** BEFORE WE START... 🚀

👩‍💻 **You need to code along with me!** You will learn **ZERO** React skills by just sitting and watching me code. You really have to write code **YOURSELF**!

SOME QUICK **CONSIDERATIONS** BEFORE WE START... 🚀

😅 **In the first sections of the course, don't worry about WHY and HOW things work, or about React "best practices".** While learning, we just want to make things **WORK**. We will worry about everything else **later in the course**

SOME QUICK **CONSIDERATIONS** BEFORE WE START... 🚀

!? If you have a problem or a question, **start by trying to solve it yourself! This is essential for your progress. If you can't solve it, check the Q&A section**. If that doesn't help, you can **ask a new question**. Use a short description, and post code on codesandbox.io

CodeSandbox

SOME QUICK **CONSIDERATIONS** BEFORE WE START... 🚀

⏳ **Before moving on from a section, make sure that you understand exactly what was covered.** Take a break, review the code we wrote, review your notes, review the projects we built, and maybe even write some code yourself

SOME QUICK **CONSIDERATIONS** BEFORE WE START... 🚀

🖥️ **I recorded this course on a Mac, but everything works the exact same way on Windows or Linux.**

If something doesn't work on your computer, it's **NOT** because you're using a different OS

SOME QUICK **CONSIDERATIONS** BEFORE WE START... 🚀

😍 **Most importantly, have fun!** It's so rewarding to see an app come to life that **YOU** have built **YOURSELF**! So if you're feeling frustrated, stop whatever you're doing, and come back later!

And I mean **REAL** fun 😅

PART 01

—

REACT FUNDAMENTALS

A FIRST LOOK AT REACT

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A FIRST LOOK AT REACT

LECTURE

WHY DO FRONT-END FRAMEWORKS EXIST?

THE RISE OF **SINGLE-PAGE APPLICATIONS**

SINGLE-PAGE APPLICATIONS WITH **VANILLA JAVASCRIPT**?

👉 *Front-end web applications are all about...*

Handling data + **displaying** data in a user interface

↓

User interface needs to **stay in sync** with data

↓

Very hard problem to solve!

KEEPING UI **IN SYNC** WITH DATA

☝ Keeping UI and data in sync would be **virtually impossible with just vanilla JavaScript**

Piece of data
=
Piece of *state*

SINGLE-PAGE APPLICATIONS WITH **VANILLA JAVASCRIPT**?

👉 *Front-end web applications are all about...*

Handling data + **displaying** data in a user interface

↓

User interface needs to **stay in sync** with data

↓

Very hard problem to solve!

PROBLEMS WITH JS jQuery

1. Requires lots of direct **DOM manipulation** and **traversing** (*imperative*) 👉 "Spaghetti code" 🍝

```
const guestsEl = document.querySelector('.guests');
const guestsPickerEl = document.querySelector('.picker');

guestsEl.addEventListener('click', function () {
  guestsEl.classList.toggle('inactive');
  guestsEl.classList.toggle('active');

  if (guestsPickerEl.style.display === 'block') {
    guestsPickerEl.style.display = 'none';
    guestsEl.firstElementChild.textContent = 'Add guests';
  } else {
    guestsPickerEl.style.display = 'block';
    guestsEl.firstElementChild.textContent = '';
  }
```

2. Data (state) is usually **stored in the DOM**, shared across entire app 👉 Hard to reason + bugs 🐛

WHY DO FRONT-END FRAMEWORKS **EXIST**?

1

JavaScript front-end frameworks exist because...

KEEPING A USER INTERFACE IN SYNC WITH DATA
IS **REALLY HARD** AND A **LOT OF WORK**

Front-end frameworks **solve this problem** and take hard work away from developers 🎉

Different approaches, same goal

2

They enforce a "**correct**" way of structuring and writing code (therefore contributing to solving the problem of "spaghetti code" 🍝)

3

They give developers and teams a **consistent** way of building front-end applications

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A FIRST LOOK AT REACT

LECTURE

WHAT IS REACT?

WHAT IS **REACT**?

REACT

JAVASCRIPT LIBRARY FOR BUILDING

USER INTERFACES

WHAT IS **REACT**?

REACT

EXTREMELY POPULAR, DECLARATIVE, COMPONENT-BASED, STATE-DRIVEN **JAVASCRIPT LIBRARY FOR BUILDING USER INTERFACES**, CREATED BY FACEBOOK 🤔 🤯 🤣

REACT IS **BASED ON COMPONENTS**

Based on components

Declarative

State-driven

JavaScript library

Extremely popular

Created by facebook

👉 Components are the **building blocks** of user interfaces in React

👉 We build complex UIs by **building and combining multiple components**

REACT IS **BASED ON COMPONENTS**

Based on components

Declarative

State-driven

JavaScript library

Extremely popular

Created by facebook

REACT IS **DECLARATIVE**

Based on components

Declarative

State-driven

JavaScript library

Extremely popular

Created by facebook

- We **describe** how components look like and how they work using a **declarative syntax called JSX**
- **Declarative**: telling React what a component should look like, **based on current data/state**
- React is **abstraction** away from DOM: we **never touch the DOM**
- **JSX**: a syntax that **combines** HTML CSS JavaScript as well as referencing **other components**

JSX returned from a component

```
return (
  <main>
    <NavBar>
      <h1 style={ fontSize: '3.2rem' }>AirBnB</h1>
      <Search />
      <a ref='#'>Become a host</a>
    </NavBar>
    <Results>
      <p style={ fontSize: '1.6rem', margin: '1.2rem' }>
        {numListings} stays in Lisbon
      </p>
      <Listing listing={listings[0]} />
      <Listing listing={listings[1]} />
      <Listing listing={listings[2]} />
    </Results>
    <Map listings={listings} onClick={moveMap} />
  </main>
);
}
```

REACT IS **STATE-DRIVEN**

- Based on components
- Declarative
- State-driven
- JavaScript library
- Extremely popular
- Created by facebook

REACT *REACTS* TO STATE CHANGES BY RE-RENDERING THE UI

REACT IS A **JAVASCRIPT LIBRARY**

- Based on components
- Declarative
- State-driven
- JavaScript library
- Extremely popular
- Created by facebook

🤔 Is React a library or a framework?

Because React is only the “view” layer. We need to pick multiple external libraries to build a complete application

NEXT.JS Remix

Complete frameworks built on top of React

REACT IS **EXTREMELY POPULAR**

Based on components

Declarative

State-driven

JavaScript library

Extremely popular

Created by facebook

(Weekly downloads from NPM)

- ✅ Many large companies have adopted React
- ✅ Huge job market with high demand for React developers 🤑
- ✅ Large and vibrant React developer community
- ✅ Gigantic third-party library ecosystem

REACT WAS **CREATED BY FACEBOOK**

- Based on components
- Declarative
- State-driven
- JavaScript library
- Extremely popular
- Created by facebook

- 👉 React was created in **2011** by Jordan Walke, an engineer working at Facebook at the time
- 👉 React was open-sourced in **2013**, and has since then completely transformed front-end web development

facebook

Meta

🎯 SUMMARY

1. Rendering components on a webpage (UI) based on their current state
2. Keeping the UI in sync with state, by re-rendering (*reacting*) when state changes

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A FIRST LOOK AT REACT

LECTURE

SETTING UP A NEW REACT PROJECT: THE TWO OPTIONS

THE **TWO OPTIONS** FOR SETTING UP A RECT PROJECT

CREATE-REACT-APP

- 👉 Complete **“starter kit”** for React applications
- 👍 Everything is **already configured**: ESLint, Prettier, Jest, etc. ESLint Prettier Jest
- 👎 Uses **slow and outdated** technologies (i.e. webpack)

Most of the course

✅ Use for **tutorials** or experiments

⛔ Don’t use for a **real-world app**

VITE

- 👉 **Modern build tool** that contains a **template** for setting up React applications
- 👎 Need to manually set up **ESLint** (and others)
- 👍 **Extremely fast** hot module replacement (HMR) and bundling

✅ Use for modern **real-world apps**

By the end of the course

WHAT ABOUT REACT **FRAMEWORKS**?

NEXT.JS Remix

- 👉 The React team now advises to use a **"React Framework"** for new projects
- 👉 Many people think that this is not the best idea: **"vanilla" React apps are important too**!
- 👉 This only makes sense for building actual products, **not for learning React**
- 👉 Of course, you still need to **learn React itself**

✌️ Don't worry about this recommendation for now. Let's just **learn React**!

LEARN REACT > INSTALLATION >

👉 react.dev

Start a New React Project

If you want to build a new app or a new website fully with React, we recommend picking one of the React-powered frameworks popular in the community. Frameworks provide features that most apps and sites eventually need, including routing, data fetching, and generating HTML.

Production-grade React frameworks

Next.js

Next.js is a full-stack React framework. It's versatile and lets you create React apps of any size—from a mostly static blog to a complex dynamic application. To create a new Next.js project, run in your terminal:

Terminal Copy

```
npx create-next-app
```

If you're new to Next.js, check out the Next.js tutorial.

Next.js is maintained by Vercel. You can deploy a Next.js app to any Node.js or serverless hosting, or to your own server. Fully static Next.js apps can be deployed to any static hosting.

Remix

Remix is a full-stack React framework with nested routing. It lets you break your app into nested parts that can load data in parallel and refresh in response to the user actions. To create a new Remix project, run:

WORKING WITH COMPONENTS, PROPS, AND JSX

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WORKING WITH COMPONENTS, PROPS, AND JSX

LECTURE

COMPONENTS AS BUILDING BLOCKS

COMPONENTS AS **BUILDING BLOCKS**

COMPONENTS

- 👉 React applications are entirely made out of components
- 👉 **Building blocks** of user interfaces in React

COMPONENTS AS **BUILDING BLOCKS**

COMPONENTS

- React applications are entirely made out of components
- **Building blocks** of user interfaces in React
- Piece of UI that has its own **data**, **logic**, and **appearance** (*how it works and looks*)
- We build complex UIs by **building multiple components** and **combining** them

COMPONENTS AS **BUILDING BLOCKS**

COMPONENTS

- React applications are entirely made out of components
- **Building blocks** of user interfaces in React
- Piece of UI that has its own **data**, **logic**, and **appearance** (*how it works and looks*)
- We build complex UIs by **building multiple components** and **combining** them
- Components can be **reused**, **nested** inside each other, and **pass data** between them

COMPONENT TREES

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WORKING WITH COMPONENTS, PROPS, AND JSX

LECTURE

WHAT IS JSX?

WHAT IS JSX?

JSX

- **Declarative** syntax to **describe** what components **look like** and **how they work**
- Components must **return** a block of JSX
- Extension of JavaScript that allows us to **embed JavaScript CSS and React components into HTML**

```
function Question(props) {
  const question = props.question;
  const [upvotes, setUpvotes] = useState(0);

  const upvote = () => setUpvotes((v) => v + 1);

  const openQuestion = () => {}; // Todo

  return (
    <div>
      <h4 style={{ fontSize: "2.4rem" }}>
        {question.title}
      </h4>
      <p>{question.text}</p>
      <p>{question.hours} hours ago</p>

      <UpvoteBtn onClick={upvote} />
      <Answers
        numAnswers={question.num}
        onClick={openQuestion}
      />
    </div>
  );
}
```

JSX returned from component

WHAT IS JSX?

JSX

- **Declarative** syntax to **describe** what components **look like** and **how they work**
- Components must **return** a block of JSX
- Extension of JavaScript that allows us to **embed JavaScript, CSS, and React components into HTML**
- Each JSX element is **converted** to a `React.createElement` function call
- We could use React **without JSX**

```
<header>
  <h1 style="color: red">
    Hello React!
  </h1>
</header>
```

↓

BABEL

```
React.createElement(
  'header',
  null,
  React.createElement(
    'h1',
    { style: { color: 'red' } },
    'Hello React!'
  )
);
```

↓

Hello React!

JSX IS **DECLARATIVE**

IMPERATIVE

"How to do things"

- 👉 Manual DOM element selections and DOM traversing
- 👉 Step-by-step DOM mutations until we reach the desired UI

```
const title = document.querySelector("title")
const upvoteBtn = document.querySelector("btn")
title.textContent = `[0] ${question.title}`;
let upvotes = 0;
upvoteBtn.addEventListener("click", function(){
  upvotes++;
  title.textContent =
    `[${upvotes}] ${question.title}`;
  title.classList.add("upvoted");
});
```

DECLARATIVE

"What we want"

- 👉 Describe what UI should look like using JSX, **based on current data**
- 👉 React is an **abstraction** away from DOM: **we never touch the DOM**
- 👉 Instead, we think of the UI as a **reflection of the current data**

```
function Question(props) {
  const question = props.question;
  const [upvotes, setUpvotes] = useState(0);
  const upvote = () => setUpvotes((v) => v + 1);

  return (
    <div>
      <h4>{question.title}</h4>
      <p>{question.text}</p>
      <UpvoteBtn
        onClick={upvote}
        upvotes={upvotes}
      />
    </div>
  );
}
```

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WORKING WITH COMPONENTS, PROPS, AND JSX

LECTURE

SEPARATION OF CONCERNS

SEPARATION OF CONCERNS?

ONE *TECHNOLOGY* PER FILE

"Traditional" **separation of concerns**

JS

```javascript
let upvotes = 0;
title.textContent = question.title;
const upvote = () => upvotes++;
upvoteBtn.addEventListener("click", upvote);

if (question.num > 0) {
  answer.classList.toggle("hidden");
  firstAnswer.classList.toggle("hidden");
}
```

```html
<div>
  <h4 class="title"></h4>
  <button class="btn">Upvote</button>

  <div class="answer"></div>
  <div class="first hidden"></div>
</div>
```

HTML

Rise of interactive SPAs → JavaScript is in charge of HTML → Logic and UI are tightly coupled → Why keep them separated? → **React Components + JSX**

SEPARATION OF CONCERNS?

ONE *COMPONENT* PER FILE

Component

- Data
- Logic
- Appearance

```
function Question({ question }) {
  const [upvotes, setUpvotes] = useState(0);
  const upvote = () => setUpvotes((v) => v + 1);

  return (
    <div>
      <h4>{question.title}</h4>
      <UpvoteBtn onClick={upvote} />

      {question.num > 0 ? (
        <Answers numAnswers={question.nu
      ) : (
        <FirstAnswer />
      )}
    </div>
  );
}
```

JS

JS

HTML

JS

HTML and JS are ***colocated***

Fundamental reason for **components**

Rise of interactive SPAs → JavaScript is in charge of HTML → Logic and UI are tightly coupled → Why keep them separated? → **React Components + JSX**

SEPARATION OF CONCERNS!

ONE *TECHNOLOGY* PER FILE

"Traditional" **separation of concerns**

COMPLETELY NEW PARADIGM

ONE *COMPONENT* PER FILE

Each component is **concerned with one piece of the UI**

Rise of interactive SPAs → JavaScript is in charge of HTML → Logic and UI are tightly coupled → Why keep them separated? → **React Components + JSX**

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SECTION

WORKING WITH COMPONENTS, PROPS, AND JSX

LECTURE

PROPS, IMMUTABILITY, AND ONE-WAY DATA FLOW

REVIEWING **PROPS**

PROPS

👉 Props are used to pass data from **parent components** to **child components** (**down** the component tree)

REVIEWING **PROPS**

PROPS

- 👉 Props are used to pass data from **parent components** to **child components** (**down** the component tree)
- 👉 Essential tool to **configure** and **customize** components (like function parameters)
- 👉 With props, parent components **control** how child components look and work

```
<Menu>
  <Button bgColor="blue" text="New" />
  <Button bgColor="green" text="Edit" />
  <Button bgColor="red" text="Delete" />
</Menu>
```

REVIEWING **PROPS**

PROPS

- 👉 Props are used to pass data from **parent components** to **child components** (**down** the component tree)
- 👉 Essential tool to **configure** and **customize** components (like function parameters)
- 👉 With props, parent components **control** how child components look and work
- 👉 **Anything** can be passed as props: single values, arrays, objects, functions, even other components

```
function CourseRating() {
  const [rating, setRating] = useState(0);

  return (
    <Rating
      text="Course rating"
      currentRating={rating}
      numOptions={3}
      options={["Terrible", "Okay", "Amazing"]}
      allRatings={{ num: 2390, avg: 4.8 }}
      setRating={setRating}
      component={Star}
    />
  );
}

function Star() {
  // To do
}
```

PROPS ARE **READ-ONLY!**

Props is data coming from the **outside**, and can **only** be updated by the **parent component**

Parent Component

State is **internal** data that can be updated by the **component's** logic

```
let x = 7;

function Component(){
  x = 23;
  return <h1>Number {x}</h1>
}
```

Don't do this!

☝️ Props are read-only, they are **immutable**! This is one of React's strict rules.

☝️ If you need to mutate props, you actually **need state**

WHY?

- 👉 Mutating props would affect parent, creating **side effects** (not pure)
- 👉 Components have to be **pure functions** in terms of props and state
- 👉 This allows React to optimize apps, avoid bugs, make apps predictable

ONE-WAY DATA FLOW

ONE-WAY DATA FLOW...

- 👍 ... makes applications more predictable and easier to understand
- 👍 ... makes applications easier to debug, as we have more control over the data
- 👍 ... is more performant

*Angular has **two-way** data flow*

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WORKING WITH COMPONENTS, PROPS, AND JSX

LECTURE

THE RULES OF JSX

RULES OF JSX

GENERAL JSX RULES

- JSX works essentially like HTML, but we can enter **"JavaScript mode"** by using `{}` (for text or attributes)
- We can place **JavaScript expressions** inside `{}`. Examples: reference variables, create arrays or objects, `[].map()`, ternary operator
- Statements are **not allowed** (`if/else`, `for`, `switch`)
- JSX produces a **JavaScript expression**

```
const el = <h1>Hello React!</h1>;
```

==

```
const el = React.createElement("h1", null, "Hello React!");
```

1. We can place **other pieces of JSX** inside `{}`
2. We can write JSX **anywhere** inside a component (in `if/else`, assign to variables, pass it into functions)

- A piece of JSX can only have **one root element**. If you need more, use `<React.Fragment>` (or the short `<>`)

DIFFERENCES BETWEEN JSX AND HTML

- `className` instead of HTML's `class`
- `htmlFor` instead of HTML's `for`
- Every tag needs to be **closed**. Examples: `<img />` or `<br />`
- All event handlers and other properties need to be **camelCased**. Examples: `onClick` or `onMouseOver`
- **Exception**: `aria-*` and `data-*` are written with dashes like in HTML
- CSS inline styles are written like this: `{{<style>}}` (to reference a variable, and then an object)
- CSS property names are also **camelCased**
- Comments need to be in `{}` (because they are JS)

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SECTION

WORKING WITH COMPONENTS, PROPS, AND JSX

LECTURE

SECTION SUMMARY

🎯 SECTION **SUMMARY**

To pass data from parent to child components

Rendering multiple components at once using the JavaScript `.map()` method

Components can be conditionally rendered using JS tools: `&&`, `?`, and multiple `return`

JSX block is what we return from a component

STATE, EVENTS, AND FORMS: INTERACTIVE COMPONENTS

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SECTION

STATE, EVENTS, AND FORMS: INTERACTIVE COMPONENTS

LECTURE

WHAT IS STATE IN REACT?

📚 WHAT WE NEED TO LEARN

WHAT REACT DEVELOPERS NEED TO LEARN ABOUT STATE:

1. **What is state** and **why** do we need it?

This section

2. How to use state in **practice**?
   - 👉 `useState`
   - 👉 `useReducer`
   - 👉 Context API

3. **Thinking** about state
   - 👉 When to use state
   - 👉 Where to place state
   - 👉 Types of state

Rest of the course...

👋 **State** is the most important concept in React

(So we will keep learning about state throughout the entire course...)

WHAT IS **STATE**?

STATE

- 👉 Data that a component **can hold over time**, necessary for information that it needs to **remember** throughout the app's lifecycle

- 👉 **"Component's memory"**

WHAT IS **STATE**?

STATE

- Data that a component **can hold over time**, necessary for information that it needs to **remember** throughout the app's lifecycle

- **"Component's memory"**

- **"State variable" / "piece of state"**: A single variable in a component (component state)

We use these terms interchangeably

WHAT IS **STATE**?

STATE

- 👉 Data that a component **can hold over time**, necessary for information that it needs to **remember** throughout the app's lifecycle
- 👉 **"Component's memory"**
- 👉 ***Component* state:** Single local component variable ("Piece of state", "state variable")
- 👉 Updating **component state** triggers React to **re-render the component**

WHAT IS **STATE**?

STATE

- 👉 Data that a component **can hold over time**, necessary for information that it needs to **remember** throughout the app's lifecycle
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- 👉 ***Component* state:** Single local component variable ("Piece of state", "state variable")
- 👉 Updating **component state** triggers React to **re-render the component**

STATE ALLOWS DEVELOPERS TO:

1. Update the component's view (by re-rendering it)
2. Persist local variables between renders

👋 *State is a **tool**. Mastering state will unlock the power of React development*

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STATE, EVENTS, AND FORMS: INTERACTIVE COMPONENTS

LECTURE

THE MECHANICS OF STATE

THE **MECHANICS** OF STATE IN REACT

We don't do direct DOM manipulations → How is a component view updated then? → ***In React, a view is updated by re-rendering the component*** → A component is re-rendered when its state is updated

Because React is **declarative**

Important React principle

STATE → **RENDER / RE-RENDER** → **UPDATED VIEW**

React calls the component function again

👉 State is preserved throughout re-renders

THE **MECHANICS** OF STATE IN REACT

We don't do direct DOM manipulations → How is a component view updated then? → *In React, a view is updated by re-rendering the component* → A component is re-rendered when its state is updated

THE **MECHANICS** OF STATE IN REACT

We don't do direct DOM manipulations → How is a component view updated then? → ***In React, a view is updated by re-rendering the component*** → A component is re-rendered when its state is updated → **So to update a view, we update state**

```
const [advice, setAdvice] =
  useState("Quality beats quantity.");
const [countAdvice, setCountAdvice] =
  useState(13);
```

RE-RENDER →

UPDATE STATE

```
setAdvice(data.slip.advice);
setCountAdvice((count) => count + 1);
```

THE **MECHANICS** OF STATE IN REACT

We don't do direct DOM manipulations → How is a component view updated then? → ***In React, a view is updated by re-rendering the component*** → A component is re-rendered when its state is updated → **So to update a view, we update state**

👉 *React is called "React" because...*

REACT *REACTS* TO STATE CHANGES BY RE-RENDERING THE UI

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MORE THOUGHTS ABOUT STATE + STATE GUIDELINES

ONE COMPONENT, ONE **STATE**

👋 Each component has and manages **its own state**, no matter how many times we render the same component

Multiple *instances* of the `Counter` component

UI AS A **FUNCTION** OF STATE

DECLARATIVE, *REVISITED*

- 👉 With state, we view UI as a **reflection of data changing over time**
- 👉 We ***describe* that reflection** of data using state, event handlers, and JSX

🎯 IN PRACTICAL TERMS...

PRACTICAL GUIDELINES ABOUT STATE

- 👉 Use a state variable for any data that the component should keep track of ("remember") over time. **This is data that will change at some point**. In Vanilla JS, that's a `let` variable, or an `[]` or `{}`

- 👉 Whenever you want something in the component to be **dynamic**, create a piece of state related to that "thing", and update the state when the "thing" should change (aka "be dynamic")

  - 👉 ***Example:*** *A modal window can be open or closed. So we create a state variable* `isOpen` *that tracks whether the modal is open or not. On* `isOpen = true` *we display the window, on* `isOpen = false` *we hide it.*

- 👉 If you want to change the way a component looks, or the data it displays, **update its state.** This usually happens in an **event handler** function.

- 👉 When building a component, imagine its view as a **reflection of state changing over time**

- 👉 For data that should not trigger component re-renders, **don't use state**. Use a regular variable instead. This is a common **beginner mistake**.

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STATE VS. PROPS

STATE **VS.** PROPS

STATE

- **Internal** data, owned by component
- Component “memory”
- Can be updated by the component itself
- Updating state causes component to re-render
- Used to make components interactive

```
function Question() {
  const [upvotes, setUpvotes] = useState(0);

  return (
    <div>
      {/* ... */}
      <Button upvotes={upvotes} bgColor="blue" />
    </div>
  );
}
```

Parent state update

```
function Button({ upvotes, bgColor }) {
  const [hovered, setHovered] = useState(false);

  return (
    <div>
      {/* ... */}
      <button
        onMouseEnter={() => setHovered(true)}
        onMouseLeave={() => setHovered(false)}
        style={{ background: bgColor }}
      >
        {hovered ? "Upvote" : `👍 ${upvotes}`}
      </button>
    </div>
  );
}
```

PROPS

- **External** data, owned by parent component
- Similar to function parameters
- Read-only
- **Receiving new props causes component to re-render.** Usually when the parent’s state has been updated
- Used by parent to configure child component (“settings”)

THINKING IN REACT: STATE MANAGEMENT

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THINKING IN REACT: STATE MANAGEMENT

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WHAT IS "THINKING IN REACT"?

“THINKING IN REACT” IS A CORE SKILL

This is where professional React apps are built

THINKING IN REACT

- 👉 *“React Mindset”*
- 👉 Thinking about components, state, data flow, effects, etc.
- 👉 Thinking in **state transitions**, not element mutations

“THINKING IN REACT” AS A **PROCESS**

Not a rigid process

THE “THINKING IN REACT” PROCESS:

1. Break the desired UI into **components** and establish the **component tree**
2. Build a **static** version in React (without state)
3. Think about **state**:
   - 👉 When to use state
   - 👉 Types of state: local vs. global
   - 👉 Where to place each piece of state
4. Establish **data flow**:
   - 👉 One-way data flow
   - 👉 Child-to-parent communication
   - 👉 Accessing global state

State management

WHEN YOU KNOW HOW TO “THINK IN REACT”, YOU WILL BE ABLE TO ANSWER:

- 🤔 How to break up a UI design into components?
- 🤔 How to make some components reusable?
- 🤔 How to assemble UI from reusable components?
- 🤔 What pieces of state do I need for interactivity?
- 🤔 Where to place state? (What component should "own" each piece of state?)
- 🤔 What types of state can or should I use?
- 🤔 How to make data flow through app?

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THINKING IN REACT: STATE MANAGEMENT

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FUNDAMENTALS OF STATE MANAGEMENT

WHAT IS STATE **MANAGEMENT?**

👉 **State management:** Deciding **when** to create pieces of state, what **types** of state are necessary, **where** to place each piece of state, and how data **flows** through the app

→

🏠 Giving each piece of state a **home**

TYPES OF STATE: LOCAL VS. GLOBAL STATE

LOCAL STATE

- State needed **only by one or few components**
- State that is defined in a component and **only that component and child components** have access to it (by passing via props)
- ***We should always start with local state***

GLOBAL STATE

- State that **many components** might need
- **Shared** state that is accessible to **every component** in the entire application

Context API

Redux

Local state

Global state

STATE: **WHEN** AND **WHERE**?

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THINKING IN REACT: STATE MANAGEMENT

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REVIEWING "LIFTING UP STATE"

PROBLEM: SHARING STATE WITH SIBLING COMPONENT

Data can only flow **down to children** (via props), not **sideways to siblings**

🤔 How do we share state with other components?

👉 `Total` component also needs access to `coupons` state

SOLUTION: LIFTING STATE UP

✌️ By **lifting state up**, we have successfully **shared** one piece of state with multiple components in **different positions** in the component tree

👉 `Total` component also needs access to `coupons` state

CHILD-TO-PARENT COMMUNICATION

👉 **Child-to-parent communication (inverse data flow)**: child updating parent state (data "flowing" **up**)

🤔 If data flows from parent to children, how can `Promotions` (child) update state in `Checkout` (parent)?

👉 `Total` component also needs access to `coupons` state

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DERIVED STATE

DERIVING STATE

- 👎 Three separate pieces of state, even though `numItems` and `totalPrice` depend on `cart`
- 👎 Need to keep them in sync (update together)
- 👎 3 state updates will cause 3 re-renders

```
const [cart, setCart] = useState([
  { name: "JavaScript Course", price: 15.99 },
  { name: "Node.js Bootcamp", price: 14.99 },
]);
const [numItems, setNumItems] = useState(2);
const [totalPrice, setTotalPrice] = useState(30.98);
```

DERIVING STATE

- 👍 **Derived state:** state that is computed from an existing piece of state or from props

- 👍 Just regular variables, no `useState`
- 👍 `cart` state is the **single source of truth** for this related data
- 👍 Works because re-rendering component will **automatically re-calculate** derived state

```
const [cart, setCart] = useState([
  { name: "JavaScript Course", price: 15.99 },
  { name: "Node.js Bootcamp", price: 14.99 },
]);
const numItems = cart.length;
const totalPrice =
  cart.reduce((acc, cur) => acc + cur.price, 0);
```

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THE CHILDREN PROP: MAKING A REUSABLE BUTTON

THE **CHILDREN** PROP

- 👉 The children prop allow us **to pass JSX into an element** (besides regular props)
- 👉 Essential tool to make **reusable** and **configurable** components (especially component **content**)
- 👉 Really useful for **generic** components that **don't know their content** before being used (e.g. modal)

PART 02

—

INTERMEDIATE REACT

THINKING IN REACT: COMPONENTS, COMPOSITION, AND REUSABILITY

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THINKING IN REACT: COMPONENTS, COMPOSITION, AND REUSABILITY

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HOW TO SPLIT A UI INTO COMPONENTS

COMPONENT SIZE **MATTERS**

Just one huge component

COMPONENT SIZE

SMALL

HUGE

- 👉 Too many **responsibilities**
- 👉 Might need too many **props**
- 👉 Hard to **reuse**
- 👉 **Complex** code, hard to understand

COMPONENT SIZE **MATTERS**

Many small components

COMPONENT SIZE

SMALL

HUGE

Generally, we need to find the right balance between too specific and too broad

- 👉 We end up with 100s of mini-components
- 👉 Confusing codebase
- 👉 Too **abstracted**

Creating something new to hide the implementation details of that thing

- 👉 Too many **responsibilities**
- 👉 Might need too many **props**
- 👉 Hard to **reuse**
- 👉 Complex code, hard to understand

HOW TO **SPLIT** A UI INTO COMPONENTS

👉 **The 4 criteria for splitting a UI into components:**

1. Logical separation of content/layout

2. Reusability

3. Responsibilities / complexity

4. Personal coding style

- ✅ Logical separation
- ✅ Some are reusable
- ✅ Low complexity

FRAMEWORK: WHEN TO CREATE A NEW COMPONENT?

💡 **SUGGESTION: When in doubt, start with a relatively big component, then split it into smaller components as it becomes necessary**

Skip if you're sure you need to reuse. But otherwise, you don't need to focus on reusability and complexity early on

1. Logical separation of content/layout

- 👉 Does the component contain pieces of content or layout that **don't belong together**?

2. Reusability

- 👉 Is it possible to reuse part of the component?
- 👉 Do you **want** or **need** to reuse it?

3. Responsibilities / complexity

- 👉 Is the component doing too **many different things**?
- 👉 Does the component rely on too **many props**?
- 👉 Does the component have too **many pieces of state** and/or effects?
- 👉 Is the code, including JSX, too **complex/confusing**?

4. Personal coding style

- 👉 Do you prefer **smaller** functions/components?

You might need a new component

👋 *These are all **guidelines**... It will become intuitive over time!*

SOME MORE GENERAL **GUIDELINES**

💰 Be aware that creating a new component **creates a new abstraction**. Abstractions have a **cost**, because **more abstractions require more mental energy** to switch back and forth between components. So try not to create new components too early

🏷️ Name a component according to **what it does** or **what it displays**. Don't be afraid of using long component names

🪆 Never declare a new component **inside another component**!

🗃️ **Co-locate related components inside the same file**. Don't separate components into different files too early

↔️ It's completely normal that an app has components of **many different sizes**, including very small and huge ones *(See next slide... 👉)*

ANY APP HAS COMPONENTS OF **DIFFERENT SIZES AND REUSABILITY**

👉 **Page component**

SMALL

REUSABLE

Components with all different sizes

Different degrees of size, reusability, responsibility, and complexity

HUGE

NON-REUSABLE

- 👉 **Some very small components are necessary!**
- 👉 Highly reusable
- 👉 Very low complexity

- 👉 **Most apps will have a few huge components**
- 👉 Not meant to be reused (**not a problem!**)

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COMPONENT CATEGORIES

COMPONENT **CATEGORIES**

👉 Most of your components will **naturally** fall into **one of three categories**:

Stateless / presentational components

- 👉 **No state**
- 👉 Can receive props and simply *present* received data or other content
- 👉 Usually **small and reusable**

Stateful components

- 👉 **Have state**
- 👉 Can still be **reusable**

Structural components

- 👉 "**Pages**", "**layouts**", or "**screens**" of the app
- 👉 Result of **composition**
- 👉 Can be **huge and non-reusable** (but don't have to)

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COMPONENT COMPOSITION

WHAT IS COMPONENT **COMPOSITION**?

"USING" A COMPONENT

```
function Modal() {
  return (
    <div className="modal">
      <Success />
    </div>
```

```
function Success() {
  return <p>Well done!</p>;
```

👉 Success is *inside* Modal: we can **NOT** reuse Modal

COMPONENT COMPOSITION

```
function Modal({ children }) {
  return (
    <div className="modal">
      {children}
    </div>
```

```
function Error() {
  return <p>This went wrong!</p>;
```

```
<Modal>
  <Success />
</Modal>
```

```
<Modal>
  <Error />
</Modal>
```

👉 Success is *passed into* Modal: we can **REUSE** Modal

WHAT IS COMPONENT **COMPOSITION**?

COMPONENT COMPOSITION

```
function Modal({ children }) {
  return (
    <div className="modal">
      {children}
    </div>
```

```
function Error() {
  return <p>This went wrong!</p>;
```

```
<Modal>
  <Success />
</Modal>
```

```
<Modal>
  <Error />
</Modal>
```

👉 `Success` is *passed into* `Modal`: we can **REUSE** `Modal`

Possible because components don't need to know their children in advance

👉 **Component composition**: combining different components using the `children` prop (or explicitly defined props)

WE COMPONENT COMPOSITION, WE CAN:

1. Create highly reusable and flexible components
2. Fix prop drilling (great for layouts)

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PROPS AS A COMPONENT API

PROPS AS AN **API**

COMPONENT CONSUMER

App

Consuming component

Component props = Public API

Abstraction that encapsulates UI and logic

Component

COMPONENT CREATOR

TOO LITTLE PROPS

- 👉 Not **flexible** enough
- 👉 Might not be **useful**

We need to find the right balance between too little and too many props, that works for both the consumer and the creator

TOO MANY PROPS

- 👉 Too **hard** to use
- 👉 Exposing too much **complexity**
- 👉 **Hard-to-write** code
- 👉 Provide good **default values**

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GOT QUESTIONS? FEEDBACK?

JUST POST IT IN THE Q&A OF THIS VIDEO, AND YOU WILL GET HELP THERE!

HOW REACT WORKS BEHIND THE SCENES

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COMPONENTS, INSTANCES, AND ELEMENTS

COMPONENT **VS.** INSTANCE **VS.** ELEMENT

Component

```
function Tab({ item }) {
  return (
    <div className='tab-content'>
      <h4>All contacts</h4>
      <p>Your post will be visible</p>
    </div>
  );
}
```

- 👉 **Description** of a piece of UI
- 👉 A component is a function that **returns React elements** (element tree), usually written as JSX
- 👉 “Blueprint” or “Template”

COMPONENT **VS.** INSTANCE **VS.** ELEMENT

```
function App() {
  return (
    <div className='tabs'>
      <Tab item={content[0]} />
      <Tab item={content[1]} />
      <Tab item={content[2]} />
    </div>
```

- 👉 Instances are created when we “**use**” components
- 👉 React internally calls `Tab()`
- 👉 Actual “**physical**” **manifestation** of a component
- 👉 Has its own state and props
- 👉 Has a **lifecycle** (can “be born”, “live”, and “die”)

COMPONENT **VS.** INSTANCE **VS.** ELEMENT

Component

↓ `<Tab />`

Component Instance

↓ **RETURNS**

React Element

```
function Tab({ item }) {
  return (
    <div className='tab-content'>
      <h4>All contacts</h4>
      <p>Your post will be visible</p>
    </div>
```

```
React.createElement(
  'div',
  {
    className: 'tab-content'
  },
  React.createElement('h4', null, 'All contacts'),
  React.createElement(
    'p',
    null,
    'Your post will be visible'
  )
);
```

```
Object
$$typeof: Symbol(react.element)
key: null
▼ props:
  ▼ children: Array(2)
    ▶ 0: {$$typeof: Symbol(react.element), type: 'h4',
    ▶ 1: {$$typeof: Symbol(react.element), type: 'p'
      length: 2
    ▶ [[Prototype]]: Array(0)
  className: "tab-content"
  ▶ [[Prototype]]: Object
ref: null
type: "div"
_owner: null
▶ _store: {validated: false}
```

REACT ELEMENT

- 👉 JSX is converted to `React.createElement()` **function calls**
- 👉 A React element is the **result of these function calls**
- 👉 Information necessary to create **DOM elements**

COMPONENT **VS.** INSTANCE **VS.** ELEMENT

Component

↓ `<Tab />`

Component Instance

↓ **RETURNS**

React Element

↓ **INSERTED TO DOM**

DOM Element (HTML)

```
▼<div class="tab-content">
   <h4>All contacts</h4>
   <p>Your post will be visible</p>
 </div>
```

All contacts

Your post will be visible to all your contacts

👉 Actual **visual representation** of the component instance in the browser

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HOW REACT WORKS BEHIND THE SCENES

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HOW RENDERING WORKS: OVERVIEW

QUICK **RECAP** BEFORE WE GET STARTED

🤔 **How does this process *actually* work?**

OVERVIEW: HOW COMPONENTS ARE **DISPLAYED** ON THE SCREEN

☝️ In React, rendering is **NOT** updating the DOM or displaying elements on the screen. Rendering only happens **internally** inside React, it does not **produce visual changes**.

HOW RENDERS ARE **TRIGGERED**

[1] RENDER IS TRIGGERED

THE TWO SITUATIONS THAT TRIGGER RENDERS:

1. **Initial render** of the application
2. **State is updated** in one or more component instances (**re-render**)

- 👉 The render process is triggered for the **entire application**
- 👉 **In practice**, it looks like React only re-renders the component where the state update happens, but that's not how it **works behind the scenes**
- 👉 Renders are **not** triggered immediately, but **scheduled** for when the JS engine has some "free time". There is also batching of multiple `setState` calls in event handlers

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HOW RENDERING WORKS: THE RENDER PHASE

REVIEW: THE MECHANICS OF STATE IN REACT

NOT TRUE #1: RENDERING IS UPDATING THE SCREEN / DOM

NOT TRUE #2: REACT COMPLETELY DISCARDS OLD VIEW (DOM) ON RE-RENDER

THE **RENDER** PHASE

[2] RENDER PHASE

THE **VIRTUAL DOM** (REACT ELEMENT TREE)

- **Virtual DOM:** Tree of all React elements created from all instances in the component tree
- Cheap and fast to create multiple trees
- Nothing to do with "shadow DOM"

- Rendering a component will **cause all of its child components to be rendered as well** (no matter if props changed or not)

THE **VIRTUAL DOM** (REACT ELEMENT TREE)

- **Virtual DOM:** Tree of all React elements created from all instances in the component tree
- Cheap and fast to create multiple trees
- Nothing to do with "shadow DOM"

- Rendering a component will **cause all of its child components to be rendered as well** (no matter if props changed or not)

  ↓

  Necessary because React doesn't know whether children will be affected

THE **RENDER** PHASE

[2] RENDER PHASE

WHAT IS **RECONCILIATION** AND WHY DO WE NEED IT?

🤔 Why not update the entire DOM whenever state changes somewhere in the app?

BECAUSE

👉 That would be inefficient and wasteful:

1. Writing to the DOM is (relatively) **slow**
2. Usually only a **small part of the DOM** needs to be updated

👉 React **reuses** as much of the existing DOM as possible

HOW?

❤️ **Reconciliation:** Deciding which DOM elements actually need to be inserted, deleted, or updated, in order to reflect the latest state changes

`showModal = true`

Only these new DOM elements are created

THE RECONCILER: **FIBER**

REACT ELEMENT TREE (VIRTUAL DOM)

ON INITIAL RENDER

FIBER TREE

FIBER
"Unit of work"

- Current state
- Props
- Side effects
- Used hooks
- Queue of work

- 👉 **Fiber tree:** internal tree that has a "fiber" for each component instance and DOM element
- 👉 Fibers are **NOT** re-created on every render
- 👉 Work can be done **asynchronously**

- 👉 Rendering process can be split into chunks, tasks can be prioritized, and work can be **paused**, **reused**, or **thrown away**
  - 👉 Enables **concurrent features** like Suspense or transitions
  - 👉 Long renders **won't block** JS engine

RECONCILIATION **IN ACTION**

State update in App, so **all remaining children** are re-rendered

```
<App>
  <Video />
  {showModal && (
    <Modal>
      <Overlay>
        <h3>Rate course!</h3>
        <button>5 ★</button>
      </Overlay>
    </Modal>
  )}
  <Btn>
    {showModal ? 'Rate' : 'Hide'}
  </Btn>
</App>
```

THE **RENDER** PHASE

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HOW RENDERING WORKS: THE COMMIT PHASE

THE **COMMIT** PHASE AND BROWSER **PAINT**

[2] RENDER PHASE

List of DOM updates

React

[3] COMMIT PHASE

Updated DOM

ReactDOM

[4] BROWSER PAINT

Updated UI on the screen

- 👉 **React writes to the DOM**: insertions, deletions, and updates (list of DOM updates are “flushed” to the DOM)
- 👉 **Committing is synchronous**: DOM is updated in one go, it can’t be interrupted. This is necessary so that the DOM never shows partial results, ensuring a consistent UI (in sync with state at all times)
- 👉 After the commit phase completes, the `workInProgress` fiber tree becomes the `current` tree **for the next render cycle**

THE **COMMIT** PHASE AND BROWSER **PAINT**

[2] RENDER PHASE

List of DOM updates

React

Does **not** touch the DOM. React **only renders**. It doesn't know where the render result will go

React can be used on different platforms ("hosts")

[3] COMMIT PHASE

Updated DOM

"RENDERERS"

ReactDOM

React Native

Remotion

Many others...

[4] BROWSER PAINT

Updated UI on the screen

iOS

android

PDF

Terrible name! **Renderers do not render**, they ***commit*** the result of render phase...

RECAP: PUTTING IT ALL TOGETHER

- 👉 Does **not** produce any visual output
- 👉 Rendering a component **also renders all of its child components**
- 👉 **Asynchronous**: work can be split, prioritized, paused, resumed
- 👉 **Synchronous**: DOM updates are written in one go, to keep UI consistent

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SECTION

HOW REACT WORKS BEHIND THE SCENES

LECTURE

HOW DIFFING WORKS

THE **RENDER** PHASE

[2] RENDER PHASE

HOW **DIFFING** WORKS

👉 **Diffing uses 2 fundamental assumptions (rules):**

1. Two elements of different types will **produce different trees**
2. Elements with a stable key prop **stay the same across renders**

👉 This allows React to go from **1,000,000,000** [O(n^3)] to **1000** [O(n)] operations per 1000 elements

1. SAME POSITION, **DIFFERENT** ELEMENT

```
<div>
  <SearchBar />
</div>
<main>...</main>
```

Different **DOM element**

```
<header>
  <SearchBar />
</header>
<main>...</main>
```

```
<div>
  <SearchBar />
</div>
<main>...</main>
```

Different **React element** (component instance)

```
<div>
  <ProfileMenu />
</div>
<main>...</main>
```

👉 React assumes **entire sub-tree is no longer valid**

👉 Old components are destroyed and removed from DOM, **including state**

👉 Tree might be rebuilt if children stayed the same (**state is reset**)

HOW **DIFFING** WORKS

👉 **Diffing uses 2 fundamental assumptions (rules):**

1. Two elements of different types will **produce different trees**
2. Elements with a stable key prop **stay the same across renders**

👉 This allows React to go from **1,000,000,000** [O(n³)] to **1000** [O(n)] operations per 1000 elements

2. SAME POSITION, **SAME** ELEMENT

```
<div className="hidden">
  <SearchBar />
</div>
<main>...</main>
```

Same **DOM element** →

```
<div className="active">
  <SearchBar />
</div>
<main>...</main>
```

```
<div>
  <SearchBar wait={1} />
</div>
<main>...</main>
```

Same **React element** (component instance) →

```
<div>
  <SearchBar wait={5} />
</div>
<main>...</main>
```

👉 Element will be kept (as well as child elements), **including state**

👉 **New props / attributes** are passed if they changed between renders

👉 Sometimes this is **not** what we want... Then we can use the key prop

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THE KEY PROP

WHAT IS THE **KEY** PROP?

KEY PROP

- 👉 Special prop that we use to tell the diffing algorithm that an element is **unique**
- 👉 Allows React to **distinguish** between multiple instances of the same component type
- 👉 When a key **stays the same across renders**, the element will be kept in the DOM (*even if the position in the tree changes*)

  1 ***Using keys in lists***

- 👉 When a key **changes between renders**, the element will be destroyed and a new one will be created (*even if the position in the tree is the same as before*)

  2 ***Using keys to reset state***

1. KEYS IN **LISTS** [STABLE KEY]

👎 NO KEYS

```
<ul>
  <Question question={q[1]} />
  <Question question={q[2]} />
</ul>
```

ADDING NEW LIST ITEM

```
<ul>
  <Question question={q[0]} />
  <Question question={q[1]} />
  <Question question={q[2]} />
</ul>
```

👉 Same elements, but **different position in tree**, so they are removed and recreated in the DOM (*bad for performance*)

👍 WITH KEYS

```
<ul>
  <Question key='q1' question={q[1]} />
  <Question key='q2' question={q[2]} />
</ul>
```

ADDING NEW LIST ITEM

```
<ul>
  <Question key='q0' question={q[0]} />
  <Question key='q1' question={q[1]} />
  <Question key='q2' question={q[2]} />
</ul>
```

👉 **Different position in the tree**, but the key **stays the same**, so the elements will be kept in the DOM 👉 **Always use keys!**

2. KEY PROP TO **RESET STATE** [CHANGING KEY]

👉 If we have the same element at the same position in the tree, the **DOM element and state** will be kept

```
<QuestionBox>
  <Question
    question={{
      title: 'React vs JS',
      body: 'Why should we use React?',
    }}
    key="q23"
  />
</QuestionBox>
```

NEW QUESTION IN SAME POSITION

```
<QuestionBox>
  <Question
    question={{
      title: 'Best course ever :D',
      body: 'This is THE React course!',
    }}

  />
</QuestionBox>
```

`Question` state (answer):

React allows us to build apps faster

State was preserved. NOT what we want

`Question` state (answer):

React allows us to build apps faster

2. KEY PROP TO **RESET STATE** [CHANGING KEY]

👍 WITH KEY

👉 If we have the same element at the same position in the tree, the **DOM element and state** will be kept

```
<QuestionBox>
  <Question
    question={{
      title: 'React vs JS',
      body: 'Why should we use React?',
    }}
    key="q23"
  />
</QuestionBox>
```

NEW QUESTION IN SAME POSITION

```
<QuestionBox>
  <Question
    question={{
      title: 'Best course ever :D',
      body: 'This is THE React course!',
    }}
    key="q89"
  />
</QuestionBox>
```

`Question` state (answer):

React allows us to build apps faster

State was RESET

`Question` state (answer):

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HOW REACT WORKS BEHIND THE SCENES

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RULES FOR RENDER LOGIC: PURE COMPONENTS

THE **TWO TYPES** OF LOGIC IN REACT COMPONENTS

1. RENDER LOGIC

- 👉 Code that lives at the **top level** of the component function
- 👉 Participates in **describing** how the component view looks like
- 👉 Executed **every time** the component renders

2. EVENT HANDLER FUNCTIONS

- 👉 Executed as a **consequence of the event** that the handler is listening for (change event in this example)
- 👉 Code that actually ***does things***: update state, perform an HTTP request, read an input field, navigate to another page, etc.

```
function Question({ question }) {
  const [newAnswer, setNewAnswer] = useState('');
  const numAnswers = question.answers.length ?? 0;

  const handleNewAnswer = function (e) {
    if (question.closed) return;
    setNewAnswer(e.target.value);
  };

  const createList = function () {
    return (
      <ul>
        {question.answers.map((q) => (
          <li>{q}</li>
        ))}
      </ul>
    );
  };

  return (
    <div>
      <h3>{question.title}</h3>
      <p>{question.body}</p>
      {question.hasAnswer ? (
        createList()
      ) : (
        <input
          value={newAnswer}
          onChange={handleNewAnswer}
        />
      )}
```

REFRESHER: FUNCTIONAL PROGRAMMING PRINCIPLES

- **Side effect:** dependency on or modification of any data outside the function scope. *"Interaction with the outside world"*. **Examples:** mutating external variables, HTTP requests, writing to DOM.

> 👋 **Side effects are not bad!** A program can only be useful if it has some interaction with the outside world

- **Pure function:** a function that has **no** side effects.
  - Does **not** change any variables outside its scope
  - Given the **same input**, a pure function always returns the **same output**

✅ **Pure function**

```
function circleArea(r) {
  return 3.14 * r * r;
}
```

☝️ **Impure function**

```
const areas = {};

function circleArea(r) {
  areas.circle = 3.14 * r * r;
}
```

Side effect: Outside variable mutation

☝️ **Impure function**

```
function circleArea(r) {
  const date = Date.now();
  const area = 3.14 * r * r;
  return `${date}: ${area}`;
}
```

Unpredictable output (`date` changes)

RULES FOR RENDER LOGIC

☝️ **Components must be pure when it comes to render logic:** given the same props (input), a component instance should always return the same JSX (output)

☝️ **Render logic must produce no side effects:** no interaction with the "outside world" is allowed. So, in render logic:

- 👉 Do NOT perform **network requests** (API calls)
- 👉 Do NOT start **timers**
- 👉 Do NOT directly **use the DOM API**
- 👉 Do NOT **mutate objects or variables** outside of the function scope
- 👉 Do NOT **update state (or refs)**: this will create an infinite loop!

This is why we can't mutate props!

👋 Side effects are allowed (and encouraged) in **event handler functions**! There is also a special hook to **register side effects** (`useEffect`)

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STATE UPDATE BATCHING

HOW STATE UPDATES ARE **BATCHED**

👉 Renders are **not** triggered immediately, but **scheduled** for when the JS engine has some “free time”. There is also batching of multiple `setState` calls in event handlers

```
const [answer, setAnswer] = useState('');
const [best, setBest] = useState(true);
const [solved, setSolved] = useState(false);

const reset = function () {
  setAnswer('');
  console.log(answer);
  setBest(true);
  setSolved(false);
};

return (
  <div>
    <button onClick={reset}>Reset</button>
    {/* ... */}
  </div>
);
```

Event handler function

HOW STATE UPDATES ARE **BATCHED**

This is NOT how React updates multiple pieces of state in the same event handler

HOW STATE UPDATES ARE **BATCHED**

EVENT HANDLER FUNCTION

```
const reset = function () {
  setAnswer('')
  console.log(answer);
  setBest(true)

  setSolved(false)
};
```

NEW STATE

```
answer = ''

best = true

solved = false
```

RENDER + COMMIT

No **wasted renders**, better for performance

Batched state update

Just ONE render and commit per event handler

UPDATING STATE IS **ASYNCHRONOUS**

EVENT HANDLER FUNCTION

```
const reset = function () {
  setAnswer('')
  console.log(answer)
  setBest(true)

  setSolved(false)
};
```

🤔 What will the value of `answer` be at this point?

State is stored in the Fiber tree during render phase

↓

At this point, re-render has **not** happened yet

↓

Therefore, `answer` still contains current state, **not** the updated state (`''`)

↓

UPDATING STATE IN REACT IS ASYNCHRONOUS

"Stale state"

- 👉 Updated state variables are **not** immediately available after `setState` call, but only after the re-render
- 👉 This also applies when **only one** state variable is updated
- 👉 If we need to update state **based on previous update**, we use `setState` with callback (`setAnswer(answer=>...)`)

BATCHING **BEYOND** EVENT HANDLER FUNCTIONS

👉 We can **opt out** of automatic batching by wrapping a state update in `ReactDOM.flushSync()` *(but you will never need this)*

```
const reset = function () {
  setAnswer('');
  console.log(answer);
  setBest(true);

  setSolved(false);
};
```

We now get automatic batching **at all times, everywhere**

👉 ***AUTOMATIC BATCHING IN...***

		REACT 17	REACT 18+
EVENT HANDLERS	`<button onClick={reset}>Reset</button>`	✅	✅
TIMEOUTS	`setTimeout(reset, 1000);`	❌	✅
PROMISES	`fetchStuff().then(reset);`	❌	✅
NATIVE EVENTS	`el.addEventListener('click', reset);`	❌	✅

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HOW EVENTS WORK IN REACT

DOM REFRESHER: EVENT PROPAGATION AND DELEGATION

- 👉 By default, event handlers listen to events on the target ***and* during the bubbling phase**
- 👉 We can **prevent bubbling** with `e.stopPropagation()`

EVENT DELEGATION

- 👉 Handling events for multiple elements centrally in **one single parent element**
- 👉 Better for performance and memory, as it needs only **one handler function**

1. Add handler to **parent** (`.options`)
2. Check for **target** element (`e.target`)
3. If **target** is one of the `<button>`s, handle the event

👋 *Very common in vanilla JS apps, but not so much in React apps*

HOW **REACT** HANDLES EVENTS

Usually `div#root`, but can be **any** DOM element

React registers all event handlers on the **root DOM container**. This is where **all events are handled**

WHEN WE ATTACH AN EVENT HANDLER...

```
<button
  className="btn"
  onClick={() ⇒ setLoading(true)}
/>
```

```
document
  .querySelector('.btn')
  .addEventListener(
    'click',
    () ⇒ setLoading(true)
  );
```

⛔ **... WHAT APPEARS TO BE HAPPENING**

```
document
  .querySelector('#root')
  .addEventListener(
    'click',
    () ⇒ setLoading(true)
  );
```

✅ **... WHAT ACTUALLY HAPPENS INTERNALLY**

👉 Behind the scenes, React performs **event delegation** for all events in our applications

SYNTHETIC EVENTS

```
<input onChange={(e) => setText(e.target.value)} />
```

- Wrapper around the DOM's native event object
- Has **same interface** as native event objects, like `stopPropagation()` and `preventDefault()`
- Fixes browser inconsistencies, so that events work in the exact **same way in all browsers**
- **Most synthetic events bubble** (including focus, blur, and change), except for scroll

EVENT HANDLERS IN VS. JS

- Attributes for event handlers are named using **camelCase** (`onClick` instead of `onclick` or `click`)
- Default behavior can **not** be prevented by returning `false` (only by using `preventDefault()`)
- Attach "`Capture`" if you need to handle during **capture phase** (example: `onClickCapture`)

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HOW REACT WORKS BEHIND THE SCENES

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LIBRARIES VS. FRAMEWORKS & THE REACT ECOSYSTEM

FIRST, AN **ANALOGY** 🍣

ALL-IN-ONE KIT

👍 **Ease of mind:** All ingredients are included

👎 **No choice:** You're stuck with the kit's ingredients

SEPARATE INGREDIENTS

👍 **Freedom:** You can choose the best ingredients

👎 **Decision fatigue:** You need to research and buy all ingredients separately

FIRST, AN **ANALOGY** 🍣

ALL-IN-ONE KIT

SEPARATE INGREDIENTS

👍 **Ease of mind:** All ingredients are included

👎 **No choice:** You're stuck with the kit's ingredients

👍 **Freedom:** You can choose the best ingredients

👎 **Decision fatigue:** You need to research and buy all ingredients separately

FRAMEWORK **VS.** LIBRARY

FRAMEWORK

"All-in-one kit"

Frameworks include everything

LARGE-SCALE ANGULAR APP

👍 **Ease of mind:** Everything you need to build a complete application **is included** in the framework ("batteries included")

👎 **No choice:** You're stuck with the framework's tools and conventions (which is not always bad!)

LIBRARY

"Separate ingredients"

"View" library

LARGE-SCALE REACT APP

External libraries

👍 **Freedom:** You can (or *need* to) **choose multiple 3rd-party libraries** to build a complete application

👎 **Decision fatigue:** You need to **research**, **download**, **learn**, and **stay up-to-date** with multiple external libraries

REACT 3RD-PARTY LIBRARY **ECOSYSTEM**

1	Routing (for SPAs)	React Router, React Location
2	HTTP requests	JS fetch(), AXIOS
3	Remote state management	React Query, SWR, APOLLO
4	Global state management	Context API, Redux, Zustand
5	Styling	CSS MODULES, styled components, tailwindcss
6	Form management	React Hook Form, FORMIK
7	Animations/transitions	Motion, react-spring
8	UI components	MUI, chakra, Mantine

👉 Library options for different React application needs

FRAMEWORKS BUILT **ON TOP** OF REACT

"Opinionated"
React frameworks

NEXT.JS

Remix

Gatsby

Full-stack frameworks!

"VANILLA" REACT APP

External libraries

NEXT.JS Remix

Included out of the box

👉 **React frameworks offer many other features**: server-side rendering (SSR), static site generation (SSG), better developer experience (DX), etc.

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SECTION SUMMARY: PRACTICAL TAKEAWAYS

🎯 PRACTICAL SUMMARY

🧩 A **component** is like a blueprint for a piece of UI that will eventually exist on the screen. When we "use" a component, React creates a **component instance**, which is like an actual physical manifestation of a component, containing props, state, and more. A component instance, when rendered, will return a **React element**

```
<Question />
```

```
function Question()
```

☎️ "Rendering" only means **calling component functions** and calculating what DOM elements need to be inserted, deleted, or updated. It has nothing to do with writing to the DOM. Therefore, **each time a component instance is rendered and re-rendered, the function is called again**

🔁 Only the **initial app render** and **state updates** can cause a render, which happens for the **entire application**, not just one single component

👨‍👩‍👧 When a component instance gets re-rendered, **all its children will get re-rendered as well**. This doesn't mean that all children will get updated in the DOM, thanks to reconciliation, which checks which elements have actually changed between two renders. But all this re-rendering can still have an impact on performance (more on that later in the course 👉)

🎯 PRACTICAL SUMMARY

🧬 Diffing is how React decides which DOM elements need to be added or modified. If, between renders, a certain React element **stays at the same position in the element tree**, the corresponding DOM element and component state will stay the same. If the element **changed to a different position**, or if it's a **different element type**, the DOM element and state will be destroyed

🔑 Giving elements a `key` prop allows React to distinguish between multiple component instances. **When a key stays the same across renders**, the element is kept in the DOM. This is why we need to use keys in lists. **When we change the key between renders**, the DOM element will be destroyed and rebuilt. We use this as a **trick to reset state**

🪆 **Never declare a new component inside another component!** Doing so will re-create the nested component every time the parent component re-renders. React will always see the nested component as **new**, and therefore **reset its state** each time the parent state is updated

🔮 The logic that produces JSX output for a component instance ("render logic") is **not allowed to produce any side effects**: no API calls, no timers, no object or variable mutations, no state updates. **Side effects are allowed in event handlers** and **`useEffect`** (next section 👉)

🎯 PRACTICAL SUMMARY

📱 The DOM is updated in the commit phase, **but not by React, but by a “renderer” called ReactDOM**. That’s why we always need to include both libraries in a React web app project. We can use other renderers to use React on different platforms, for example to build mobile or native apps

🗂️ Multiple state updates inside an event handler function are **batched**, so they happen all at once, **causing only one re-render**. This means we can **not access a state variable immediately after updating it**: state updates are **asynchronous**. Since React 18, batching also happens in timeouts, promises, and native event handlers.

🌐 When using events in event handlers, we get access to a **synthetic event object**, not the browser’s native object, so that **events work the same way across all browsers**. The difference is that **most synthetic events bubble**, including focus, blur, and change, which do not bubble as native browser events. Only the scroll event does not bubble

🛠️ **React is a library, not a framework**. This means that you can assemble your application using your favorite third-party libraries. The downside is that you need to find and learn all these additional libraries. No problem, as you will learn about the most commonly used libraries in this course

EFFECTS AND DATA FETCHING

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EFFECTS AND DATA FETCHING

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THE COMPONENT LIFECYCLE

COMPONENT (INSTANCE) **LIFECYCLE**

🐣

MOUNT / INITIAL RENDER

→

🐓 *(Optional)*

RE-RENDER 🔄

→

💀

UNMOUNT

- 👉 Component instance is rendered for the **first time**
- 👉 Fresh state and props are **created**

HAPPENS WHEN:

- 👉 **State** changes
- 👉 **Props** change
- 👉 **Parent** re-renders
- 👉 **Context** changes

- 👉 Component instance is **destroyed** and **removed**
- 👉 State and props are **destroyed**

👋 *We can define code to run at these specific **points in time***

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A FIRST LOOK AT EFFECTS

WHERE TO CREATE **SIDE EFFECTS**

SIDE EFFECT

We need side effects all the time. They make our applications *do something*. **Not** in render logic!

(can be made in...)

Triggered by EVENTS:
`onClick`, `onSubmit`, etc.

Sometimes this is **not enough** for the application's needs

EVENT HANDLERS

Triggered by RENDERING

EFFECTS (`useEffect`)

👉 Effects allow us to write code that will run at **different moments**: mount, re-render, or unmount

👉 **REVIEW:** A **side effect** is basically any "*interaction between a React component and the world outside the component*". We can also think of a side as "*code that actually does something*". **Examples:** Data fetching, setting up subscriptions, setting up timers, manually accessing the DOM, etc.

EVENT HANDLERS **VS.** EFFECTS

Produce the same result, but at **different moments**

EVENT HANDLERS

```
function handleClick() {
  fetch(`http://www.omdbapi.com/?s=inception`)
    .then((res) => res.json())
    .then((data) => setMovies(data.Search));
}
```

EFFECTS (`useEffect`)

```
useEffect(function () {
  fetch(`http://www.omdbapi.com/?s=inception`)
    .then((res) => res.json())
    .then((data) => setMovies(data.Search));

  return () => console.log('Cleanup');
}, []);
```

Effect

Cleanup function

Dependency array

🤔 **When?**

- 👉 Executed when the **corresponding event happens**
- 👉 Used to **react** to an event

☝️ **Preferred way of creating side effects!**

Thinking about synchronization, **not** lifecycles

- 👉 Executed **after the component mounts** (initial render), and **after subsequent re-renders** (according to dependency array)
- 👉 Used to keep a component **synchronized with some external system** (in this example, with the API movie data)

(We'll come back to all this after using `useEffect` in practice...)

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THE USEEFFECT DEPENDENCY ARRAY

WHAT'S THE USEEFFECT **DEPENDENCY** ARRAY?

THE DEPENDENCY ARRAY

- 👉 By default, effects run **after every render**. We can prevent that by passing a **dependency array**
- 👉 Without the dependency array, React doesn't know **when** to run the effect
- 👉 ***Each time one of the dependencies changes, the effect will be executed again***
- ☝️ **Every state variable and prop used inside the effect MUST be included in the dependency array**

```
const title = props.movie.Title;
const [userRating, setUserRating] = useState('');

useEffect(
  function () {
    if (!title) return;
    document.title = `${title} ${
      userRating && `(Rated ${userRating} 🌟)`
    }`;

    return () => (document.title = 'usePopcorn');
  },
  [title, userRating]
);
```

Otherwise, we get a "**stale closure**". We will go more into depth in a future section 👉

USEEFFECT IS A **SYNCHRONIZATION** MECHANISM

THE MECHANICS OF EFFECTS

- 👉 `useEffect` is like an **event listener** that is listening for one dependency to change. **Whenever a dependency changes, it will execute the effect again**
- 👉 Effects **react** to updates to state and props used inside the effect (the dependencies). So **effects are "reactive"** (like state updates re-rendering the UI)

COMPONENT STATE/PROPS → **SYNCHRONIZE WITH** → EXTERNAL SYSTEM (SIDE EFFECT)

SYNCHRONIZATION **AND** LIFECYCLE

DEPENDENCY (STATE OR PROPS) CHANGES

→ **EFFECT IS EXECUTED AGAIN**

→ **COMPONENT IS RE-RENDERED**

Effects and **component lifecycle** are deeply connected

👉 We can use the dependency array to run effects **when the component renders or re-renders**

	🔄 **SYNCHRONIZATION**	🐣 **LIFECYCLE**
`useEffect(fn, [x, y, z]);` →	Effect synchronizes with **x**, **y**, and **z**	Runs on **mount** and **re-renders** triggered by updating x, y, or z
`useEffect(fn, []);` →	Effect synchronizes with **no state/props**	Runs only on **mount** (initial render)
`useEffect(fn);` →	Effect synchronizes with **everything**	Runs on **every render** (usually bad ⛔)

WHEN ARE EFFECTS **EXECUTED**?

`title = 'Interstellar'`

`title = 'Interstellar Wars'`

time

MOUNT (INITIAL RENDER)

COMMIT

BROWSER PAINT

EFFECT ✨

```
<MovieDetails />
```

If an effect sets state, an **additional render** will be required

```
document.title = `${title} ${
  userRating && `(Rated ${userRating} 🌟)`
}`;
```

Interstellar

`title` CHANGES

RE-RENDER

COMMIT

LAYOUT EFFECT

BROWSER PAINT

EFFECT ✨

Another type of effect that is **very rarely** necessary (`useLayoutEffect`)

```
[title, userRating]
```

```
document.title = `${title} ${
  userRating && `(Rated ${userRating} 🌟)`
}`;
```

Interstellar Wars

UNMOUNT

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THE USEEFFECT CLEANUP FUNCTION

WHEN ARE EFFECTS **EXECUTED?**

`title = 'Interstellar'`

`title = 'Interstellar Wars'`

time

MOUNT (INITIAL RENDER)

```
<MovieDetails />
```

COMMIT

BROWSER PAINT

EFFECT ✨

```
document.title = `${title} ${
  userRating && `(Rated ${userRating} 🌟)`
}`;
```

Interstellar

`title` CHANGES

RE-RENDER

COMMIT

LAYOUT EFFECT

BROWSER PAINT

```
() => (document.title = 'usePopcorn');
```

usePopcorn

CLEANUP 🧹

EFFECT ✨

```
document.title = `${title} ${
  userRating && `(Rated ${userRating} 🌟)`
}`;
```

Interstellar Wars

UNMOUNT

CLEANUP 🧹

```
() => (document.title = 'usePopcorn');
```

usePopcorn

THE **CLEANUP** FUNCTION

USEEFFECT CLEANUP FUNCTION

- 👉 Function that we can **return from an effect** (*optional*)
- 👉 Runs on two different occasions:
  1. Before the effect is **executed again**
  2. After a component has **unmounted**
- 👉 Necessary whenever the side effect **keeps happening after the component has been re-rendered or unmounted**
- ☝️ Each effect should do **only one thing**! Use **one `useEffect` hook for each side effect**. This makes effects easier to clean up

COMPONENT **RENDERS**	→	Execute effect if **dependency array** includes updated data
COMPONENT **UNMOUNTS**	→	Execute **cleanup function**

Examples

✨ EFFECT		🧹 POTENTIAL CLEANUP
👉 HTTP request	→	Cancel request
👉 API subscription	→	Cancel subscription
👉 Start timer	→	Stop timer
👉 Add event listener	→	Remove listener

CUSTOM HOOKS, REFS, AND MORE STATE

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CUSTOM HOOKS, REFS, AND MORE STATE

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REACT HOOKS AND THEIR RULES

WHAT ARE REACT **HOOKS**?

REACT HOOKS

- 👉 Special built-in functions that allow us to **“hook” into React internals:**
  - 👉 Creating and accessing **state** from Fiber tree
  - 👉 Registering **side effects** in Fiber tree
  - 👉 Manual **DOM selections**
  - 👉 Many more...
- 👉 Always start with “**`use`**” (`useState`, `useEffect`, etc.)
- 👉 Enable easy **reusing of non-visual logic**: we can compose multiple hooks into our own **custom hooks**
- 👉 Give **function components** the ability to own state and run side effects at different lifecycle points (before v16.8 only available in class **components**)

OVERVIEW OF ALL **BUILT-IN** HOOKS

🥇 MOST USED

- ✅ `useState`
- ✅ `useEffect`
- 👉 `useReducer`
- 👉 `useContext`

📜 LESS USED

- 👉 `useRef`
- 👉 `useCallback`
- 👉 `useMemo`
- 👉 `useTransition`
- 👉 `useDeferredValue`
- ❌ `useLayoutEffect`
- ❌ `useDebugValue`
- ❌ `useImperativeHandle`
- ❌ `useId`

🗄️ ONLY FOR LIBRARIES

- ❌ `useSyncExternalStore`
- ❌ `useInsertionEffect`

✅ Have learned
👉 Will learn
❌ Will **not** learn

👋 *As of React v18.x*

THE **RULES** OF HOOKS

☝️ **RULES OF HOOKS**

1 **Only call hooks at the top level**

- 👉 Do **NOT** call hooks inside **conditionals**, **loops**, **nested functions**, or after an **early return**
- 👉 This is necessary to ensure that hooks are always called in the **same order** (hooks rely on this)

2 **Only call hooks from React functions**

- 👉 Only call hooks inside a **function component** or a **custom hook**

👋 *These rules are **automatically enforced** by React's ESLint rules*

HOOKS RELY ON **CALL ORDER**

☝️ ***Hypothetical example**! This code does **NOT** work*

```
const [A, setA] = useState(23)   1
                           ~~23~~ 7

if (A === 23) false
  const [B, setB] = useState('')   2

useEffect(fnZ, [])   3
```

Violates Rule #1

List built based on hooks **call order**

LINKED LIST OF USED HOOKS

`A===23` is now `false`, so after re-render, this hook would no longer exist, **destroying the linked list** 😢

👉 **Hooks need to called in the same order on every render**

HOOKS RELY ON **CALL ORDER**

Order num uniquely identifies each hook

👍 *Correct code!*

```
const [A, setA] = useState(23)   1

  const [B, setB] = useState('')   2

useEffect(fnZ, [])   3
```

List built based on hooks **call order**

LINKED LIST OF USED HOOKS

👉 Hooks need to called in the same order on every render

☝️ Hooks can only be called at top level

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CUSTOM HOOKS, REFS, AND MORE STATE

LECTURE

USESTATE SUMMARY

SUMMARY OF DEFINING AND UPDATING STATE

1 **CREATING STATE**

Simple

```
const [count, setCount] = useState(23);
```

Based on function (lazy evaluation)

```
const [count, setCount] = useState(
  () ⇒ localStorage.getItem('count')
);
```

👉 Function must be **pure** and accept **no arguments**. Called only on **initial render**

Make sure to **NOT** mutate objects or arrays, but to **replace** them

2 **UPDATING STATE**

Simple

```
setCount(1000);
```

Based on current state

```
setCount((c) ⇒ c + 1)
```

👉 Function must be **pure** and return next state

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INTRODUCING ANOTHER HOOK: USEREF

WHAT ARE **REFS**?

REF WITH `useRef`

- 👉 "Box" (object) with a **mutable** `.current` property that is **persisted across renders** (*"normal" variables are always reset*)
- 👉 Two big use cases:
  1. **Creating a variable that stays the same between renders (e.g. previous state, `setTimeout` id, etc.)**
  2. **Selecting and storing DOM elements**
- 👉 Refs are for **data that is NOT rendered**: usually only appear in event handlers or effects, not in JSX (otherwise use state)
- ☝️ Do **NOT** read write or read `.current` in render logic (like state)

```
const myRef = useRef(23);
```

We can write to and read from the ref using `.current`

```
myRef.current = 1000;
```

STATE **VS.** REFS

	PERSISTS ACROSS RENDERS	UPDATING CAUSES RE-RENDER	IMMUTABLE	ASYNCHRONOUS UPDATES
STATE	✅	✅	✅	✅
REFS	✅	❌	❌	❌

Need to store data → Will data change at some point?

(Taken from lecture "Fundamentals of state management")

- NO → Regular `const` variable
- YES ↓ Should it re-render component?
  - NO → Ref (`useRef`)
  - YES ↓ State (`useState`)

Examples: preserving previous state, or storing the id of a `setTimeout`

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CUSTOM HOOKS, REFS, AND MORE STATE

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WHAT ARE CUSTOM HOOKS?
WHEN TO CREATE ONE?

REUSING LOGIC WITH CUSTOM HOOKS

- 👉 Allow us to reuse **non-visual logic** in multiple components
- 👉 One custom hook should have **one purpose**, to make it **reusable** and **portable** (even across multiple projects)
- 👉 **Rules of hooks** apply to custom hooks too

Function name needs to start with **use**

```
function useFetch (url) {
  const [data, setData] = useState ([]);
  const [isLoading, setIsLoading] =
    useState false);

  useEffect(function () {
    fetch(url)
      .then((res) ⇒ res.json())
      .then((res) ⇒ setData(res));
  }, []);

  return [data, isLoading]
}
```

Needs to use **one or more hooks**

Unlike components, can receive and return **any relevant data** (usually [] or {})

REACT BEFORE HOOKS: CLASS-BASED REACT

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REACT BEFORE HOOKS: CLASS-BASED REACT

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CLASS COMPONENTS VS. FUNCTION COMPONENTS

FUNCTION COMPONENTS **VS.** CLASS COMPONENTS

Existed since beginning, but without hooks

	FUNCTION COMPONENTS	CLASS COMPONENTS
Introduced in	v16.8 (2019, with hooks)	v0.13 (2015)
How to create	JavaScript function (any type)	ES6 class, extending `React.Component`
Reading props	Destructuring or `props.X`	`this.props.X`
Local state	`useState` hook	`this.setState()`
Side effects/lifecycle	`useEffect` hook	Lifecycle methods
Event handlers	Functions	Class methods
Returning JSX	Return JSX from function	Return JSX from `render` method

Hooks are THE big difference

Advantages

- 👍 Easier to build (less boilerplate code)
- 👍 Cleaner code: `useEffect` combines all lifecycle-related code in a single place
- 👍 Easier to share stateful logic
- 👍 We don't need `this` keyword anymore

- 👍 Lifecycle might be easier to understand for beginners

PART 03

—

ADVANCED REACT + REDUX

THE ADVANCED USEREDUCER HOOK

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THE ADVANCED USEREDUCER HOOK

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MANAGING STATE WITH USEREDUCER

WHY USEREDUCER?

👉 **STATE MANAGEMENT WITH `useState` IS NOT ENOUGH IN CERTAIN SITUATIONS:**

1. When components have **a lot of state variables and state updates**, spread across many event handlers **all over the component**
2. When **multiple state updates** need to happen **at the same time** (as a reaction to the same event, like “starting a game”)
3. When updating one piece of state **depends on one or multiple other pieces of state**

👉 **IN ALL THESE SITUATIONS, `useReducer` CAN BE OF GREAT HELP**

MANAGING STATE WITH USEREDUCER

STATE WITH useReducer

- An alternative way of setting state, ideal for **complex state** and **related pieces of state**
- Stores related pieces of state in a `state` object
- `useReducer` needs `reducer:` function containing **all logic to update `state`. Decouples state logic from component**
- `reducer:` pure function (***no side effects!***) that takes current `state` and `action`, **and returns the next `state`**
- `action:` object that describes **how to update state**
- `dispatch:` function to trigger state updates, by **"sending" actions** from **event handlers** to the `reducer`

Like `setState()` with superpowers

Instead of `setState()`

```
const [state, dispatch] =
  useReducer(reducer, initialState);
```

```
function reducer(state, action) {
  switch (action.type) {
    case 'dec':
      return state - 1;
    case 'inc':
      return state + 1;
    case 'setCount':
      return action.payload;
    default:
      throw new Error('Unknown');
  }
}
```

HOW REDUCERS UPDATE STATE

```
const [state, dispatch] = useReducer(reducer, initialState);
```

useReducer

useState

A **MENTAL MODEL** FOR REDUCERS

👉 **REAL-WORLD TASK:** WITHDRAWING $5,000 FROM YOUR BANK ACCOUNT

YOU DO **NOT** GO TO YOUR BANK AND TAKE MONEY STRAIGHT FROM THE BANK'S VAULT 😂

A **MENTAL MODEL** FOR REDUCERS

👉 **REAL-WORLD TASK:** WITHDRAWING $5,000 FROM YOUR BANK ACCOUNT

I would like to withdraw $5,000 from account 923577

(**How** to make the update)

ACTION

```
type: 'withdraw',
payload: {
  amount: 5000,
  account: 923577,
},
```

DISPATCHER

(**Who *requests*** the update)

REDUCER

(**Who *makes*** the update)

STATE

(**What** needs to be updated)

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THE ADVANCED USEREDUCER HOOK

LECTURE

SECTION SUMMARY: USESTATE VS. USEREDUCER

USESTATE **VS.** USEREDUCER

`useState`

- 👉 Ideal for **single, independent pieces of state** (numbers, strings, single arrays, etc.)
- 👉 Logic to update state is placed directly in event handlers or effects, **spread all over one or multiple components**
- 👉 State is updated by **calling `setState`** (setter returned from `useState`)
- 👉 **Imperative** state updates

```
setScore(0);
setPlaying(true);
setTimerSec(0);
```

- 👉 **Easy** to understand and to use

`useReducer`

- 👉 Ideal for multiple **related pieces of state** and **complex state** (e.g. object with many values and nested objects or arrays)
- 👉 Logic to update state lives in **one central place, decoupled from components**: the reducer
- 👉 State is updated by **dispatching an action** to a reducer
- 👉 **Declarative** state updates: complex state transitions are **mapped** to actions

```
dispatch({ type: 'startGame' });
```

- 👉 More **difficult** to understand and implement

WHEN TO USE USEREDUCER?

```
setScore(0);
setPlaying(true);
setTimerSec(0);
```

☝️ `useState` should remain your **default choice** for managing state

REACT ROUTER: BUILDING SINGLE-PAGE APPLICATIONS (SPA)

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REACT ROUTER: BUILDING SINGLE PAGE APPLICATIONS (SPA)

LECTURE

ROUTING AND SINGLE-PAGE APPLICATIONS (SPAS)

WHAT IS **ROUTING**?

ROUTING

"Client-side routing"

- With routing, we match **different URLs** to **different UI views** (React components): **routes**
- This enables users to **navigate between different applications screens**, using the browser URL
- Keeps the UI **in sync** with the current browser URL
- Allows us to build **Single-Page Applications**

→ React Router

`www.example.com/`

`www.example.com/login`

`www.example.com/app`

SINGLE-PAGE APPLICATIONS (SPA)

SINGLE-PAGE APPLICATION

- 👉 Application that is **executed entirely on the client** (browsers)
- 👉 **Routes**: different URLs correspond to different views (components)
- 👉 **JavaScript** (React) is used to update the page (DOM)
- 👉 ***The page is never reloaded***
- 👉 Feels like a **native app**
- 👉 Additional data **might be loaded** from a web API

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REACT ROUTER: BUILDING SINGLE PAGE APPLICATIONS (SPA)

LECTURE

STYLING OPTIONS FOR REACT APPLICATIONS

STYLING OPTIONS IN REACT

React doesn't care about styling

STYLING OPTION	WHERE?	HOW?	SCOPE	BASED ON
👉 **Inline CSS**	JSX elements	`style` prop	Local JSX element	CSS
👉 **CSS or Sass file**	External file	`className` prop	Global, causes problems Entire app	CSS
👉 **CSS Modules**	One external file per component	`className` prop	Component	CSS
👉 **CSS-in-JS**	External file or component file	Creates new component	Component	JavaScript
👉 **Utility-first CSS** tailwindcss	JSX elements	`className` prop	JSX element	CSS

👋 Alternative to styling with CSS: UI libraries like MUI, Chakra UI, Mantine, etc. chakra Mantine

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REACT ROUTER: BUILDING SINGLE PAGE APPLICATIONS (SPA)

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STORING STATE IN THE URL

THE URL FOR **STATE MANAGEMENT**

👉 The URL is an excellent place to store UI state and an alternative to `useState` in some situations!
Examples: open/closed panels, currently selected list item, list sorting order, applied list filters

1. Easy way to store state in a **global place**, accessible to **all components** in the app
2. Good way to **"pass" data** from one page into the next page
3. Makes it possible to **bookmark and share** the page with the exact UI state it had at the time

```
www.example.com/app/cities/lisbon?lat=38.728&lng=-9.141
```

React Router tools: path, params, query string

EXAMPLE: **PARAMS** AND **QUERY STRING**

www.example.com/**app/cities/lisbon?lat=38.728&lng=-9.141**

👉 **City name** and **GPS location** were retrieved from the **URL** instead of application state!

www.example.com/**app/cities/berlin?lat=52.536&lng=13.377**

ADVANCED STATE MANAGEMENT: THE CONTEXT API

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ADVANCED STATE MANAGEMENT: THE CONTEXT API

LECTURE

WHAT IS THE CONTEXT API?

A SOLUTION TO **PROP DRILLING**

👉 **TASK: Passing state into multiple deeply nested child components**

💡 **SOLUTION 1: PASSING PROPS**

⛔ **PROBLEM: "PROP DRILLING"**

✅ **SOLUTION 2: CONTEXT API**

👍 **READ STATE FROM EVERYWHERE**

👋 Remember that a good solution to "prop drilling" is **better component composition** (see "Thinking in React" section)

WHAT IS THE **CONTEXT** API?

CONTEXT API

- System to pass data throughout the app **without manually passing props** down the tree
- Allows us to **"broadcast" global state** to the entire app

1. **Provider:** gives all child components access to `value`
2. **`value`:** data that we want to make available (usually state and functions)
3. **Consumers:** all components that read the provided context `value`

A new way of re-rendering components!

`value` is updated → All consumers re-render

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ADVANCED STATE MANAGEMENT: THE CONTEXT API

LECTURE

THINKING IN REACT: ADVANCED STATE MANAGEMENT

REVIEW: WHAT IS STATE MANAGEMENT?

🏠 **State management:** Giving each piece of state the right **home**

- ✅ **When** to use state
- ✅ **Types** of state (**accessibility**): local vs. global
- 👉 **Types** of state (**domain**): UI vs. remote
- 👉 **Where** to place each piece of state
- 👉 **Tools** to manage all types of state

This lecture!

From Lecture "Fundamentals of State Management". You can keep using this 👌

TYPES OF STATE

1️⃣ STATE ACCESSIBILITY

*"If this component was rendered **twice**, should a state update in one of them reflect in the other one?"*

NO

🏠 LOCAL STATE

- 👉 Needed only by **one or few components**
- 👉 Only accessible in **component and child components**

VS.

🌍 GLOBAL STATE

- 👉 Might be needed by **many components**
- 👉 Accessible to **every component** in the application

2️⃣ STATE DOMAIN

🌐 REMOTE STATE

- 👉 All application data **loaded from a remote server** (API)
- 👉 Usually **asynchronous**
- 👉 Needs re-fetching + updating

VS.

🪄 UI STATE

- 👉 **Everything else** 😅
- 👉 Theme, list filters, form data, etc.
- 👉 Usually **synchronous** and stored in the application

STATE **PLACEMENT** OPTIONS

🤔 *Where to place state?*	TOOLS 👇	WHEN TO USE? 👇
🏠 **Local component**	`useState`, `useReducer`, or `useRef`	Local state
👩‍👧 **Parent component**	`useState`, `useReducer`, or `useRef`	Lifting up state
🌐 **Context**	Context API + `useState` or `useReducer`	Global state (preferably UI state)
🗃️ **3rd-party library**	Redux, React Query, SWR, Zustand, etc.	Global state (remote or UI)
📍 **URL**	React Router	Global state, passing between pages
👩‍💻 **Browser**	Local storage, session storage, etc.	Storing data in user's browser

STATE MANAGEMENT **TOOL** OPTIONS

🤔 *How to manage different types of state in practice?*

1️⃣ **STATE ACCESSIBILITY**

2️⃣ **STATE DOMAIN**

	🏠 **LOCAL STATE**	🌍 **GLOBAL STATE**
🪄 **UI STATE**	👉 `useState` 👉 `useReducer` 👉 `useRef`	👉 Context API + `useState`/`useReducer` 👉 Redux, Zustand, Recoil, etc. 👉 React Router
🌐 **REMOTE STATE**	👉 `fetch` + `useEffect` + `useState`/`useReducer`	👉 Context API + `useState`/`useReducer` 👉 Redux, Zustand, Recoil, etc. 👉 React Query 👉 SWR 👉 RTK Query

Mostly in small applications

Tools highly specialized in handling **remote** state

PERFORMANCE OPTIMIZATION AND ADVANCED USEEFFECT

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PERFORMANCE OPTIMIZATION AND ADVANCED USEEFFECT

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PERFORMANCE OPTIMIZATION AND WASTED RENDERS

PERFORMANCE OPTIMIZATION **TOOLS**

1 PREVENT WASTED RENDERS

- 👉 `memo`
- 👉 `useMemo`
- 👉 `useCallback`
- 👉 Passing elements as `children` or regular prop

2 IMPROVE APP SPEED/ RESPONSIVENESS

- 👉 `useMemo`
- 👉 `useCallback`
- 👉 `useTransition`

3 REDUCE BUNDLE SIZE

- 👉 Using fewer 3rd-party packages
- 👉 Code splitting and lazy loading

👋 This list of tools and techniques is, by no means, exhaustive. You're already doing many optimizations by following the best practices I have been showing you ✌️

WHEN DOES A COMPONENTS INSTANCE **RE-RENDER**?

👉 *A component instance only gets re-rendered in 3 different situations:*

🧠 **STATE CHANGES**

🌐 **CONTEXT CHANGES**

👪 **PARENT RE-RENDERS**

Creates the false impression that **changing props** re-renders a component. This is **NOT** true.

👋 **Remember:** a render does ***not* mean that the DOM actually gets updated**, it just means the component function gets called. But this can be an expensive operation.

⬇

Usually no problem, as React is very fast!

👉 **Wasted render:** a render that didn't produce any change in the DOM

👉 Only a problem when they happen **too frequently** or when the **component is very slow**

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PERFORMANCE OPTIMIZATION AND ADVANCED USEEFFECT

LECTURE

UNDERSTANDING MEMO

WHAT IS **MEMOIZATION**?

👉 **Memoization:** Optimization technique that executes a pure function once, and saves the result in memory. If we try to execute the function again with the **same arguments as before**, the previously saved result will be returned, **without executing the function again**.

- 👉 Memoize **components** with `memo`
- 👉 Memoize **objects** with `useMemo`
- 👉 Memoize **functions** with `useCallback`

1. **Prevent wasted renders**
2. **Improve app speed/responsiveness**

THE `MEMO` FUNCTION

`memo`

Memoized component

- Used to create a component that will **not re-render when its parent re-renders**, as long as the **props stay the same between renders**
- **Only affects props**! A memoized component will still re-render when its **own state changes** or when a **context that it's subscribed to changes**
- Only makes sense when the component is **heavy** (slow rendering), **re-renders often**, and does so **with the same props**

⛔ REGULAR BEHAVIOR (NO `MEMO`)

✅ MEMOIZED CHILD WITH `MEMO`

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PERFORMANCE OPTIMIZATION AND ADVANCED USEEFFECT

LECTURE

UNDERSTANDING USEMEMO AND USECALLBACK

AN **ISSUE** WITH `MEMO`

In React, everything is **re-created on every render** (including objects and functions)

↓

In JavaScript, two objects or functions that look the same, **are actually different** (`{} != {}`)

THEREFORE ↓

If objects or functions are passed as props, the child component will always see them as **new props on each re-render**

↓

If props are different between re-renders, *`memo` will not work*

SOLUTION ↓

We need to memoize objects and functions, to make them stable (preserve) between re-renders (`memoized {} == memoized {}`)

TWO NEW HOOKS: `USEMEMO` AND `USECALLBACK`

`useMemo` AND `useCallback`

- 👉 Used to memoize values (**`useMemo`**) and functions (**`useCallback`**) **between renders**
- 👉 Values passed into `useMemo` and `useCallback` will be stored in memory ("cached") and **returned in subsequent re-renders, as long as dependencies** ("*inputs*") **stay the same**
- 👉 `useMemo` and `useCallback` have a **dependency array** (like `useEffect`): whenever one **dependency changes**, the value will be **re-created**

⛔ REGULAR BEHAVIOR (NO `USEMEMO`)

✅ MEMOIZING A VALUE WITH `USEMEMO`

TWO NEW HOOKS: `USEMEMO` AND `USECALLBACK`

`useMemo` AND `useCallback`

- 👉 Used to memoize values (**`useMemo`**) and functions (**`useCallback`**) **between renders**
- 👉 Values passed into `useMemo` and `useCallback` will be stored in memory ("cached") and **returned in subsequent re-renders, as long as dependencies** ("*inputs*") **stay the same**
- 👉 `useMemo` and `useCallback` have a **dependency array** (like `useEffect`): whenever one **dependency changes**, the value will be **re-created**
- 👉 Only use them for one of the three **use cases**!

THREE BIG USES CASES:

1. Memoizing props to prevent wasted renders (together with `memo`)
2. Memoizing values to avoid expensive re-calculations on every render
3. Memoizing values that are used in dependency array of another hook

For example to avoid infinite `useEffect` loops

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PERFORMANCE OPTIMIZATION AND ADVANCED USEEFFECT

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OPTIMIZING BUNDLE SIZE WITH CODE SPLITTING

THE **BUNDLE** AND **CODE SPLITTING**

- 👉 **Bundle:** JavaScript file containing the **entire application code**. Downloading the bundle will load **the entire app at once**, turning it into a SPA
- 👉 **Bundle size:** Amount of JavaScript users have to download to start using the app. One of the most important things to be optimized, so that the bundle takes **less time to download**
- 👉 **Code splitting:** Splitting bundle into multiple parts that can be **downloaded over time** (“lazy loading”)

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PERFORMANCE OPTIMIZATION AND ADVANCED USEEFFECT

LECTURE

DON'T OPTIMIZE PREMATURELY!

DON'T OPTIMIZE **PREMATURELY!**

DO

- ✅ **Find performance bottlenecks using the Profiler and visual inspection (laggy UI)**
- ✅ Fix those real performance issues
- ✅ Memoize expensive re-renders
- ✅ Memoize expensive calculations
- ✅ Optimize context if it has many consumers and changes often
- ✅ Memoize context value + child components
- ✅ Implement code splitting + lazy loading for SPA routes

DON'T!

- 🚫 **Don't optimize prematurely!**
- 🚫 Don't optimize anything if there is nothing to optimize...
- 🚫 Don't wrap all components in `memo()`
- 🚫 Don't wrap all values in `useMemo()`
- 🚫 Don't wrap all functions in `useCallback()`
- 🚫 Don't optimize context if it's not slow and doesn't have many consumers

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USEEFFECT RULES AND BEST PRACTICES

USEEFFECT DEPENDENCY ARRAY **RULES**

DEPENDENCY ARRAY RULES

- ☝️ **Every state variable, prop used inside the effect MUST be included in the dependency array**
- ☝️ **All "reactive values" must be included!** That means any **function** or **variable** that reference **any other** reactive value
- ☝️ Dependencies choose themselves: **NEVER** ignore the `exhaustive-deps` ESLint rule!
- ☝️ Do **NOT** use **objects** or **arrays** as dependencies (objects are recreated on each render, and React sees new objects as **different**, `{} !== {}`)

Reactive value: state, prop, or context value, ***or*** any other value that *references* a reactive value

```
const [number, setNumber] = useState(5);
const [duration, setDuration] = useState(0);
const mins = Math.floor(duration);
const secs = (duration - mins) * 60;

const formatDur = function () {
  return `${mins}:${secs < 10 ? '0' : ''}${secs}`;
};

useEffect(
  function () {
    document.title =
      `${number}-exercise workout (${formatDur()})`;
  },
  [number, formatDur]
);
```

All reactive values used in effect

👋 The **same rules** apply to the dependency arrays of other hooks: `useMemo` and `useCallback`

REMOVING **UNNECESSARY** DEPENDENCIES

🤖 REMOVING FUNCTION DEPENDENCIES

- 👉 Move function **into the effect**
- 👉 If you need the function in multiple places, **memoize it** (`useCallback`)
- 👉 If the function doesn't reference any reactive values, move it **out of the component**

📦 REMOVING OBJECT DEPENDENCIES

- 👉 Instead of including the entire object, include **only the properties you need** (primitive values)
- 👉 If that doesn’t work, use the same strategies as for functions (**moving** or **memoizing** object)

🎯 OTHER STRATEGIES

- 👉 If you have **multiple related reactive values** as dependencies, try using a **reducer** (`useReducer`)
- 👉 You don’t need to include `setState` (from `useState`) and `dispatch` (from `useReducer`) in the dependencies, as **React guarantees them to be stable** across renders

WHEN **NOT** TO USE AN EFFECT

☝️ Effects should be used as a **last resort**, when no other solution makes sense. React calls them an “escape hatch” to step outside of React

Avoid these as a beginner

THREE CASES WHERE EFFECTS ARE OVERUSED:

1. **Responding to a user event**. An event handler function should be used instead
2. **Fetching data on component mount**. This is fine in small apps, but in real-world app, a library like React Query should be used
3. **Synchronizing state changes with one another** (setting state based on another state variable). Try to use derived state and event handlers

We actually do this in the current project, but for a good reason 😅

REDUX AND MODERN REDUX TOOLKIT (WITH THUNKS)

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REDUX AND MODERN REDUX TOOLKIT (WITH THUNKS)

LECTURE

INTRODUCTION TO REDUX

WHAT IS **REDUX**?

REDUX

- 3rd-party library to manage **global state**
- **Standalone** library, but easy to integrate with React apps using `react-redux` library
- All global state is stored in one **globally accessible store**, which is easy to update using **"actions"** (like `useReducer`)
- It's conceptually similar to using the Context API + `useReducer`
- Two "versions": **(1)** Classic Redux, **(2)** Modern Redux Toolkit

We will learn both 😎

Redux

Global store is updated

↓

All consuming components re-render

☝️ **You need to have a really good understanding of the `useReducer` hook in order to understand Redux!**

DO YOU NEED TO **LEARN** REDUX?

👋 Historically, Redux was used in most React apps for all global state. Today, that has changed, because there are many alternatives. **Many apps don't need Redux anymore**, unless they need **a lot of global UI state**.

You might not need to learn Redux...

🤔 WHY LEARN REDUX IN THIS COURSE?

1. Redux can be hard to learn, and this course teaches it well 😅
2. You will encounter Redux code in your job, so you should understand it
3. Some apps *do* require Redux (or a similar library)

REDUX **USE CASES**

👋 Historically, Redux was used in most React apps for all global state. Today, that has changed, because there are many alternatives. **Many apps don't need Redux anymore**, unless they need **a lot of global UI state**.

	🏠 LOCAL STATE	🌍 GLOBAL STATE
🪄 UI STATE	👉 `useState` 👉 `useReducer` 👉 `useRef`	👉 Context API + `useState/useReducer` 👉 Redux, Zustand, Recoil, etc. 👉 React Router
🌐 REMOTE STATE	👉 `fetch` + `useEffect` + `useState/useReducer`	👉 Context API + `useState/useReducer` 👉 Redux, Zustand, Recoil, etc. 👉 React Query 👉 SWR 👉 RTK Query

Ideal use case for Redux, when there is **lots** of state that updates frequently

For *remote* global state, we have better, more specialized tools

THE REASON WHY MANY APPS DON'T USE REDUX

THE **MECHANISM** OF THE USEREDUCER HOOK

THE **MECHANISM** OF REDUX

THE **MECHANISM** OF REDUX

- 👉 **Redux cycle**
- 👉 **Goal:** make the state update logic separate from the rest of the application

THE **MECHANISM** OF REDUX

👉 **REAL-WORLD TASK:** DEPOSITING $50 INTO YOUR BANK ACCOUNT

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REDUX AND MODERN REDUX TOOLKIT (WITH THUNKS)

LECTURE

REDUX MIDDLEWARE AND THUNKS

WHAT IS REDUX **MIDDLEWARE**?

🤔 Where to make an **asynchronous API call** (or any other async operation) in Redux?

A function that sits between dispatching the action and the store. Allows us to run code ***after*** dispatching, but ***before*** reaching the reducer in the store.

🤷‍♂️ Can make asynchronous operations and then dispatch

🤷‍♂️ Fetching data in components is not ideal

👍 Perfect for asynchronous code

👍 API calls, timers, logging, etc.

👍 The place for side effects

🚫 No asynchronous operations

🚫 Reducers need to be pure functions

REDUX **THUNKS**

🤔 Where to make an **asynchronous API call** (or any other async operation) in Redux?

🤷‍♂️ Can make asynchronous operations and then dispatch

🤷‍♂️ Fetching data in components is not ideal

👍 Perfect for asynchronous code

👍 API calls, timers, logging, etc.

👍 The place for side effects

🚫 No asynchronous operations

🚫 Reducers need to be pure functions

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LECTURE

WHAT IS REDUX TOOLKIT (RTK)?

WHAT IS **REDUX TOOLKIT**?

REDUX TOOLKIT

- 👉 The **modern and preferred** way of writing Redux code
- 👉 An **opinionated** approach, forcing us to use Redux best practices
- 👉 100% compatible with “classic” Redux, allowing us to **use them together**
- 👉 Allows us to write **a lot less code** to achieve the same result (less “boilerplate”)
- 👉 Gives us 3 big things (but there are many more...):

1. We can write code that **“mutates”** state inside reducers (will be converted to **immutable** logic behind the scenes by “Immer” library)
2. Action creators are **automatically** created
3. **Automatic** setup of thunk middleware and DevTools

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REDUX AND MODERN REDUX TOOLKIT (WITH THUNKS)

LECTURE

REDUX VS. CONTEXT API

CONTEXT API **VS.** REDUX

CONTEXT API + `useReducer`

- 👍 Built into React
- 👍 Easy to set up a **single context**
- 👎 Additional state "slide" requires new context **set up from scratch** ("provider hell" in `App.js`)
- 👎 **No** mechanism for async operations
- 👎 Performance optimization is a **pain**
- 👎 Only React DevTools

REDUX

- 👎 Requires additional package (larger bundle size)
- 👎 More work to set up **initially**
- 👍 Once set up, it's easy to create **additional state "slices"**
- 👍 Supports **middleware** for async operations
- 👍 Performance is optimized **out of the box**
- 👍 Excellent DevTools

Keep in mind that we should **not** use these solutions for **remote** state

WHEN TO USE CONTEXT API OR REDUX?

CONTEXT API + useReducer

*"Use the Context API for global state management in **small** apps"*

- 👉 When you just need to share a value that **doesn't change often** *[Color theme, preferred language, authenticated user, ...]*
- 👉 When you need to solve a simple **prop drilling** problem
- 👉 When you need to manage state in a **local sub-tree** of the app

For example in the compound component pattern

These are not super common in UI state

REDUX

*"Use Redux for global state management in **large** apps"*

- 👉 When you have lots of global UI state that needs to be **updated frequently** *(because Redux is optimized for this) [Shopping cart, current tabs, complex filters or search, ...]*
- 👉 When you have **complex state** with nested objects and arrays *(because you can mutate state with Redux Toolkit)*

👋 There is no right answer that fits every project. It all depends on the project needs!

PART 04

—

PROFESSIONAL REACT DEVELOPMENT

REACT ROUTER WITH DATA LOADING (V6.4+)

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REACT ROUTER WITH DATA LOADING (V6.4+)

LECTURE

APPLICATION PLANNING

THE PROJECT: 🍕 FAST REACT PIZZA CO.

REMEMBER OUR VERY FIRST PROJECT?

🍕 FAST REACT PIZZA CO.

- 👉 Now the same restaurant (business) needs a simple way of allowing customers to **order pizzas and get them delivered** to their home
- 👉 We were hired to build the application front-end 🎉

🎯 HOW TO **PLAN** AND **BUILD** A REACT APPLICATION

FROM THE EARLIER "THINKING IN REACT" LECTURE:

1. Break the desired UI into **components**
2. Build a **static** version (no state yet)
3. Think about **state management + data flow**

↓

- 👉 This works well for small apps with **one page and a few features**
- 👉 In **real-world apps**, we need to adapt this process

🎯 HOW TO **PLAN** AND **BUILD** A REACT APPLICATION

This is just a rough overview. In the real-world, things are never this linear

1. Gather application **requirements and features**

2. Divide the application into **pages**

   - 👉 Think about the **overall** and **page-level** UI
   - 👉 Break the desired UI into **components** ← From earlier
   - 👉 Design and build a **static** version (no state yet) ← From earlier

3. Divide the application into **feature categories**

   - 👉 Think about **state management + data flow** ← From earlier

4. Decide on what **libraries** to use (technology decisions)

👨‍💼 PROJECT **REQUIREMENTS** FROM THE BUSINESS

STEP 1

- 👉 Very simple application, where users can order **one or more pizzas from a menu**
- 👉 Requires **no user accounts** and no login: users just input their names before using the app
- 👉 The pizza menu can change, so it should be **loaded from an API** ✅ DONE
- 👉 Users can add multiple pizzas to a **cart** before ordering
- 👉 Ordering requires just the **user's name**, **phone number**, and **address**
- 👉 If possible, **GPS location** should also be provided, to make delivery easier
- 👉 User's can **mark their order as "priority"** for an additional 20% of the cart price
- 👉 Orders are made by **sending a POST request** with the order data (user data + selected pizzas) to the API
- 👉 Payments are made on delivery, so **no payment processing** is necessary in the app
- 👉 Each order will get a **unique ID** that should be displayed, so the **user can later look up their order** based on the ID
- 👉 Users should be able to mark their order as "priority" order **even after it has been placed**

From these requirements, we can understand the features we need to implement

FEATURES + PAGES

STEP 2 + 3

FEATURE CATEGORIES	NECESSARY PAGES	
1 User	1 Homepage	`/`
2 Menu	2 Pizza menu	`/menu`
3 Cart	3 Cart	`/cart`
4 Order	4 Placing a new order	`/order/new`
	5 Looking up an order	`/order/:orderID`

All features can be placed into one of these. So this is what the app will essentially be about

STATE MANAGEMENT + TECHNOLOGY **DECISIONS**

STEP 3 + 4

STATE "DOMAINS" / "SLICES"

These usually map quite nicely to the app features

TYPES OF STATE

1. **User** → **Global UI** state *(no accounts, so stays in app)*
2. **Menu** → **Global remote** state *(menu is fetched from API)*
3. **Cart** → **Global UI** state *(no need for API, just stored in app)*
4. **Order** → **Global remote** state *(fetched and submitted to API)*

This is just one of many tech stacks we could have chosen

👉 **Routing**	**React Router**	*The standard for React SPAs*
👉 **Styling**	**tailwindcss**	*Trendy way of styling applications that we want to learn*
👉 **Remote state management**	**React Router**	*New way of fetching data right inside React Router (v6.4+) that is worth exploring ("**render-as-you-fetch**" instead of "**fetch-on-render**"). Not really state **management**, as it doesn't persist state.*
👉 **UI State management**	**Redux**	*State is fairly complex. Redux has many advantages for UI state. Also, we want to practice Redux a bit more*

TAILWIND CSS CRASH COURSE: STYLING THE APP

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TAILWIND CSS CRASH COURSE: STYLING THE APP

LECTURE

WHAT IS TAILWIND CSS?

WHAT IS **TAILWIND CSS**?

TAILWIND CSS

- 👉 *"A utility-first CSS framework packed with utility classes like `flex`, `text-center` and `rotate-90` that can be composed to build any design, directly in your markup (HTML or JSX)"*
- 👉 **Utility-first CSS approach:** writing tiny classes with one single purpose, and then combining them to build entire layouts
- 👉 In tailwind, **these classes are already written for us**. So we're not gonna write any new CSS, but instead use some of tailwind's hundreds of classes

tailwindcss

THE **GOOD AND BAD** ABOUT TAILWIND

THE GOOD

These two are enough to give tailwind a try!

- 👍 **You don't need to think about class names**
- 👍 **No jumping between files to write markup and styles**
- 👍 Immediately understand styling in any project that uses tailwind
- 👍 Tailwind is a design system: many design decisions have been taken for you, which makes UIs look better and more consistent
- 👍 Saves a lot of time, e.g. on responsive design
- 👍 Docs and VS Code integration are great

THE BAD

- 👎 **Markup (HTML or JSX) looks very unreadable**, with lots of class names *(you get used to it)*
- 👎 You have to learn a lot of class names *(but after a day of usage you know fundamentals)*
- 👎 You need to install and set up tailwind on each new project
- 👎 You're giving up on "vanilla CSS" 😢

> 👋 **Many people love to hate on tailwind for no reason. Please don't be that person! Try it before judging 🙏**

SETTING UP OUR BIGGEST PROJECT + STYLED COMPONENTS

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SETTING UP OUR BIGGEST PROJECT + STYLED COMPONENTS

LECTURE

APPLICATION PLANNING

THE PROJECT: **THE WILD OASIS**

THE WILD OASIS

- 👉 “The Wild Oasis” is a small boutique **hotel** with 8 luxurious wooden cabins
- 👉 They need a custom-built application to manage everything about the hotel: **bookings**, **cabins** and **guests**
- 👉 This is the **internal application** used inside the hotel to **check in guests as they arrive**
- 👉 They have nothing right now, so they **also need the API**
- 👉 Later they will probably want a **customer-facing website** as well, where customers will be able to **book stays**, using the same API

REVIEW: HOW TO PLAN A REACT APPLICATION

1. Gather application **requirements and features**
2. Divide the application into **pages**
3. Divide the application into **feature categories**
4. Decide on what **libraries** to use (technology decisions)

👨‍💼 PROJECT **REQUIREMENTS** FROM THE BUSINESS

STEP 1

- 👉 Users of the app are hotel employees. They need to be logged into the application to perform tasks
- 👉 New users can only be signed up inside the applications (to guarantee that only actual hotel employees can get accounts)
- 👉 Users should be able to upload an avatar, and change their name and password
- 👉 App needs a table view with all cabins, showing the cabin photo, name, capacity, price, and current discount
- 👉 Users should be able to update or delete a cabin, and to create new cabins (including uploading a photo)
- 👉 App needs a table view with all bookings, showing arrival and departure dates, status, and paid amount, as well as cabin and guest data
- 👉 The booking status can be “unconfirmed” (booked but not yet checked in), “checked in”, or “checked out”. The table should be filterable by this important status
- 👉 Other booking data includes: number of guests, number of nights, guest observations, whether they booked breakfast, breakfast price
- 👉 Users should be able to delete, check in, or check out a booking as the guest arrives (no editing necessary for now)
- 👉 Bookings may not have been paid yet on guest arrival. Therefore, on check in, users need to accept payment (outside the app), and then confirm that payment has been received (inside the app)
- 👉 On check in, the guest should have the ability to add breakfast for the entire stay, if they hadn’t already
- 👉 Guest data should contain: full name, email, national ID, nationality, and a country flag for easy identification
- 👉 The initial app screen should be a dashboard, to display important information for the last 7, 30, or 90 days:
  - 👉 A list of guests checking in and out on the current day. Users should be able to perform these tasks from here
  - 👉 Statistics on recent bookings, sales, check ins, and occupancy rate
  - 👉 A chart showing all daily hotel sales, showing both “total” sales and “extras” sales (only breakfast at the moment)
  - 👉 A chart showing statistics on stay durations, as this is an important metric for the hotel
- 👉 Users should be able to define a few application-wide settings: breakfast price, min and max nights/booking, max guests/booking
- 👉 App needs a dark mode

👨‍💼 PROJECT **REQUIREMENTS** FROM THE BUSINESS

AUTHENTICATION

- 👉 Users of the app are hotel employees. They need to be logged into the application to perform tasks
- 👉 New users can only be signed up inside the applications (to guarantee that only actual hotel employees can get
- 👉 Users should be able to upload an avatar, and change their name and password

CABINS

- 👉 App needs a table view with all cabins, showing the cabin photo, name, capacity, price, and current discount
- 👉 Users should be able to update or delete a cabin, and to create new cabins (including uploading a photo)

BOOKINGS

- 👉 App needs a table view with all bookings, showing arrival and departure dates, status, and paid amount, as well as cabin and guest data
- 👉 The booking status can be “unconfirmed” (booked but not yet checked in), “checked in”, or “checked out”. The ta by this important status
- 👉 Other booking data includes: number of guests, number of nights, guest observations, whether they booked breakfast, breakfast price

CHECK IN / OUT

- 👉 Users should be able to delete, check in, or check out a booking as the guest arrives (no editing necessary for now)
- 👉 Bookings may not have been paid yet on guest arrival. Therefore, on check in, users need to accept payment (ou then confirm that payment has been received (inside the app)
- 👉 On check in, the guest should have the ability to add breakfast for the entire stay, if they hadn’t already

GUESTS

- 👉 Guest data should contain: full name, email, national ID, nationality, and a country flag for easy identification

DASHBOARD

- 👉 The initial app screen should be a dashboard, to display important information for the last 7, 30, or 90 days:
  - 👉 A list of guests checking in and out on the current day. Users should be able to perform these tasks from here
  - 👉 Statistics on recent bookings, sales, check ins, and occupancy rate
  - 👉 A chart showing all daily hotel sales, showing both “total” sales and “extras” sales (only breakfast at the moment)
  - 👉 A chart showing statistics on stay durations, as this is an important metric for the hotel

SETTINGS

- 👉 Users should be able to define a few application-wide settings: breakfast price, min and max nights/booking, ma
- 👉 App needs a dark mode

FEATURES + PAGES

STEP 2 + 3

FEATURE CATEGORIES

1. Bookings
2. Cabins
3. Guests
4. Dashboard
5. Check in and out
6. App settings
7. Authentication

NECESSARY PAGES

1	Dashboard	`/dashboard`
2	Bookings	`/bookings`
3	Cabins	`/cabins`
4	Booking check in	`/checkin/:bookingID`
5	App settings	`/settings`
6	User sign up	`/users`
7	Login	`/login`
8	Account settings	`/account`

👋 We will discuss state later.
Most of it will be **global**

CLIENT-SIDE RENDERING (CSR) **OR** SERVER-SIDE RENDERING (SSR)?

CSR WITH PLAIN REACT

- 👉 Used to build **Single**-Page Applications (SPAs)
- 👉 All HTML is rendered on the **client**
- 👉 All JavaScript needs to be downloaded before apps start running: **bad for performance**
- 👉 **One perfect use case:** apps that are used "internally" as tools inside companies, that are entirely hidden behind a login

This is exactly what we want to build in this project

SSR WITH FRAMEWORK

- 👉 Used to build **Multi**-Page Applications (MPAs)
- 👉 Some HTML is rendered in the **server**
- 👉 **More performant**, as less JavaScript needs to be downloaded
- 👉 The **React team** is moving more and more in this direction

NEXT.JS Remix

STEP 4

TECHNOLOGY **DECISIONS**

STEP 4

👉 **Routing**	React Router	*The standard for React SPAs*
👉 **Styling**	styled components	*Very popular way of writing component-scoped CSS, right inside JavaScript. A technology worth learning*
👉 **Remote state management**	React Query	*The best way of managing remote state, with features like caching, automatic re-fetching, pre-fetching, offline support, etc. Alternatives are SWR and RTK Query, but this is the most popular*
👉 **UI State management**	`Context API`	*There is almost no UI state needed in this app, so one simple context with `useState` will be enough. No need for Redux*
👉 **Form management**	React Hook Form	*Handling bigger forms can be a lot of work, such as manual state creation and error handling. A library can simplify all this*
👉 **Other tools**	React icons / React hot toast / Recharts / date-fns / Supabase	

SUPABASE CRASH COURSE: BUILDING A BACK-END!

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SUPABASE CRASH COURSE: BUILDING A BACK-END!

LECTURE

WHAT IS SUPABASE?

WHAT IS **SUPABASE**?

SUPABASE

- 👉 Service that allows developers to easily **create a back-end with a Postgres database**
- 👉 Automatically creates a **database** and **API** so we can easily request and receive data from the server
- 👉 **No** back-end development needed 🥳
- 👉 Perfect to get up and running **quickly**!
- 👉 Not just an API: Supabase also comes with easy-to-use **user authentication** and **file storage**

BACK-END

WITH SUPABASE, WE DON'T NEED TO DO ANY OF THIS MANUALLY! IT'S ALL INCLUDED

supabase

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SUPABASE CRASH COURSE: BUILDING A BACK-END!

LECTURE

MODELING APPLICATION STATE

MODELING **STATE**

STATE “DOMAINS” / “SLICES”	FEATURE CATEGORIES
1 Bookings	1 Bookings
2 Cabins	2 Cabins
3 Guests	3 Guests
4 Settings	4 Dashboard
5 Users	5 Check in and out
	6 App settings
	7 Authentication

- 👉 All this state will be **global remote state**, stored within Supabase
- 👉 There will be one **table** for each state “slice” in the **database**

supabase

React Query

THE **BOOKINGS** TABLE

- **Bookings** are about a **guest** renting a **cabin**
- So a booking needs information about what **guest** is booking which **cabin:** we need to **connect** them
- Supabase uses a Postgres DB, which is SQL (relational DB). So we **join** tables using **foreign keys**

REACT QUERY: MANAGING REMOTE STATE

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REACT QUERY: MANAGING REMOTE STATE

LECTURE

WHAT IS REACT QUERY?

WHAT IS **REACT QUERY**?

REACT QUERY

- Powerful library for managing **remote (server) state**
- Many features that allow us to write a **lot less code**, while also **making the UX a lot better**:
  - Data is stored in a cache
  - Automatic loading and error states
  - Automatic re-fetching to keep state synched
  - Pre-fetching
  - Easy remote state mutation (updating)
  - Offline support
- Needed because remote state is **fundamentally** different from regular (UI) state

ADVANCED REACT PATTERNS

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ADVANCED REACT PATTERNS

LECTURE

AN OVERVIEW OF REUSABILITY IN REACT

HOW TO **REUSE** CODE IN REACT?

👉 I need to reuse:

UI

- Components and props
- `children` prop
- Render props pattern
- Compound component pattern

STATEFUL LOGIC

- Custom hooks

Use props as a component API, to enable custom behavior. Can be stateless, stateful, or structural components

To customize the component's content

Logic with hooks

For complete control over **what** the component renders, by passing in a function that tells the component what to render. Was more common before hooks, but still useful

For very self-contained components that need/want to manage their own state. Compound components are like fancy super-components

👋 There are even more patterns, but these ones matter most

PART 05

—

FULL-STACK REACT

OVERVIEW OF NEXT.JS WITH THE "APP" ROUTER

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OVERVIEW OF NEXT.JS WITH THE "APP" ROUTER

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AN OVERVIEW OF SERVER-SIDE RENDERING (SSR)

REVIEW: THE RISE OF **SINGLE-PAGE APPLICATIONS**

1 THE “OLD” WAY

3 GETTING MODERN AGAIN

SERVER-SIDE RENDERING

NEXT.JS
Remix

SERVER / BACK-END

CLIENT / FRONT-END

CLIENT-SIDE RENDERING

2 THE “MODERN” WAY

CLIENT-SIDE RENDERING (CSR) **VS.** SERVER-SIDE RENDERING (SSR)

CLIENT-SIDE RENDERING

- 👉 HTML is rendered on the **client** (the *user's* computer) using JavaScript
- 👎 **Slower initial page loads:**
  - 👉 Bigger JavaScript bundle needs to be downloaded before app starts running
  - 👉 Data is fetched after components mount
- 👍 **Highly interactive:** All the code and content has already been loaded (except data)
- 👎 **SEO can be problematic**

NEXT.JS SERVER-SIDE RENDERING

- 👉 HTML is rendered on the **server** (the *developer's* computer)
- 👍 **Faster initial page loads:**
  - 👉 Less JavaScript needs to be downloaded and executed
  - 👉 Data is fetched before HTML is rendered
- 👎 **Less interactive:** Pages might be downloaded on demand and require full page reloads
- 👍 **SEO-friendly:** Content is easier for search engines to index

WHEN TO USE **CSR** AND **SSR**?

CLIENT-SIDE RENDERING

- **SPAs:** Perfect for building highly interactive web apps
- **Apps that don't need SEO:**
  - Apps that are used "internally" as tools inside companies
  - Apps that are entirely hidden behind a login

This is what we've been doing so far

NEXT.JS SERVER-SIDE RENDERING

- **Content-driven websites or apps where SEO is essential:** E-commerce, blogs, news, marketing websites, etc.

More on this later

TWO TYPES OF SSR:

1. **Static:** HTML generated at **build time** (often called Static Site Generation, or SSG)
2. **Dynamic:** HTML generated each time **server receives new request** (some call *only* this SSR)

TYPICAL TIMELINE OF CSR VS. SSR WITH DATA FETCHING

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THE MISSING PIECE: HYDRATION

WHAT IS **HYDRATION**?

HYDRATION

- Adds back the **interactivity and event handlers** that were lost when HTML was server-side rendered
- *Watering the "dry" HTML with the "water" of interactivity and event handlers*
- React builds the component tree on the client and compares it with the actual SSRd DOM: **They must be the same** so React can adopt it!
- **Common hydration error causes:** incorrect HTML element nesting, different data used for rendering, using browser-only APIs, side effects, etc.

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OVERVIEW OF NEXT.JS WITH THE "APP" ROUTER

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WHAT IS NEXT.JS?

WHAT IS **NEXT.JS?**

NEXT.JS

*"THE REACT **FRAMEWORK** FOR THE WEB"*

▲Vercel

- 👉 **Meta-framework built on top of React:** we still use components, props, react hooks, etc.
- 👉 **Opinionated way of building React apps**: Set of conventions and best practices regarding routing, data fetching, etc.
- 👉 Allows us to build **complex full-stack** web apps and sites
- 👉 Allows us to use **cutting-edge React** features that need to be integrated into a framework: Suspense, Server Components, Server Actions, steaming, etc.

NEXT.JS

React's full-stack architecture vision

THE **NEXT.JS** KEY INGREDIENTS

- 👉 Dynamic or static can be **selected** for each route

- 👉 **Folders** as routes
- 👉 Special **files** for pages, layouts, loaders, etc.

- 👉 Fetching data directly in **Server Components**
- 👉 Mutations in **Server Actions**

- 👉 Images
- 👉 Fonts
- 👉 SEO
- 👉 Preloading

TWO FLAVOURS OF NEXT.JS: "**APP**" AND "**PAGES**" ROUTER

MODERN NEXT.JS: “APP” ROUTER

- 👉 Introduced in Next.js 13.4 (2023)
- 👉 Recommend for **new projects**
- 👉 Implements **React’s full-stack architecture**: Server Components, Server Actions, Streaming, etc.
- 👍 Easy fetching with `fetch()` right in components
- 👍 Extremely easy to create **layouts**, loaders, etc.
- 👍 More advanced routing (parallel routing, etc.)
- 👍 Better **DX** (Developer Experience) and **UX**
- 👎 **Caching** is very aggressive and confusing
- 👎 Steep learning curve (but it’s React)

LEGACY NEXT.JS: “PAGES” ROUTER

- 👉 The first Next.js router since v1 (2016)
- 👉 **Still supported** and updated in the future
- 👍 Overall more **simple and easy** to learn
- 👎 Simple things like **layouts** are confusing to implement
- 👎 Data fetching using Next.js-specific APIs such as `getStaticProps` and `getServerSideProps`

> 👋 *We’re gonna learn the “**app**” router from the start. At the end, there is a section on the fundamentals of the “pages” router*

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WHAT ARE REACT SERVER COMPONENTS?

WHY REACT SERVER COMPONENTS?

We "hack" this by storing fetched **data** in **state** too

Closer to what a real-world app is

`UI = f(state)`

`UI = f(data, state)`

`UI = f(data)`

100% Client-Side

100% Server-side

RSC

- 👍 **Interactive**
- 👍 Components
- 👎 Requires lots of JS
- 👎 Client-server data waterfalls

- 👎 NO components
- 👍 Easy and fast to **fetch all data**
- 👍 Close to the **data source**
- 👍 Needs to ship **0 kb** of JS

🤔 **What if we could take the best of both worlds?**

🧩 The answer is a completely new React paradigm: **React Server Components (RSC)**

WHAT ARE REACT SERVER COMPONENTS?

REACT SERVER COMPONENTS (RSC)

- 👉 A new **full-stack architecture** for React apps
- 👉 Introduces the server as an integral part of React component trees: **server components**
- 👉 We write **frontend code** next to **backend code** in a natural way that "feels" like regular React
- ☝️ RSC is **NOT** active by default in new React apps (e.g. Vite apps): it needs to be **implemented** by a framework like **Next.js** ("app router")

Name of the new **PARADIGM**

Name of the new **COMPONENT TYPE**

1 CLIENT COMPONENTS

`UI = f(state)`

- 👉 **"Regular" components**
- 👉 Created with **`"use client"`** directive at the top of the module

2 SERVER COMPONENTS

`UI = f(data)`

- 👉 **Components that are only rendered on the server**
- 👉 Don't make it into the bundle (**0 kb**)
- 👉 We can build the **back-end with React**!
- 👉 **Default** in apps that use the RSC architecture (like Next.js)

AN **EXAMPLE** + THE SERVER-CLIENT **BOUNDARY**

(Simplified tree)

SERVER COMPONENTS **VS.** CLIENT COMPONENTS

	CLIENT COMPONENTS `“use client”`	SERVER COMPONENTS Default
⚡ State/hooks	✅ YES	❌ NO
⬆️ Lifting state up	✅ YES	❌ N.A.
⬇️ Props	✅ YES	✅ YES (Must be serializable when passed to client components. **No functions** or classes)
📥 Data fetching	🤷 Also possible, preferably with library	✅ Preferred. Use `async/away` in component
📦 Can import	Only client components (can’t go back in the client-server boundary)	Client and server components
✍️ Can render	Client components and server components ***passed as props***	Client and server components
🔄 When re-render?	On **state** change	On **URL** change (navigation)

A SIMPLE NEW MENTAL MODEL

THE **GOOD AND BAD** OF THE RSC ARCHITECTURE

THE GOOD

- 👍 We can compose entire full-stack apps **with React components alone** (*+ server actions* 👉)
- 👍 **One single codebase** for front and back-end
- 👍 Server components have **more direct and secure access** to the data source (no API, no exposing API keys, etc.)
- 👍 **Eliminate client-server waterfalls** by fetching all the data needed for a page **at once** before sending it to the client (*not* each component)
- 👍 **"Disappearing code":** server components ship no JS, so they can import huge libraries "for free"

THE BAD

- 👎 Makes React **more complex**
- 👎 More things to **learn and understand**
- 👎 Things like **Context API** don't work in server components
- 👎 **More decisions** to make: "Should this be a client or a server component?", "Should I fetch this data on the server or the client?", etc.
- 👎 Sometimes you still need to **build an API** (for example if you also have a mobile app)
- 👎 Can only be used within a **framework**

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HOW RSC WORKS BEHIND THE SCENES

A QUICK REVIEW OF **RENDERING** IN REACT

“TRADITIONAL” REACT

Components

↓

Tree of component instances (Component tree)

↓ RENDER

React element tree (“Virtual DOM”)

↓ COMMIT TO DOM

DOM Elements (HTML)

A **B** **C**

🤔 **How does this work in RSC?** 👉

HOW RSC WORKS **BEHIND THE SCENES**

"HOLE" WHERE THE CC WILL BE RENDERED

- Serialized **props** passed from SC to CC
- URL to **script** with component code

Powered by the framework's bundler

```
0:["Ghpc41Qpj7pbJRqNxkRTJ",[["children","cabins","children","__P
1:["$L3","$L4",null]
2:[["$","meta","0",{"name":"viewport","content":"width=device-wi
5:I[7716,["326","static/chunks/326-3a855edfc7b89d3c.js","413","s
6:"$Sreact.suspense
8:I[570,["326","static/chunks/326-3a855edfc7b89d3c.js","413","st
4:["$","div",null,{"children":[["$","h1",null,{"className":"text
3:null
9:I[413,["326","static/chunks/326-3a855edfc7b89d3c.js","413","st
a:I[8326,["326",
7:["$","div",null,{"className":"grid sm:grid-cols-1 md:grid-cols
```

HOW RSC WORKS **BEHIND THE SCENES**

"HOLE" WHERE THE CC WILL BE RENDERED

- ⬇️ Serialized **props** passed from SC to CC
- 📄 URL to **script** with component code

Powered by the framework's bundler

🤔 Why RSC Payload? Why not render SCs as HTML?

- 👉 Describes the UI as **data**, not as **finished HTML**
- 👉 **When a SC is re-rendered:** React is able to **merge** ("reconcile") the **current tree** on the client with a **new tree** coming from the server
- 👉 As a result, UI **state can be preserved** when a SC re-renders, instead of completely re-generating the page as HTML

A SIMPLIFIED **REVIEW**

"TRADITIONAL" REACT

Component tree

RENDER

"Virtual DOM"

COMMIT

DOM Elements

REACT WITH RSC

SERVER

1

Component tree of SC and CC

RENDER SC

"Virtual DOM" of SC + Component trees of CC

RSC PAYLOAD – FOR EACH CC IN TREE:

- "Hole" where CC will render
- Serialized props from SC
- URL to script with code

CLIENT

SEND "RSC PAYLOAD" TO CLIENT

2

RENDER CC

Complete "Virtual DOM"

COMMIT

DOM Elements

Steps **don't wait** for one another. Completed render work is **streamed** to client

~~UI = f(data, state)~~

UI = f(**data**)(**state**)

1 2

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OVERVIEW OF NEXT.JS WITH THE "APP" ROUTER

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RSC VS. SSR: HOW ARE THEY RELATED?

REVIEW: SERVER-SIDE RENDERING (SSR)

👋 We'll be talking about **dynamic SSR** (HTML generated at **runtime**)

👉 ***SSR:*** *"Just take this component tree, render it as HTML, and send that HTML to the browser"*

👉 *"Also send the React code to make the HTML **interactive**"*

THE **RELATIONSHIP** BETWEEN RSC AND SSR

👉 ***SSR:*** *"Just take this component tree, render it as HTML, and send that HTML to the browser"*

👉 *"Also send the React code to make the HTML **interactive**"*

RSC VS. SSR

- 👉 RSC is **NOT** the same as SSR: they are separate technologies
- 👉 RSC does **NOT** replace SSR
- 👉 **They usually work together:** frameworks can combine them
- 👉 Both client and server components are **initially rendered on the server** when SSR is used
- 👉 In the RSC model, "server" just means *"the developer's computer"*
- 👉 **Result:** RSC does **NOT** require a running web server! Components could run only **once at built time** (static site generation)

THE **RELATIONSHIP** BETWEEN RSC AND SSR

So that React has the entire **component tree** on the client, **not just HTML**. Necessary to preserve UI state on future SC re-renders

👋 SSR happens only on **initial render**. On re-renders, client components only render on the **actual client**

👉 ***SSR:*** *"Just take this component tree, render it as HTML, and send that HTML to the browser"*

👉 *"Also send the React code to make the HTML **interactive**"*

RSC VS. SSR

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STARTING TO BUILD THE "WILD OASIS" WEBSITE

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STARTING TO BUILD THE "WILD OASIS" WEBSITE

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PROJECT PLANNING: "THE WILD OASIS" CUSTOMER WEBSITE

THE PROJECT: **THE WILD OASIS WEBSITE**

THE WILD OASIS

- 👉 **Remember:** “The Wild Oasis” is a small boutique **hotel** with 8 luxurious wooden cabins
- ✅ We built their application to manage everything about the hotel: **bookings**, **cabins** and **guests**
- ✅ We also build the **API** using Supabase
- 👉 Now they need a **customer-facing website** where guests can learn about the hotel, browse all cabins, reserve a cabin, and create and update their profile
- 👉 Updating data in the internal app should update the website, so we use the same DB and API
- 👉 **We are hired again** 😎🎉

👨‍💼 PROJECT **REQUIREMENTS** FROM THE BUSINESS

- 👉 Users of the app are potential guests and actual guests

ABOUT

- 👉 Guests should be able to learn all about the Wild Oasis Hotel

CABINS

- 👉 Guests should be able to get information about each cabin and see booked dates
- 👉 Guests should be able to filter cabins by their maximum guest capacity

RESERVATIONS

- 👉 Guests should be able to reserve a cabin for a certain date range
- 👉 Reservations are not paid online. Payments will be made at the property upon arrival. Therefore, new reservations should be set to “unconfirmed” (booked but not yet checked in)
- 👉 Guests should be able to view all their past and future reservations
- 👉 Guests should be able to update or delete a reservation

AUTHENTICATION

- 👉 Guests need to sign up and log in before they can reserve a cabin and perform any operation
- 👉 On sign up, each guest should get a profile in the DB

PROFILE

- 👉 Guests should be able to set and update basic data about their profile to make check-in at the hotel faster

FEATURES + PAGES

FEATURE CATEGORIES

1. About
2. Cabins
3. Reservations
4. Authentication
5. Profile

NECESSARY PAGES

1	Homepage	`/`
2	About page	`/about`
3	Cabin overview	`/cabins/`
4	Cabin detail	`/cabins/:cabinId`
5	Login	`/login`
6	Reservation list	`/account/reservations`
7	Edit reservation	`/account/reservations/edit`
8	Update profile	`/account/profile`

TECHNOLOGY **DECISIONS**

👉 **Framework**	NEXT.JS	*The most popular React meta-framework. Handles routing, SSR, data fetching and even remote state management (in a way...), therefore replacing many tools we had to include before*
👉 **UI State management**	`Context API`	*We might still need global UI state in a Next.js app. For that, we can use the Context API, Redux, or any of the other solutions. In this case the Context API will be enough.*
👉 **DB / API**	supabase	*We'll use the data and API we already built in the first "Wild Oasis" project. If you skipped that project, please go back to the "Supabase" section to set everything up*
👉 **Styling**	tailwindcss	*Modern way of writing CSS. Extremely easy to integrate into Next.js. Most styles and markup will be pre-written anyway in this project.*

DATA FETCHING, CACHING, AND RENDERING

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DATA FETCHING, CACHING, AND RENDERING

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WHAT IS REACT SUSPENSE?

WHAT IS REACT **SUSPENSE**?

SUSPENSE

- 👉 Built-in React component that we can use to catch/isolate components (or entire subtrees) that are **not ready to be rendered** (“suspending”)
- 👉 What causes a component to be **suspending**?
  1. **Fetching data** (with a supported library)
  2. **Loading code** (with React’s lazy loading)
- 👉 Native way to support **asynchronous** operations in a **declarative** way (no more `isLoading` states and render logic 🎉)

HOW DOES SUSPENSE **WORK**?

While rendering, **suspending** component is found

↓

Go to **closest `Suspense` parent** ("boundary") and discard already rendered `children`

↓

Display **fallback** component/JSX

↓ AFTER ASYNC WORK IS DONE

Render subtree under `Suspense` boundary

☝️ **Important:** Components do **NOT** automatically suspend just because an async operation is happening inside them. Integrating async operations with `Suspense` is hard, so we use libraries (React Query, Next.js, etc.)

A LOOK **BEHIND THE SCENES**

Reconciliation + Diffing

FIBER TREE REPRESENTATION

🤔 How does `Suspense` actually know that a component is suspending?

☝️ Fallback will **NOT** be shown again if the `Suspense` trigger is wrapped in a **transition** (`startTransition`). In Next.js, that's the case with **page navigations**. We can **reset** the `Suspense` boundary with a unique **key** prop

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DIFFERENT TYPES OF SSR: STATIC VS. DYNAMIC RENDERING

SERVER-SIDE **RENDERING** IN NEXT.JS

- 👉 Next.js is a **React** framework, so rendering is done by React, following the rules we learned earlier
- 👉 **Remember:** Both **Server** and **Client** components are rendered on the server on the initial render
- 👉 In Next.js, the server-side rendering work is **split by routes**
- 👉 Each route can be either **static** (also called pre-rendered) or **dynamic**
- 👉 There is also **Partial Pre-Rendering** (PPR) which mixes dynamic and static rendering in the same route (*more later* 👉)

STATIC **VS.** DYNAMIC RENDERING

STATIC RENDERING

- 👉 HTML is generated at **built time**, or **periodically in the background** by re-fetching data (ISR, *more on this later* 👉)
- 👉 Useful when data **doesn't change often** and is **not personalized** to user (e.g. product page)
- 👉 **Default rendering strategy** in Next.js (even when a page or component fetches data)
- 👉 When deployed to **Vercel**, each static route is automatically hosted on a CDN

Content Delivery Network

- 👉 If all routes of an app are static, the entire app can be **exported as a static site** (SSG)

DYNAMIC RENDERING

- 👉 HTML is generated at **request time** (for each new request reaches the server)
- 👉 Makes sense if:
  1. The **data changes frequently** and is **personalized** to the user (e.g. cart)
  2. Rendering a route requires information that **depends on request** (e.g. search params)
- 👉 A route **automatically switches to dynamic** rendering in certain conditions (*next slide* 👉)
- 👉 When deployed to **Vercel**, each dynamic route becomes a serverless function

WHEN NEXT.JS SWITCHES TO **DYNAMIC** RENDERING

👉 Usually, developers **don't directly choose** whether a route should be static or dynamic. Next.js will **automatically switch to dynamic** rendering in the following scenarios:

1. The route has a **dynamic segment** (page uses `params`)
2. `searchParams` are used in the *page component* `/product?quantity=23`
3. `headers()` or `cookies()` are used in any of the route's *server components*
4. An **uncached data request** is made in any of the route's *server components*

👉 This is necessary because any of these values **can not be known** by Next.js at built time

👉 We can also **force** Next.js to render a route dynamically:

- 👉 `export const dynamic = 'force-dynamic';` from *page.js*
- 👉 `export const revalidate = 0;` from *page.js*
- 👉 `{ cache: 'no-store' }` added to a `fetch` request in any of the route's *server components*
- 👉 `noStore()` in any of the route's *server components*

These influence caching 4
More on this later 👉

SOME **TERMINOLOGY** YOU MIGHT NEED

- 👉 **Content Delivery Network (CDN):** A network of servers located around the globe that cache and deliver a website's **static content** (HTML, CSS, JS, images) from as close as possible to each user.

- 👉 **Serverless computing:** With the serverless computing model, we can run application code, usually back-end code, without managing the server ourselves. Instead, we can just run single functions on a cloud provider: **serverless functions**. The server is initialized and active only for the duration the serverless function is running, unlike a traditional Node.js app where the server is constantly running. *Remember:* each dynamic route becomes a serverless function.

- 👉 **The "edge":** "As close as possible to the user". A CDN is part of an "edge" network, but there is also **serverless "edge" computing**. This is serverless computing that does not happen on a central server, but on a network that's distributed around the globe, as close as possible to the user (like a CDN but for running code). *Important:* we can select certain routes to run on the edge when deployed to Vercel.

- 👉 **Incremental Static Regeneration (ISR):** A Next.js feature that allows developers to update the content of a **static page**, in the background, even after the website has already been built and deployed. This happens by **re-fetching the data** of a component or entire route after a certain interval. *More on this later* 👉

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PARTIAL PRE-RENDERING

PARTIAL PRE-RENDERING (PPR): A WHOLE NEW WAY OF RENDERING

- **Idea/problem:** Most pages don't need to be 100% static or 100% dynamic
- **Solution:** Partial Pre-Rendering
- **New rendering strategy** that combines **static** and **dynamic** rendering in the same route

1. A **static** (*pre-rendered*) shell is served immediately from a CDN, leaving holes for dynamic content
2. The slower **dynamic** content is streamed in as it's rendered on the server

- **Result:** Even faster pages that can mostly be delivered from the edge (CDN) even when there are small dynamic parts.

HOW TO **USE** PARTIAL PRE-RENDERING

👋 As of Next.js 14, PPR is **highly experimental** and should not be used in production

- 👉 PPR needs to be **turned on** in config file
- 👉 By default, as much as possible of any route will be **statically rendered**, creating a **static shell**
- 👉 Dynamic parts (components) should be placed inside **`Suspense` boundaries**
- 👉 There are no new APIs to learn 🎉
- 👉 These boundaries tell Next.js that **anything within the boundary is dynamic**
- 👉 The boundary prevents the dynamic part (e.g. reading a header or making a non-cached fetch request) from spreading onto the entire route.
- 👉 We provide a **static fallback** to be shown while the dynamic part is rendering
- 👉 Dynamic components or sub-trees are **inserted** into the static shell as they become available

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HOW NEXT.JS CACHES DATA

CACHING IN NEXT.JS

NEXT.JS CACHING

👉 **Caching:** Storing fetched or computed data in a temporary location for future access, instead of having to re-fetch or re-compute the data every time it's needed

👉 Next.js caches **very aggressively**: everything that is possible to cache, is cached

👉 Next.js provides APIs for **cache revalidation**: removing data from the cache and updating it with **fresh data** (re-fetched or re-computed)

👍 Makes Next.js apps **more performant** and **saves costs** (computing and data access)

👎 **Caching always ON by default:** strange and unexpected behavior in some situations. Some caches can't be turned off 🤯

👎 **Very confusing:** Many different Next.js APIs affect and control caching

THE **CACHING** MECHANISMS

	⚡ REQUEST MEMOIZATION	DATA CACHE	FULL ROUTE CACHE	ROUTER CACHE
🗺️ **Where?**	Server	Server	Server	**Client**
💾 **What data?**	Data fetched with **similar GET requests** (same url and options in `fetch` function)	Data fetched in a **route** or a **single `fetch` request**	Entire **static** pages (HTML and RSC payload)	Pre-fetched and visited pages: **static** and **dynamic**
⏱️ **How long?**	**One page request** (one render, one user)	**Indefinitely**, even across de-deploys (can revalidate or opt out)	Until the "Data cache" is **invalidated** (or app is re-deployed)	30 sec dynamic / 5 min static (throughout one user session)
🧩 **Enables**	No need to fetch at the top of tree: the **same** `fetch` in multiple components only makes **one request**	Data for static pages + ISR when revalidated	Static pages	SPA-like navigation (instant navigation and no full reloads)

Only in components (not route handlers or server actions)

👋 *This is the behavior in **production** mode. Caching doesn't work in development*

THE **CACHING** MECHANISMS

	⚡ REQUEST MEMOIZATION	🗄️ DATA CACHE	📄 FULL ROUTE CACHE	🧑‍💻 ROUTER CACHE
🔄 **How to revalidate?**	N.A.	👉 **Time-based (automatic) for *all* data on page:** `export const revalidate = <time>;` *(page.js)* 👉 **Time-based (automatic) for *one* data request:** `fetch('…', { next: { revalidate: <time>} })` 👉 **On-demand (manual):** `revalidatePath` or `revalidateTag`		👉 `revalidatePath` or `revalidateTag` **in SA** 👉 `router.refresh` 👉 `cookies.set` or `cookies.delete` **in SA**
🙅‍♂️ **How to opt out?**	`AbortController`	👉 **Entire page:** `export const revalidate = 0;` *(page.js)* 👉 **Entire page:** `export const dynamic = 'force-dynamic';` *(page.js)* 👉 **Individual request:** `fetch('…', { cache: 'no-store' })` 👉 **Individual server component:** `noStore()`		**Not possible**

Revalidating **Data Cache** also revalidates **Full Route Cache**

These forces page to become **dynamic**, which also opts out of the **Full Route Cache**

Can be very problematic

CLIENT AND SERVER INTERACTIONS

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CLIENT AND SERVER INTERACTIONS

LECTURE

BLURRING THE BOUNDARY BETWEEN SERVER AND CLIENT

THE SERVER-CLIENT **BOUNDARY**: FRONT-END VS. BACK-END

TRADITIONAL

- **Very clear** server-client boundary
- Communication happens via an **API**
- Once JSON arrives from the back-end, the front-end takes over

NEXT.JS WITH RSC + SA

NEXT.JS

- **No clear separation** between front-end and back-end anymore
- **"Knitting":** pieces of server and client code interweave (composability)
- Allow us to build true **full-stack applications** in just one codebase
- **No need** for an intermediary API in many times

IMPORTING **VS.** RENDERING

Where client-server boundaries are

DEPENDENCY TREE (MODULE IMPORTS)

```
import B from 'B';
import C from 'C';
import D from 'D';

function A() {
  return (
    <div>
      <B>
        <D>Hey 😎 </D>
      </B>
      <C />
    </div>
  );
}
```

COMPONENT TREE

🤔 **Is `C` a server or a client component?**

👉 **It can be both!** A component **imported** inside the client-server boundary creates a **client component *instance***

🤔 **A client component rendering a server component?**

👉 Possible if **server** component is passed as **prop** (`children` or other)

👉 `D` has already been executed here...

	CLIENT COMPONENTS	SERVER COMPONENTS
📦 Can import	Only client components (can't go back in client-server boundary)	Client and server components
✍️ Can render	Client components and server components ***passed as props***	Client and server components

AUTHENTICATION WITH NEXTAUTH (AUTH.JS)

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AUTHENTICATION WITH NEXTAUTH (AUTH.JS)

LECTURE

WHAT IS MIDDLEWARE IN NEXT.JS?

HOW **MIDDLEWARE** WORKS IN NEXT.JS

HOW **MIDDLEWARE** WORKS IN NEXT.JS

MIDDLEWARE DETAILS:

- By default, middleware runs **before every route** in a project, but we can specify which paths using a **`matcher`**
- **Analogy:** chunk of code that's in every `page.js` component
- Only **one** middleware function: needs to be exported from **`middleware.js`** (or `.ts`) in the project **root folder**
- Middleware needs to **produce a response**: 1 or 2

USE CASES:

- **Read and set cookies and headers**
- Authentication and authorization
- Server-side analytics
- Redirect based on geolocation
- A/B testing

MUTATIONS WITH SERVER ACTIONS + MODERN REACT HOOKS

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MUTATIONS WITH SERVER ACTIONS + MODERN REACT HOOKS

LECTURE

WHAT ARE SERVER ACTIONS?

WHAT ARE **SERVER ACTIONS**?

SERVER ACTIONS

- 👉 The missing piece in the RSC architecture that enables ***interactive* full-stack applications**
- 👉 Async functions that run **exclusively on the server**, allowing us to perform **data mutations**

That is able to handle user input

🎯 **INTERACTIVE FULL-STACK APPLICATIONS**

⬇

RSC ARCHITECTURE

1 **DATA FETCHING**

2 **MUTATIONS**

SERVER COMPONENTS 📦

SERVER ACTIONS ⚙️

HOW TO **CREATE** SERVER ACTIONS

SERVER ACTIONS

- 👉 The missing piece in the RSC architecture that enables ***interactive* full-stack applications**
- 👉 Async functions that run **exclusively on the server**, allowing us to perform **data mutations**
- 👉 Created with the **`“use server”`** directive at the top of the function or an entire module
- 👉 **Behind the scenes:** Next.js creates **API endpoint** (with **URL**) for each server action. Whenever a server action is called, a **POST request** is made to its URL (the function itself **never** reaches client)
- 👉 Unlike server components, server actions actually require a **running web server**

We don’t have to manually create APIs or route handlers to mutate data 🎉

NOT for server *components*, but for server *actions*

SERVER ACTIONS CAN BE DEFINED AT THE TOP OF:

1. An async function in a server component. Can be used in component or passed to a client component (unlike functions)
2. Standalone file: exported functions become server actions that can be imported into **any** component **[recommended]**

HOW TO **USE** SERVER ACTIONS

SERVER ACTIONS

- 👉 The missing piece in the RSC architecture that enables ***interactive* full-stack applications**
- 👉 Async functions that run **exclusively on the server**, allowing us to perform **data mutations**
- 👉 Created with the **"`use server`"** directive at the top of the function or an entire module
- 👉 **Behind the scenes:** Next.js creates **API endpoint** (with **URL**) for each server action. Whenever a server action is called, a **POST request** is made to its URL (the function itself **never** reaches client)
- 👉 Unlike server components, server actions actually require a **running web server**

SERVER ACTIONS CAN BE CALLED FROM:

1. `action` attribute in a `<form>` element (in server and client components)
2. Event handlers (only client components)
3. `useEffect` (only client components)

Code is running on the back-end, so we need to assume inputs are **unsafe**

IN SERVER ACTIONS, WE CAN:

- 👉 Perform **data mutations** (create, update, delete)
- 👉 **Update the UI with new data:** Revalidate cache with `revalidatePath` and `revalidateTag`
- 👉 Work with cookies
- 👉 Many more...