CS 4530: Fundamentals of Software Engineering
Module 7: React

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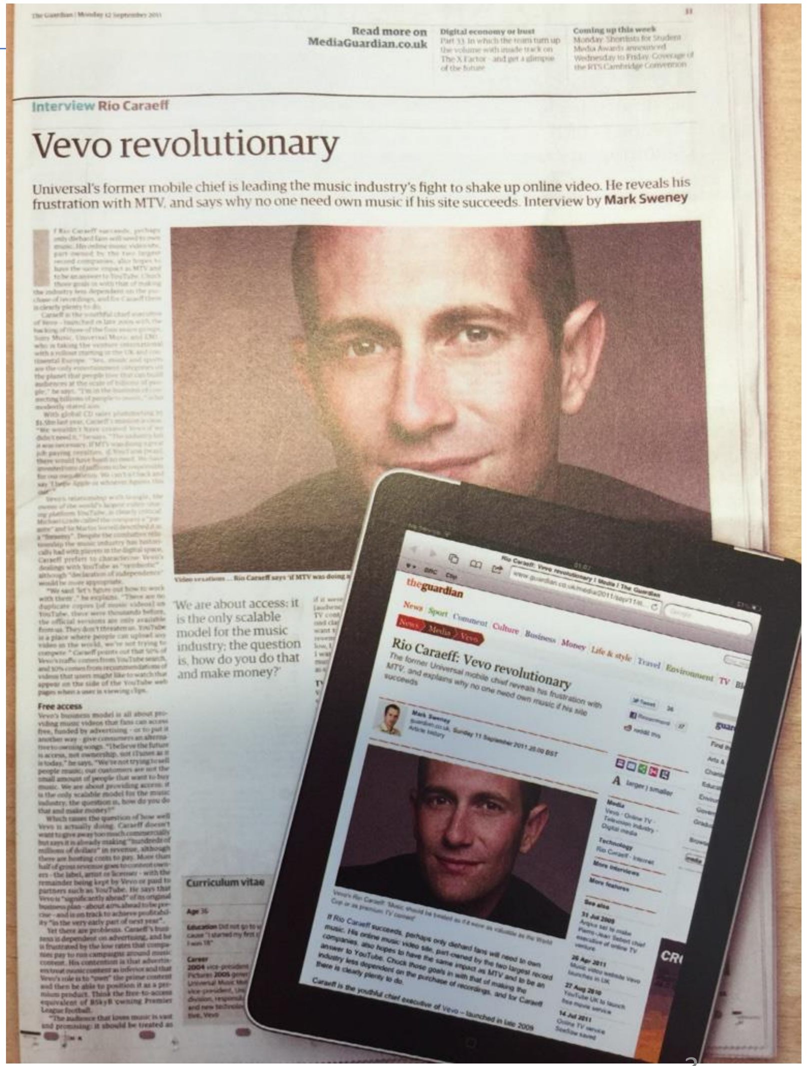
Learning Objectives for this Lesson

- By the end of this lesson, you should be able to:
  - Understand how the React framework binds data (and changes to it) to a UI
  - Create simple React components that use state and properties

HTML: The Markup Language of the Web

- Language for describing structure of a document
- Denotes hierarchy of elements
- What might be elements in this document?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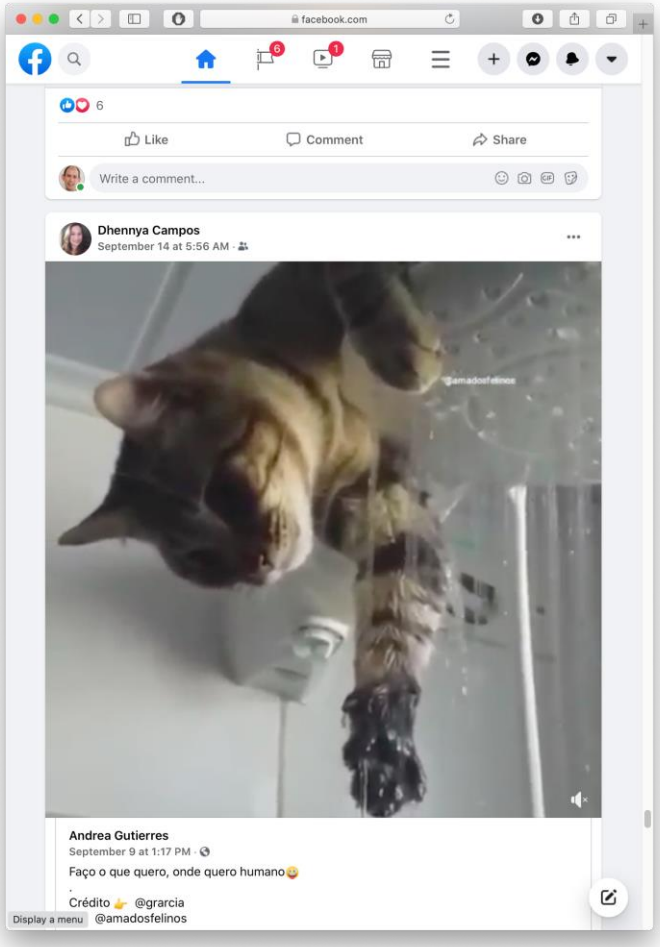
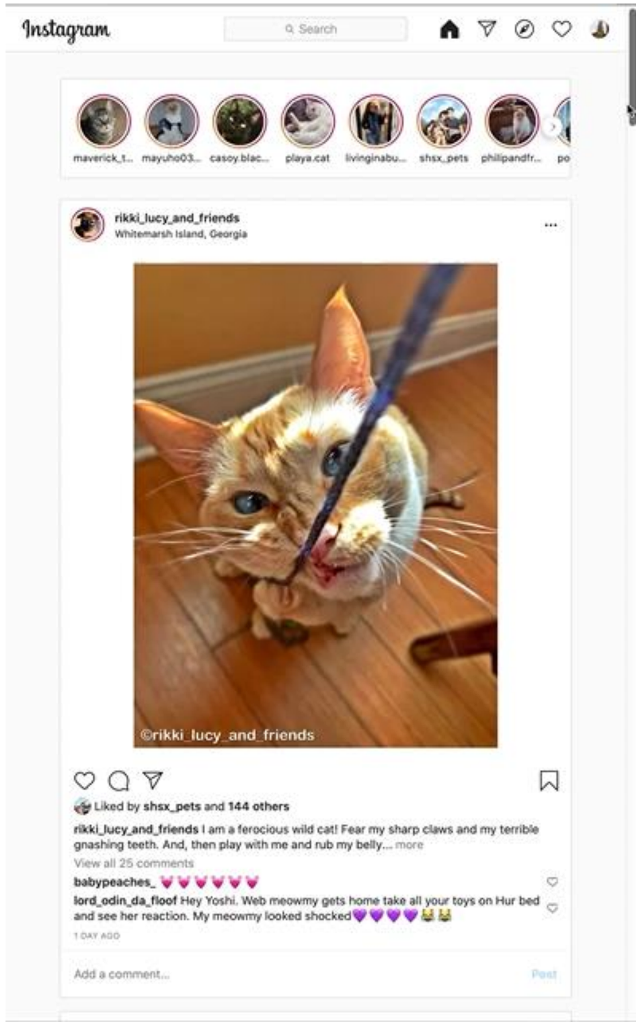
Digital economy or bust
Coming up this week
Interview Rio Caraeff
Vevo revolutionary
Universal's former mobile chief is leading the music industry's fight to shake up online video. He reveals his frustration with MTV, and says why no one need own music if his site succeeds. Interview by Mark Sweney
'We are about access: it is the only scalable model for the music industry; the question is, how do you do that and make money?'
Curriculum vitae
theguardian
Rio Caraeff: Vevo revolutionary

Rich, interactive web apps

- Infinite scrolling of cats





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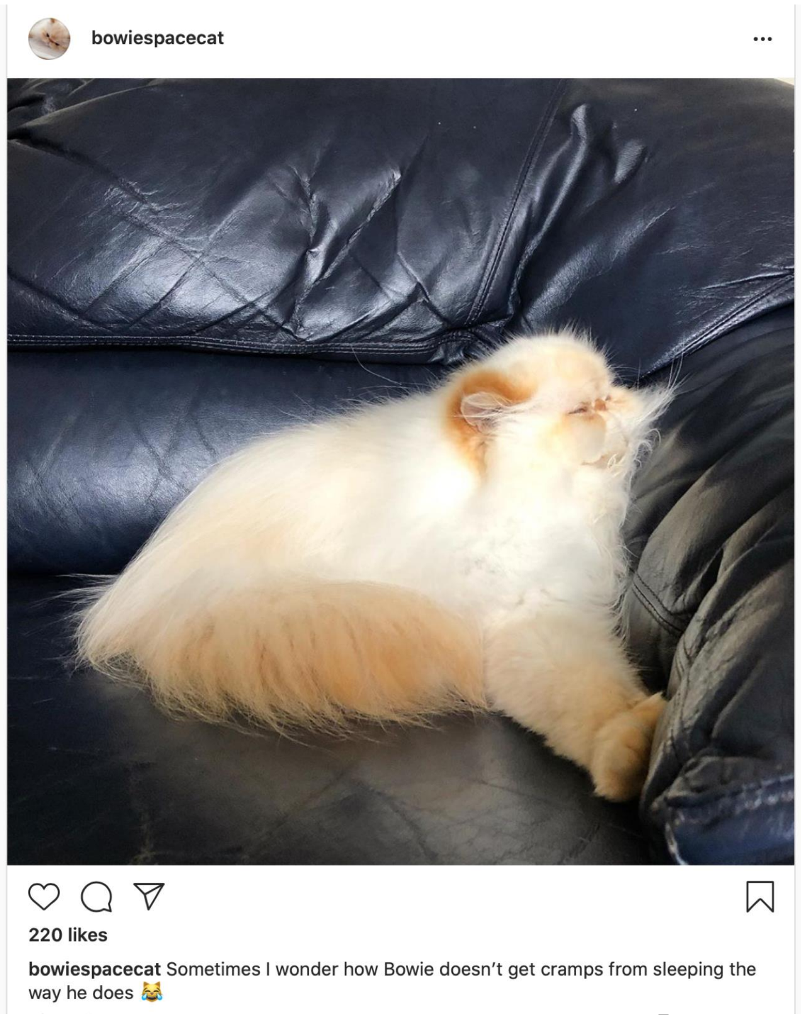
rikki_lucy_and_friends I am a ferocious wild cat! Fear my sharp claws and my terrible gnashing teeth. And, then play with me and rub my belly.... more
View all 25 comments
babypeaches_ 💗💗💗💗💗💗
lord_odin_da_floof Hey Yoshi. Web meowmy gets home take all your toys on Hur bed and see her reaction. My meowmy looked shocked💜💜💜💜😹😹
1 DAY AGO
Add a comment...
Post

Typical properties of web app UIs

- Each widget has both visual presentation & logic
- Some widgets occur more than once
  - e.g., comment/like widgets
- Changes to data should cause changes to widget
  - e.g., new images, new comments should show up in real time
- Widgets have hierarchical structure
- Action on a widget may affect other widgets
  - e.g., clicking on 'like' button executes some logic related to the widget itself,
  - It may also affect the widget the contains the ‘like’ button

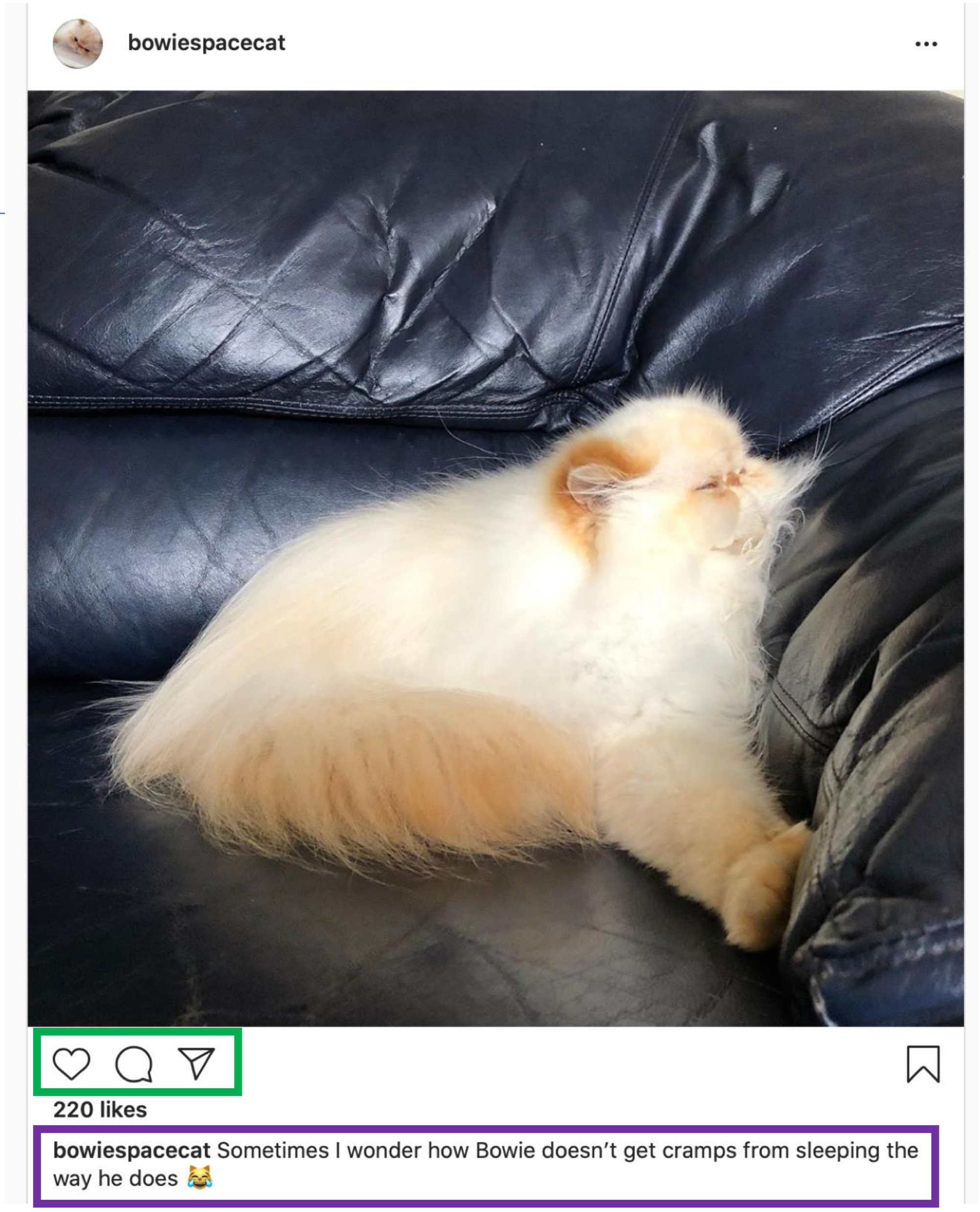


220 likes

bowiespacecat Sometimes I wonder how Bowie doesn’t get cramps from sleeping the way he does 😹

Components represent widgets in object-like style

- Organize related logic and presentation into a single unit
  - Includes necessary state and the logic for updating this state
  - Includes presentation for rendering this state into HTML
- Synchronizes state and visual presentation
  - Whenever state changes, HTML should be rendered again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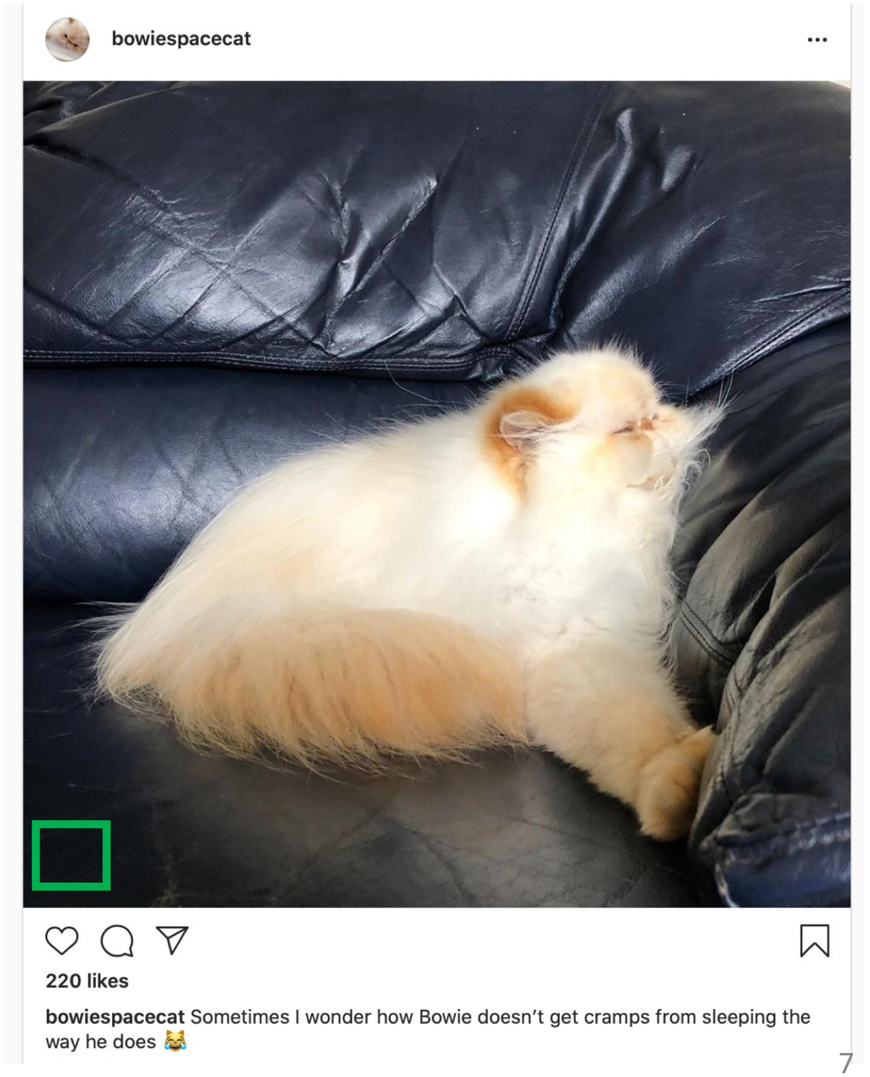
Components
Example: Like button component

- What does the button keep track of?
  - Is it liked or not
  - What post this is associated with

- What logic does the button have?
  - When changing like status, send update to server

- How does the button look?
  - Filled in if liked, hollow if not



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Server side vs. client side

- Where should template/component be instantiated?

- Server-side frameworks: Template instantiated on server
  - Examples: JSP, ColdFusion, PHP, ASP.NET
  - Logic executes on server, generating HTML that is served to browser

- Front-end framework: Template runs in web browser
  - Examples: React, Angular, Meteor, Ember, Aurelia, …
  - Server passes template to browser; browser generates HTML on demand

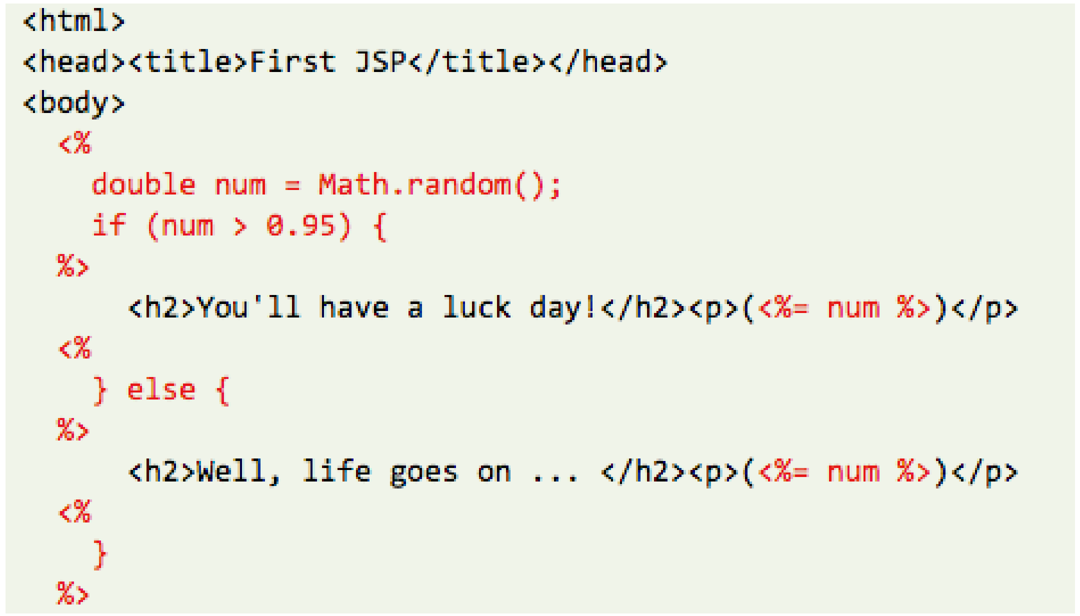
Expressing Logic

- Templates/components require combining logic with HTML
  - Conditionals - only display presentation if some expression is true
  - Loops - repeat this template once for every item in collection

- How should this be expressed?
  - Embed code in HTML (ColdFusion, JSP, Angular)
  - Embed HTML in code (React)

Embedding Code in HTML

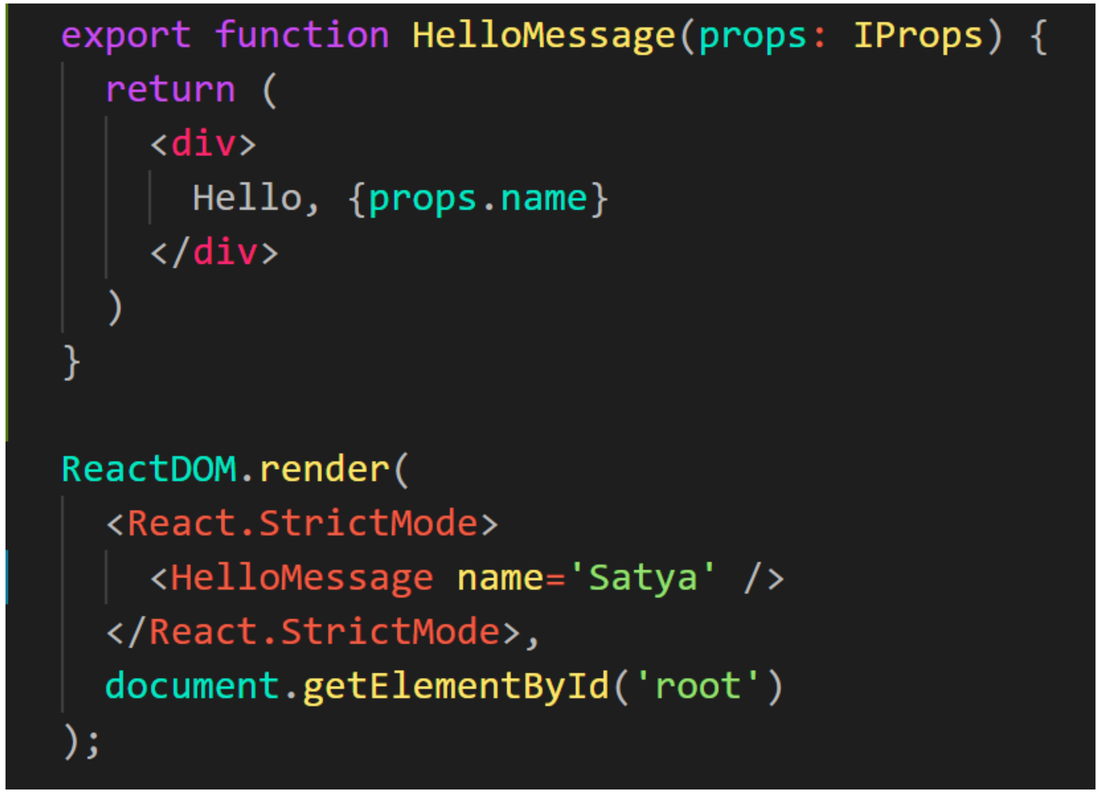
- Template takes the form of an HTML file, with extensions
  - Popular for server-side frameworks
  - Uses another language (e.g., Java, C) or custom language to express logic
  - Found in frameworks such as PHP, Angular, ColdFusion, ASP (NOT React)
  - Can’t type check anything



```
<html>
<head><title>First JSP</title></head>
<body>
  <%
    double num = Math.random();
    if (num > 0.95) {
  %>
      <h2>You'll have a luck day!</h2><p>(<%= num %>)</p>
  <%
    } else {
  %>
      <h2>Well, life goes on ... </h2><p>(<%= num %>)</p>
  <%
    }
  %>
```

Embedding HTML in TypeScript Aka JSX or TSX

- How do you embed HTML in TypeScript and get syntax checking?
- Idea: extend the language: JSX, TSX
  - JavaScript (or TypeScript) language, with additional feature that expressions may be HTML
- It's a new language
  - Browsers do not natively run JSX (or TypeScript)
  - We use build tools that compile everything into JavaScript



```
export function HelloMessage(props: IProps) {
  return (
    <div>
      Hello, {props.name}
    </div>
  )
}

ReactDOM.render(
  <React.StrictMode>
    <HelloMessage name='Satya' />
  </React.StrictMode>,
  document.getElementById('root')
);
```

JSX/TSX Embeds HTML in TypeScript

- Example:

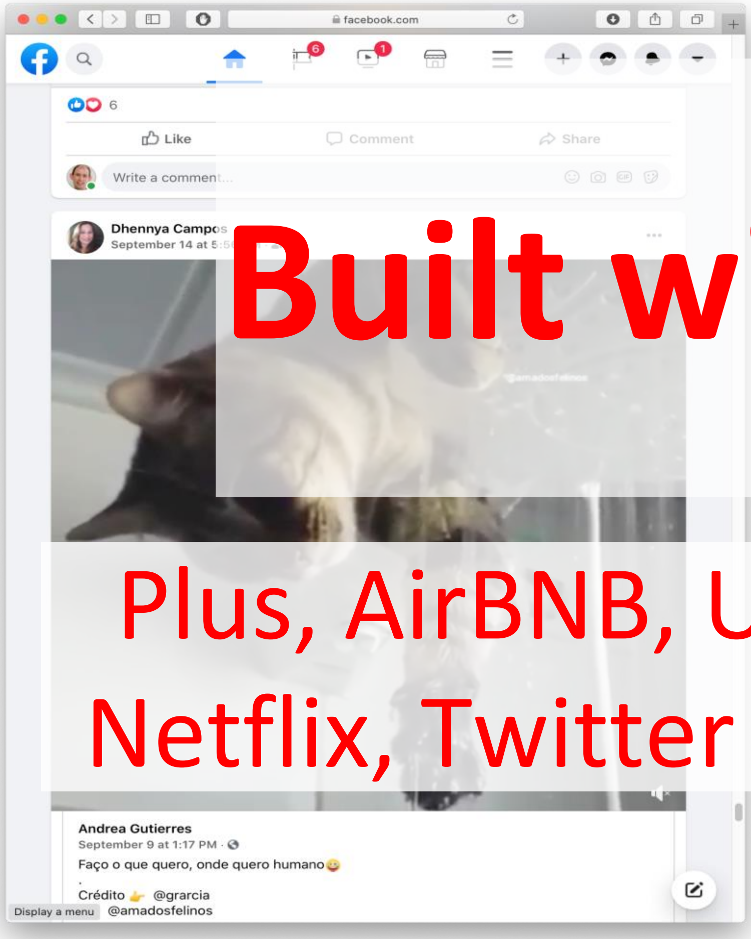
```
return <div>Hello {someVariable}</div>;
```

- HTML embedded in TypeScript
  - HTML can be used as an expression
  - HTML is checked for correct syntax
- Can use { expr } to evaluate an expression and return a value
  - e.g., { 5 + 2 }, { foo() }
- To wrap on multiple lines, wrap the TSX/JSX in parentheses (…)
- Value of expression is a piece of HTML

React is a Framework for Components

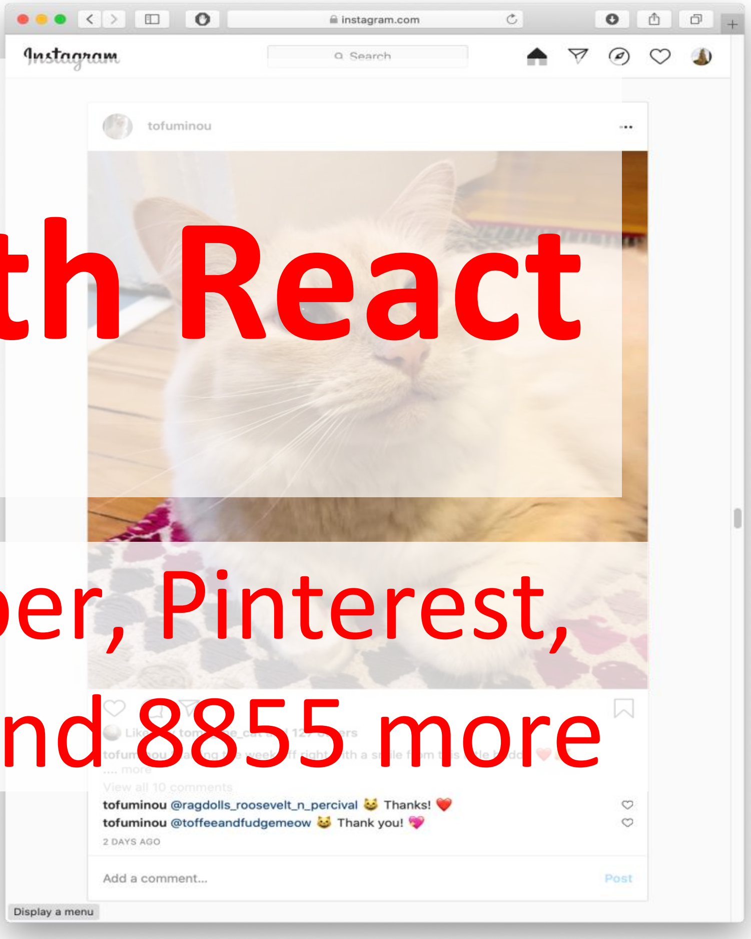
- Created by Facebook
- Powerful abstractions for describing UI components
- Official documentation & tutorials: https://reactjs.org/
- Components are constructed in the browser ("front-end")
- Key concepts:
  - Embed HTML in TypeScript
  - Track application "state"
  - Automatically and efficiently re-render page in browser based on changes to state
- But: some implementations of React allow components to be pre-constructed in the server.

React makes it easy to build rich, interactive web apps (perhaps with infinite scrolling of cats!)



Dhennya Campos
September 14 at 5:5

Andrea Gutierres
September 9 at 1:17 PM ·
Faço o que quero, onde quero humano😂
.
Crédito 👉 @grarcia
@amadosfelinos



tofuminou @ragdolls_roosevelt_n_percival 😺 Thanks! ❤️
tofuminou @toffeeandfudgemeow 😺 Thank you! 💖
2 DAYS AGO

Built with React

Plus, AirBNB, Uber, Pinterest, Netflix, Twitter and 8855 more

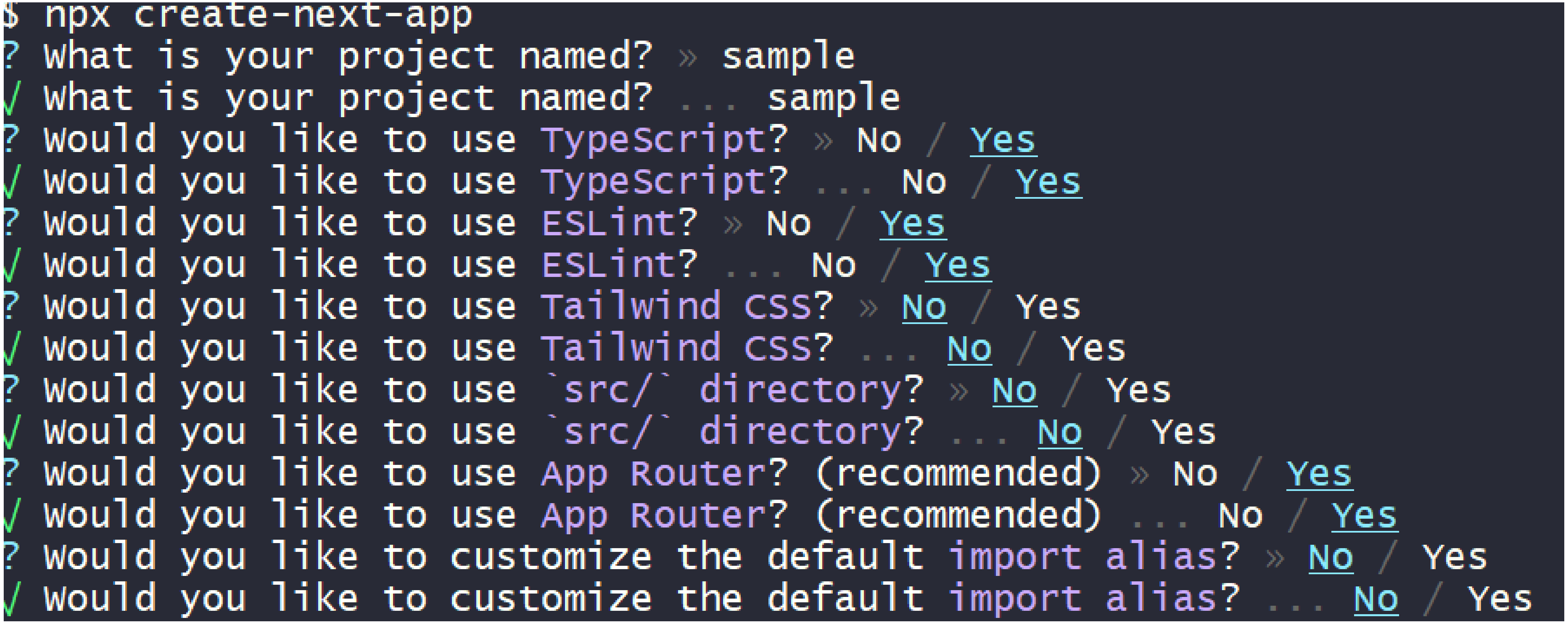
Creating React applications

- A React application is a complicated beast.
- There are several popular frameworks for building such an application
- The one we will use is called **next.js** .
- It is a full-featured framework; we will use only a small fraction of its features.

Creating New React Applications

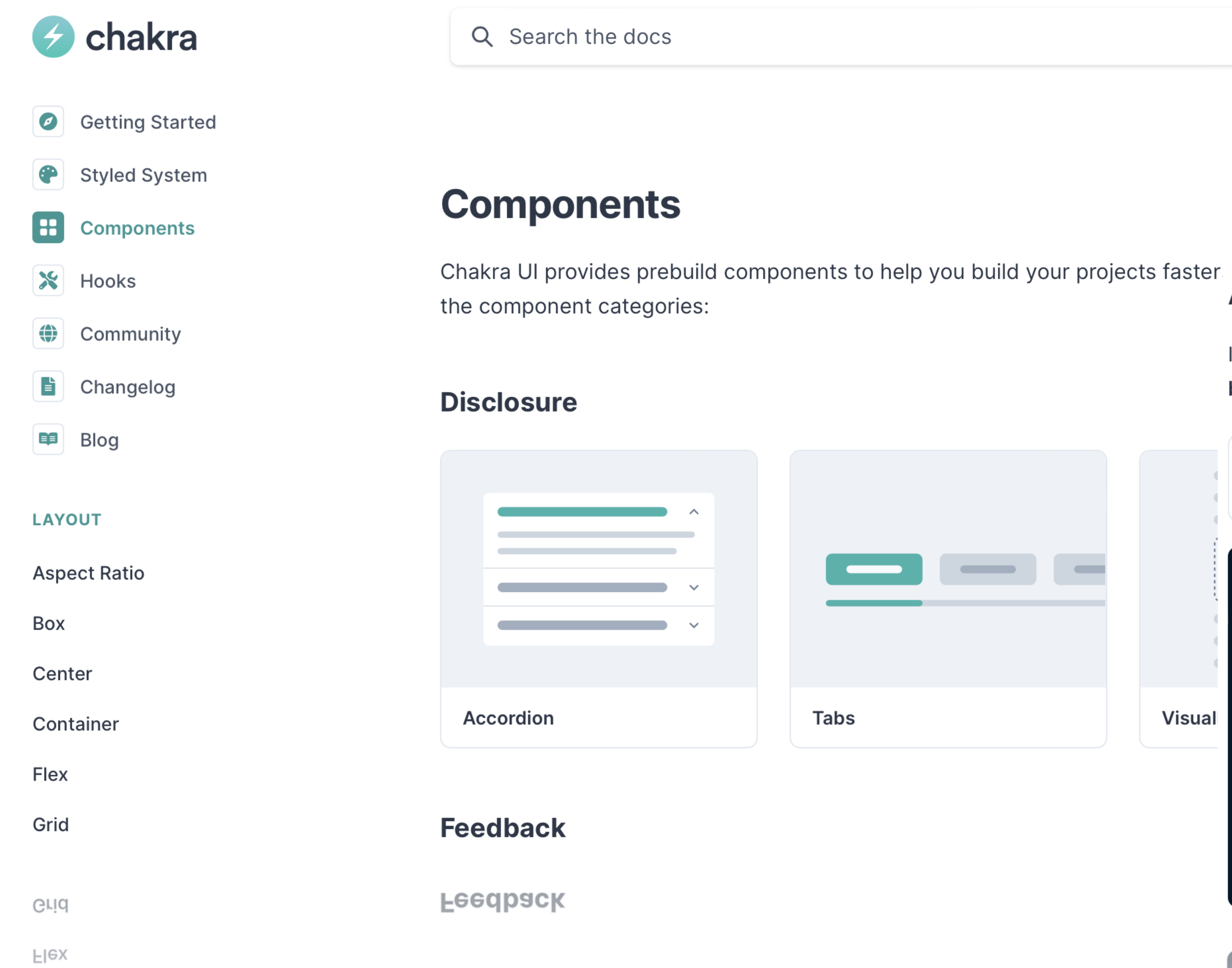
- React applications must be compiled into a format that browsers can understand
- `create-next-app` is a set of scripts to automate this process.
- `npx create-next-app` starts an interactive session that creates a fully-featured TS package
- Probably you will never do this in this course– the “fully-featured TS package” is a big beast.
- Better plan is to modify one of the packages that we supply you.

Here’s a sample interaction…



```
$ npx create-next-app
? What is your project named? » sample
√ What is your project named? ... sample
? Would you like to use TypeScript? » No / Yes
√ Would you like to use TypeScript? ... No / Yes
? Would you like to use ESLint? » No / Yes
√ Would you like to use ESLint? ... No / Yes
? Would you like to use Tailwind CSS? » No / Yes
√ Would you like to use Tailwind CSS? ... No / Yes
? Would you like to use `src/` directory? » No / Yes
√ Would you like to use `src/` directory? ... No / Yes
? Would you like to use App Router? (recommended) » No / Yes
√ Would you like to use App Router? (recommended) ... No / Yes
? Would you like to customize the default import alias? » No / Yes
√ Would you like to customize the default import alias? ... No / Yes
```

React Has a Rich Component Library



chakra

Search the docs ⌘ K

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- Getting Started
- Styled System
- Components
- Hooks
- Community
- Changelog
- Blog

LAYOUT

- Aspect Ratio
- Box
- Center
- Container
- Flex
- Grid

Components

Chakra UI provides prebuild components to help you build your projects faster. Here is an overview of the component categories:

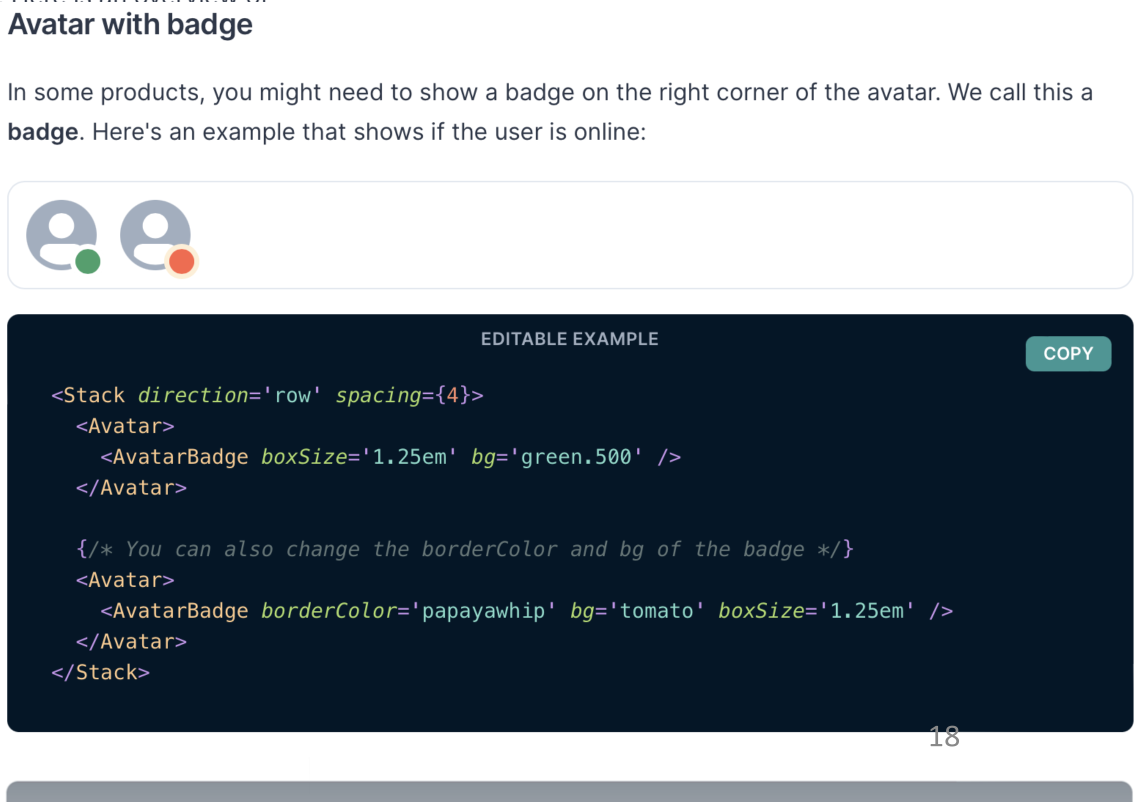
Disclosure

Accordion

Tabs

Visual

Feedback



Avatar with badge

In some products, you might need to show a badge on the right corner of the avatar. We call this a **badge**. Here's an example that shows if the user is online:

EDITABLE EXAMPLE

COPY

```
<Stack direction='row' spacing={4}>
  <Avatar>
    <AvatarBadge boxSize='1.25em' bg='green.500' />
  </Avatar>

  {/* You can also change the borderColor and bg of the badge */}
  <Avatar>
    <AvatarBadge borderColor='papayawhip' bg='tomato' boxSize='1.25em' />
  </Avatar>
</Stack>
```

Installing Chakra for next.js:

- Just say:

```
npm i --save @chakra-ui/react @chakra-ui/next-js \
 @emotion/react @emotion/styled framer-motion
```

Hello World in React

app/Apps/HelloWorld.tsx

```
import * as React from 'react';
import {
  Heading,
  VStack
} from '@chakra-ui/react';

function HelloWorldComponent() {
    return (
        <VStack>
            <Heading>Hello World</Heading>
        </VStack>
  )
}

export default function App() {
    return (<HelloWorldComponent />)
}
```

"Return the following HTML whenever the component is rendered"

The HTML is dynamically generated by the library.

app/page.tsx

Next.js renders whatever is in app/page.tsx

```
import App from './Apps/HelloWorld'
// import App from './Apps/HelloWorldDave'
// import App from './Apps/App1';


export default function HomePage() {
  return (
      <ChakraProvider>
        <App />
      </ChakraProvider>
  )
}
```

You may see “Class” components, too – but we won’t write them

```
var HelloMessage = React.createClass({
  render: function() {
    return <div>Hello, World!</div>
  }
})
```

Hello World, Circa 2016
(Before the “Class” keyword!)

```
class HelloMessage extends React.Component {
  render(){
    return <div>Hello, World!</div>
  }
}
```

Hello World, Circa 2020
(Defined as a Class)

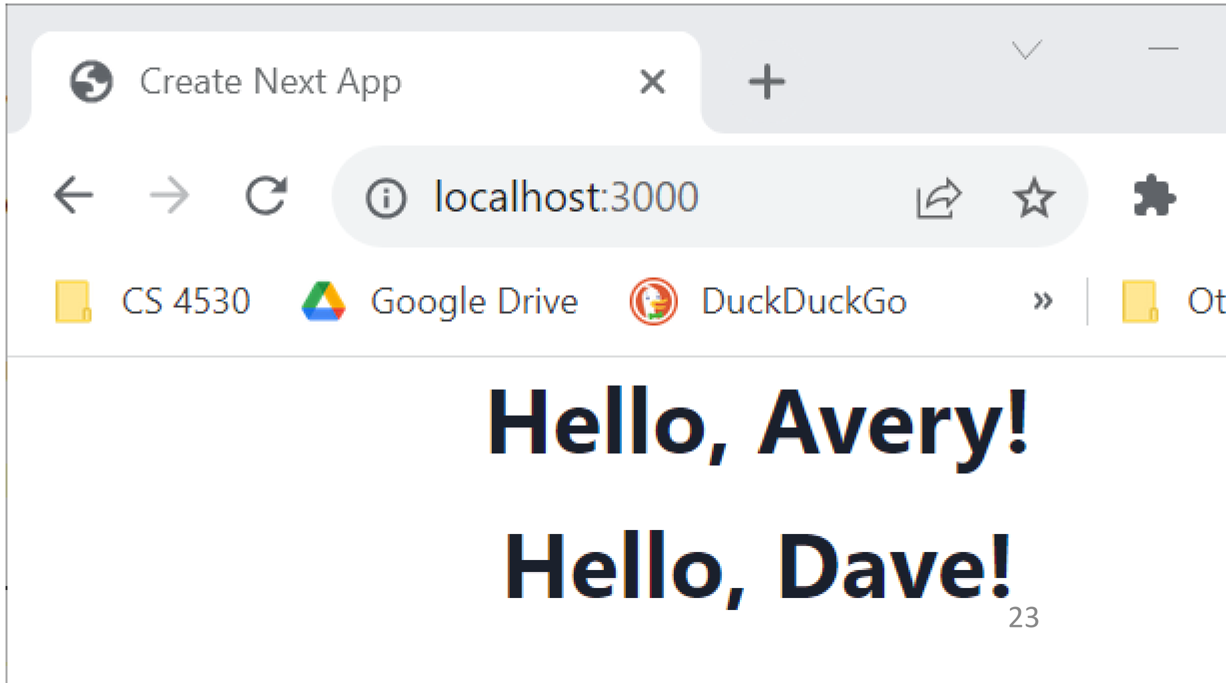
```
export function HelloMessage(){
  return <div>Hello, World!</div>
}
```

Hello World, Circa 2022
(Defined as a function)

React Components Can Receive Properties.

- Properties are passed in an argument to the component
- Properties are specified as attributes when the component is instantiated
- Properties can *not* be changed by the component

```
export default function App() {
    return (<VStack>
      <HelloWorldWithName name='Avery'/>
      <HelloWorldWithName name='Dave'/>
      </VStack>
    )
}
```



Hello, Avery!

Hello, Dave!

Component State is Data That Changes

- State is data that, when changed, should trigger UI update
- State is created by `useState.`
- The state is accessed through *state variables* in the component.
- The first variable is the accessor, the second is the setter.
- The only way to change the value of a state variable is with the setter

```
import { useState } from 'react';
function Foo() {
 const [count, setCount] = useState(0)
 ….
}
```

You could choose any names for the variable and its setter; for this class, please follow the naming convention (goodVariableNlame, setGoodVariablename) that we'e used here.

app/Apps/SimplestState.tsx

Example

```
export default function App() {

  const [count, setCount] = useState(0)

  function handleClick() { setCount(count + 1) }

  return (
    <VStack>
      <Box> count = {count} </Box>
      <Button onClick={handleClick} >
        Increment Count!
      </Button>
    </VStack>
  )

}
```

(Some styling has been removed to reduce clutter on this screen.}

app/Apps/SimplestStateWithConsole.tsx

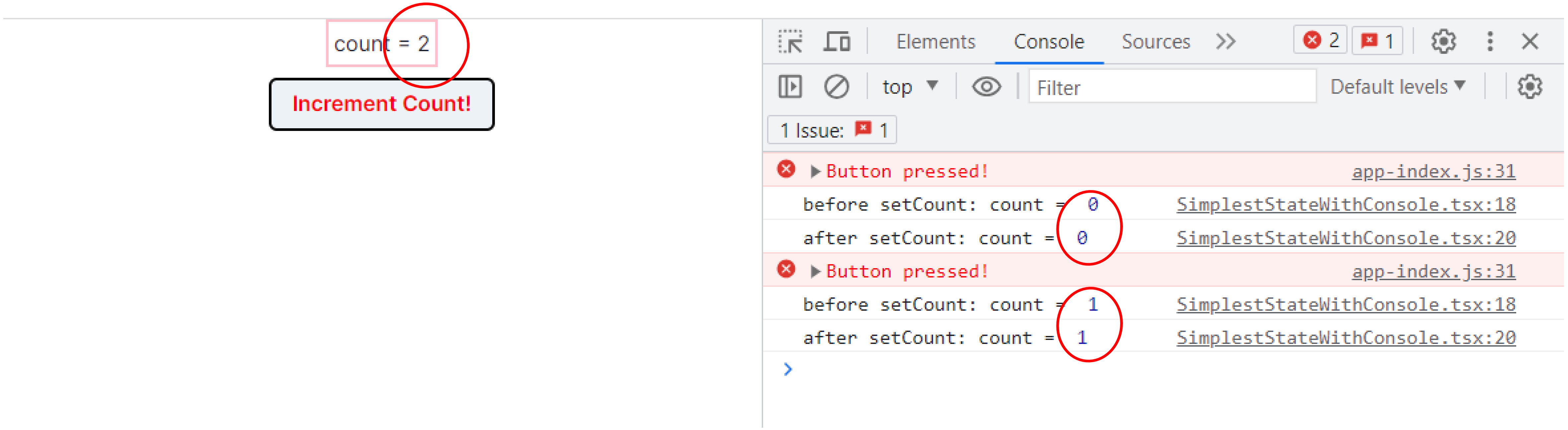
Setters are asynchronous

- ***A setter doesn't change the state immediately***: it is a request to REACT to update the state when this component is redisplayed.

```
function handleClick() {
    console.error('Button pressed!');
    console.log('before setCount: count = ', count)
    setCount(count + 1)
    console.log('after setCount: count = ', count)
  }
```

Console methods: https://developer.mozilla.org/en-US/docs/Web/API/console app/Apps/SimplestStateWithConsole.tsx

Setters are asynchronous



```
Button pressed!                          app-index.js:31
before setCount: count = 0               SimplestStateWithConsole.tsx:18
after setCount: count = 0                SimplestStateWithConsole.tsx:20
Button pressed!                          app-index.js:31
before setCount: count = 1               SimplestStateWithConsole.tsx:18
after setCount: count = 1                SimplestStateWithConsole.tsx:20
```

Nest Components, Passing State as Properties

app/Apps/TwoCountingButtons.tsx

```
import { CountingButton } from './CountingButton';

export default function App() {
  const [globalCount, setGlobalCount] = useState(0)

  function handleClick() {setGlobalCount(globalCount + 1)}

  return (
    <VStack>
      <Box border="1px" padding='1'>Total count = {globalCount}</Box>
      <Box h="20px" />
      <CountingButton name="Button A" onClick={handleClick} />
      <Box h="20px" />
      <CountingButton name="Button B" onClick={handleClick} />
    </VStack>
  )}
```

A common pattern in React is to nest components, passing information from parent to child via props.

CountingButton.tsx

app/Apps/CountingButton.tsx

```
export function CountingButton(props: {
  name:string, onClick:() => void }) {

  const name = props.name
  const [localCount, setLocalCount] = useState(0)

  function handleClick() {
    console.error(props.name, 'pressed!');
    setLocalCount(localCount + 1)
    props.onClick() // propagate to parent

  }
```

```
return (
  <VStack>
    <Box>
      count for {props.name} = {localCount}
    </Box>

    <Button onClick={handleClick}>
      Increment {name}!
    </Button>
  </VStack>
)

}
```

(Some styling has been removed to reduce clutter on this screen.}

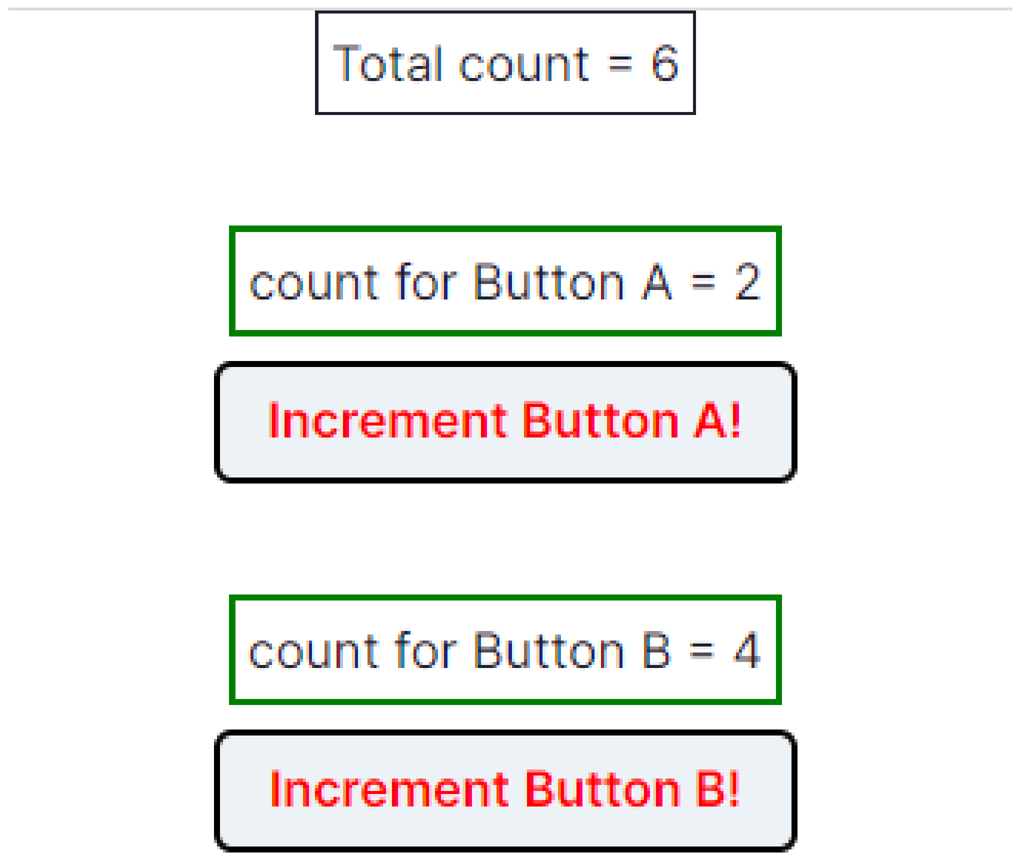
Nest Components, Passing State as Properties

app/Apps/TwoCountingButtons.tsx

```
import { CountingButton } from './CountingButton';

export default function App() {
  const [globalCount, setGlobalCount] = useState(0)

  function handleClick() {setGlobalCount(globalCount + 1)}

  return (
    <VStack>
      <Box border="1px" padding='1'>Total count = {globalCount}</Box>
      <Box h="20px" />
      <CountingButton name="Button A" onClick={handleClick} />
      <Box h="20px" />
      <CountingButton name="Button B" onClick={handleClick} />
    </VStack>
  )}
```

A common pattern in React is to nest components, passing information from parent to child via props.

TwoCountingButtons demo

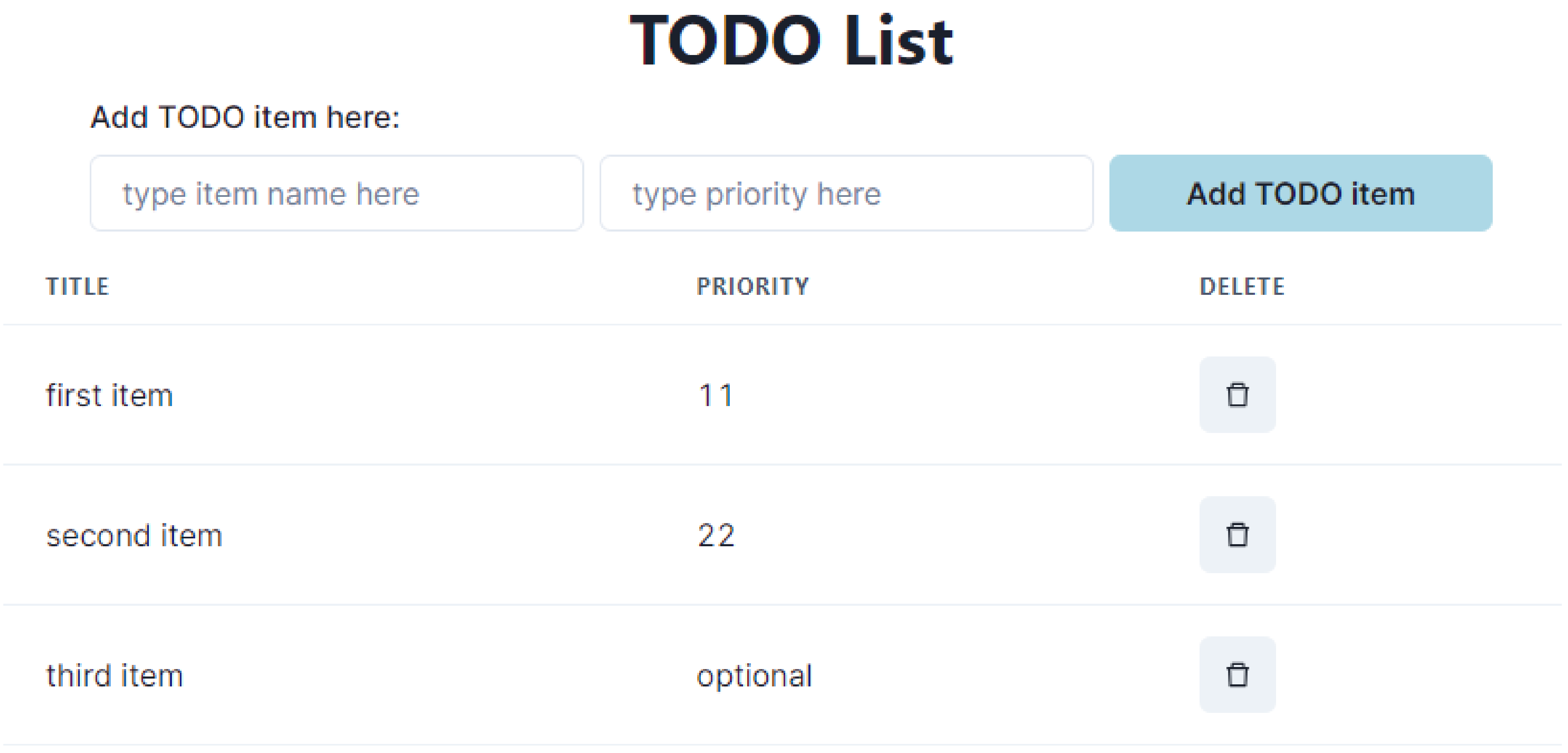


A ToDo App

app/Apps/ToDoApp.tsx

```
export default function ToDoApp () {
  const [todoList,setTodolist] = useState<TodoItem[]>([])
  function handleAdd (newItem:TodoItem) {
    if (newItem.title === '') {return}   // ignore blank button presses
    setTodolist(todoList.concat(newItem))
  }
  function handleDelete(targetId:string) {
    const newList = todoList.filter(item => item.id != targetId)
    setTodolist(newList)
  }

  return (
  <VStack>
    <Heading>TODO List</Heading>
    <ToDoItemEntryForm onAdd={handleAdd}/>
    <ToDoListDisplay items={todoList} onDelete={handleDelete}/>
  </VStack>
  )
}
```

Typical Page



TODO List

Add TODO item here:

TITLE	PRIORITY	DELETE
first item	11	🗑
second item	22	🗑
third item	optional	🗑

Pattern: display a list of items using **map**

```
export function ToDoListDisplay(props: { items: ToDoItem[],
                                         onDelete:(id:string) => void })

  return (
    <Table>
      <Tbody>
       {
          props.items.map((eachItem) =>
              <ToDoItemDisplay item={eachItem}
                key={eachItem.id}
                onDelete={props.onDelete} />)
        }
      </Tbody>
    </Table>
  )
}
```

But using map comes with a big gotcha.

```
export function ToDoListDisplay(props: { items: ToDoItem[],
                                         onDelete:(id:string) => void })
  return (
    <Table>
      <Tbody>
       {
          props.items.map((eachItem) =>
              <ToDoItemDisplay item={eachItem}
                key={eachItem.id}
                onDelete={props.onDelete} />)
        }
      </Tbody>
    </Table>
  )
}
```

app/Apps/ToDoItemEntryForm.tsx

We set up the key in the input form

```
export function ToDoItemEntryForm (props: {onAdd:(item:ToDoItem)=>void}) {
    // state variables for this form
    const [title,setTitle] = useState<string>("")
    const [priority,setPriority] = useState("")
    const [key, setKey] = useState(0)     // key is assigned when the item is cre

    function handleClick(event) { --- } // on next slide…

    return (
      <VStack spacing={0} align='left'>
        <form>
          <FormControl>
            <VStack align='left' spacing={0}>
            <FormLabel as="b">Add TODO item here:</FormLabel>
            <HStack w='200' align='left'>

            <Input
              name="title"
              value={title}
              placeholder='type item name here'
              onChange={(event => {
                setTitle(event.target.value);
                console.log('setting Title to:', event.target.value)
              })}
            />
```

The state of the form is kept in the state variables of the component

One <Input> component for each blank space in the form.

Update the state variable at every keypress

handleClick actually assigns the key

```
// state variables for this form
const [title,setTitle] = useState<string>("")
const [priority,setPriority] = useState("")
const [key, setKey] = useState(1)     // key is assigned when the item is created.

function handleClick(event) {
  event.preventDefault()  // magic, sorry.
  const newItem:ToDoItem = {title: title, priority: priority, key: key}
  console.log('adding:', newItem)
  props.onAdd(newItem)    // tell the parent about the new item
  setTitle('')            // resetting the values redisplays the placeholders
  setPriority('')
  setKey(key => key + 1)  // generate a new unique key for the next item
}
```

The key attribute must be unique *and stable*.

- This doesn’t work:

```
props.items.map((eachItem,index) =>
   <ToDoItemDisplay item={eachItem} key={index} onDelete={props.onDelete} />
)
```

Summarizing React Behavior

- React uses default state for the first render of our component.
- When setter is called, React *asynchronously* re-renders our component and updates the state variable.
- Updating the DOM in the browser is slow - it is *vital* that React does efficient diff'ing
  - Example: adding a new comment on a YouTube video shouldn't make the browser re-layout the whole page
- React makes re-rendering faster by updating only the part that changes.
  - This is called "Reconciliation"
  - It uses some magic like keeping track of state of each component (e.g., second component was liked)
  - Keys are necessary for correct re-rendering of lists. These should be unique and stable (don't change with each update)

Review

- Now that you've studied this lesson, you should be able to:
  - Understand how the React framework binds data (and changes to it) to a UI
  - Create simple React components that use state and properties
- In Module 08, we'll study another feature of React that enhances modularity: hooks.