CS 4530: Fundamentals of Software Engineering
Module 8: React

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Learning Objectives for this Lesson

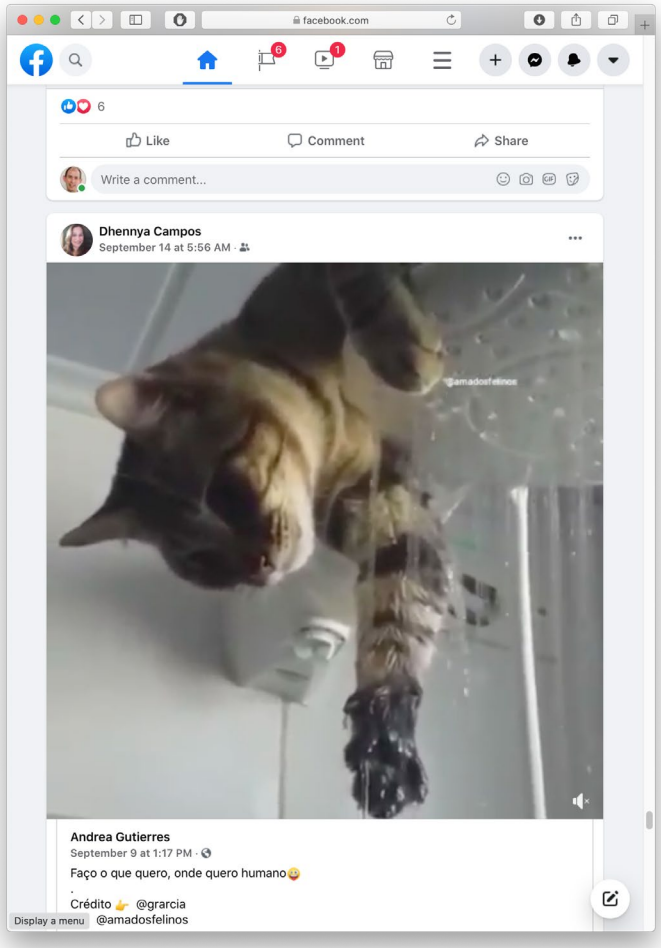
- By the end of this lesson, you should be able to:
  - Understand how the React framework binds data (and changes to it) to a UI
  - Create simple React components that use state and properties

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?

Rich, interactive web apps

- Infinite scrolling of cats

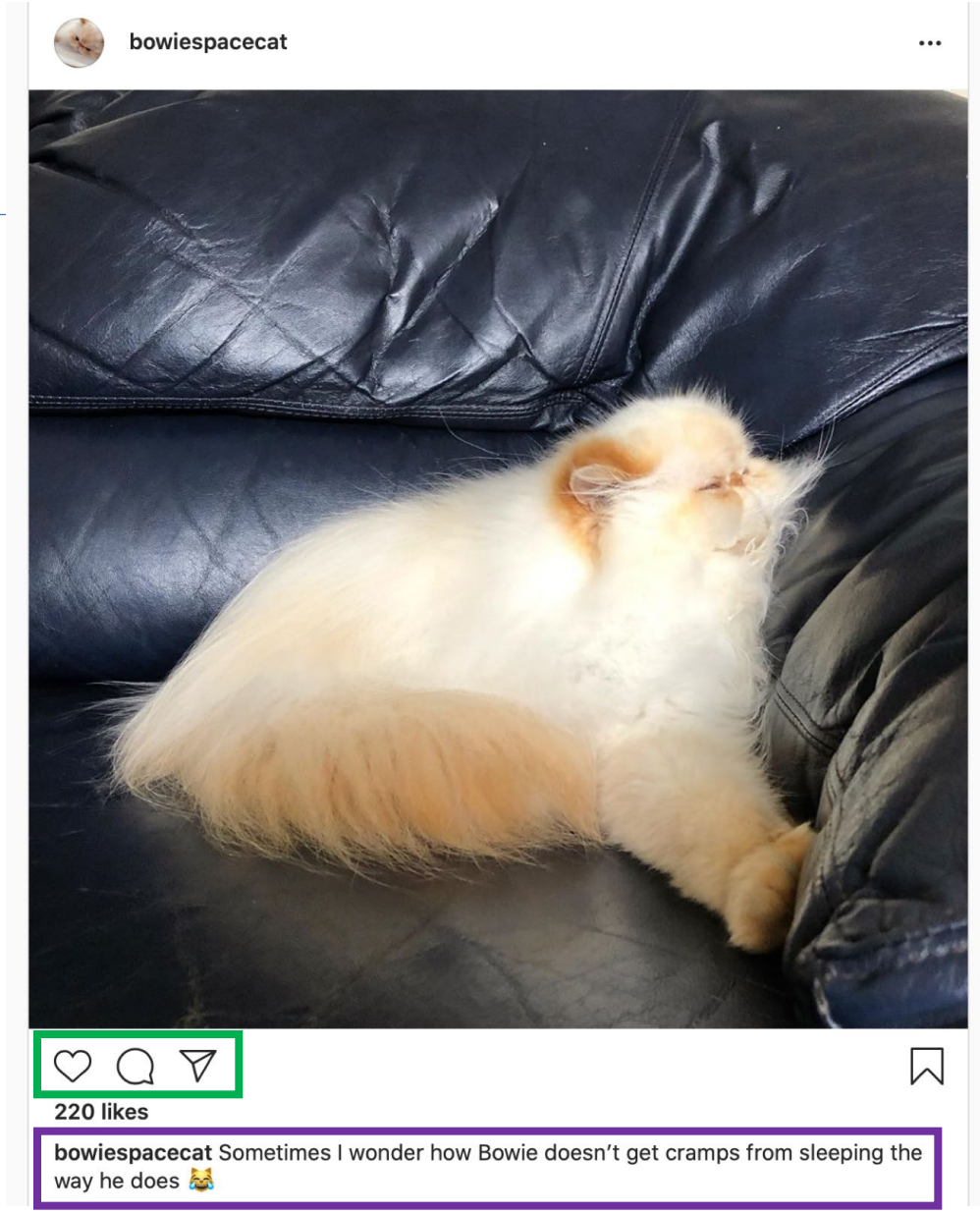


Typical properties of web app UIs

- 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

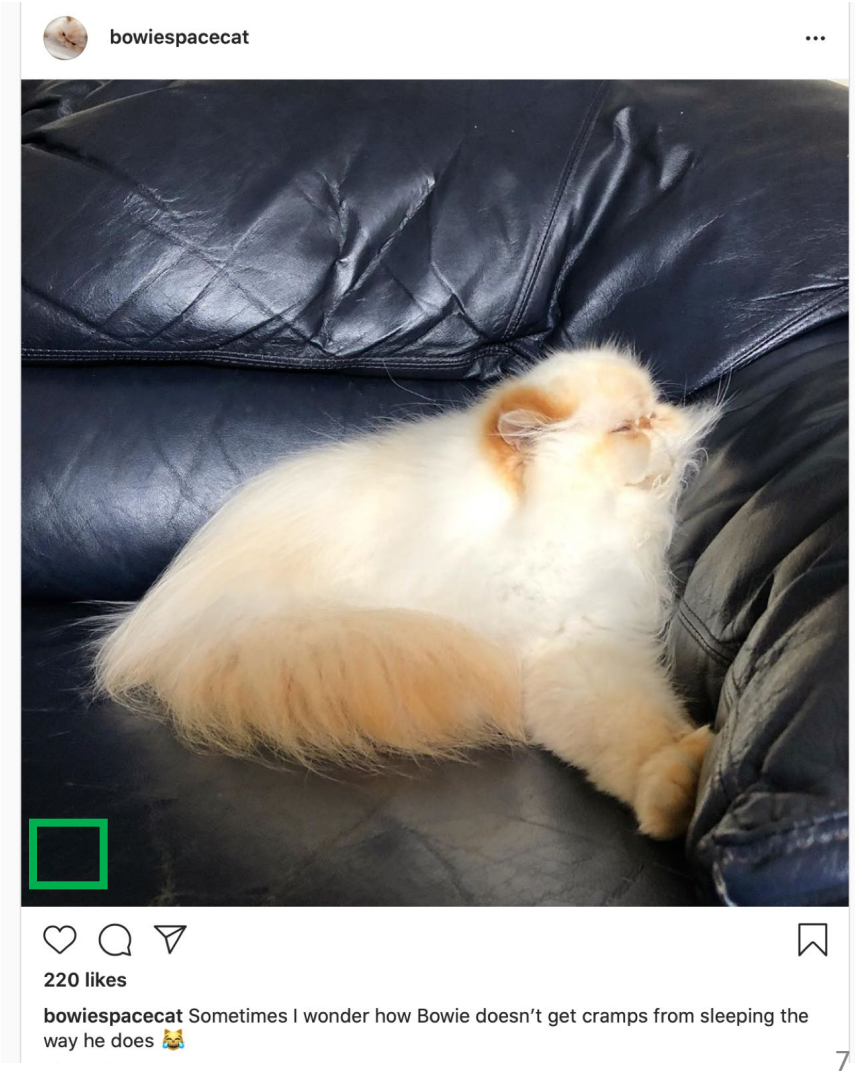
Components represent widgets in object-like style

- 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



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



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:

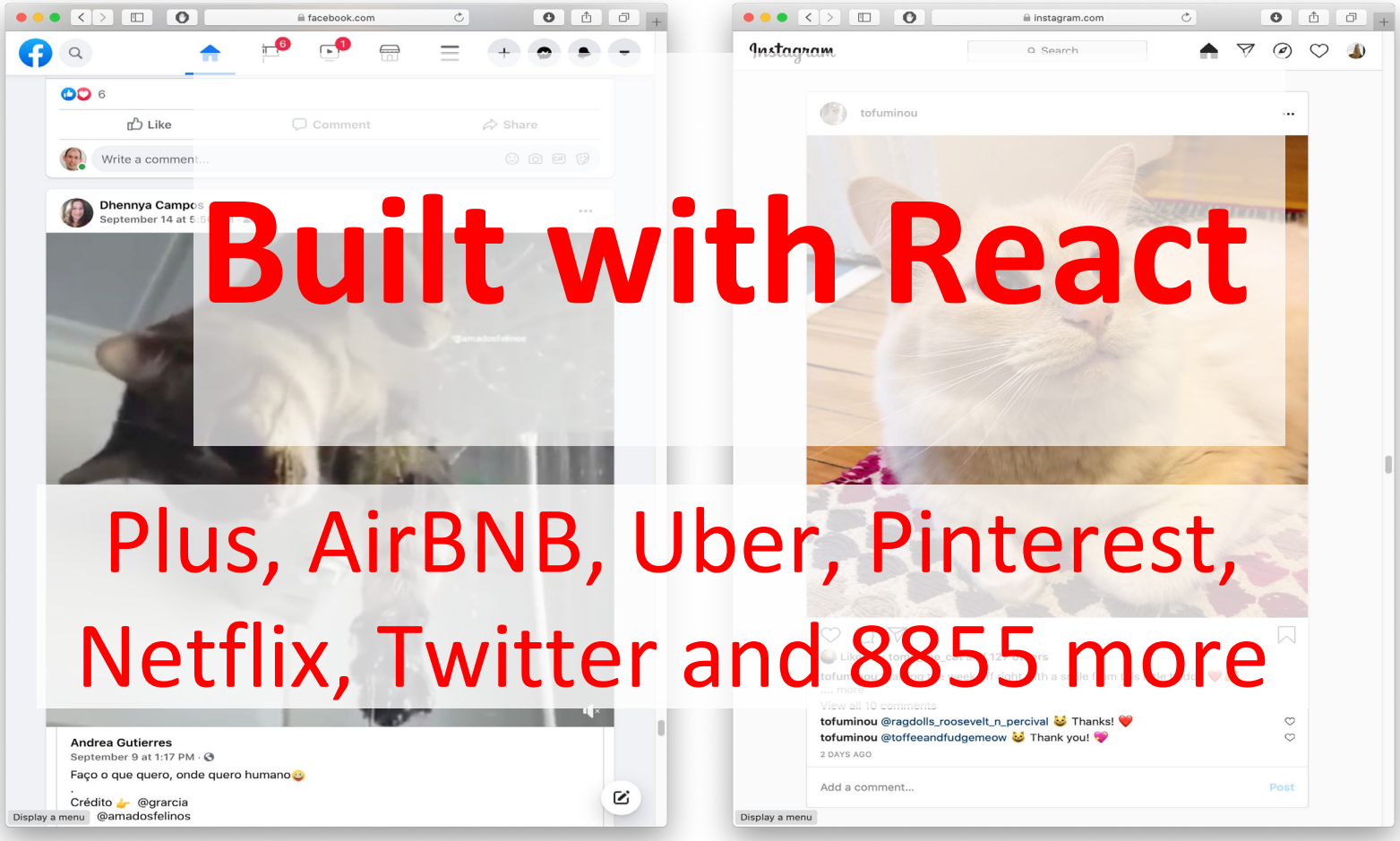
```
return <div>Hello {someVariable}</div>;
```

- 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!)



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

v2.2.9

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

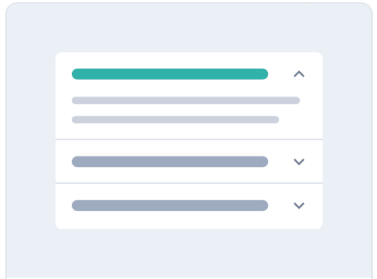
LAYOUT

- 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)

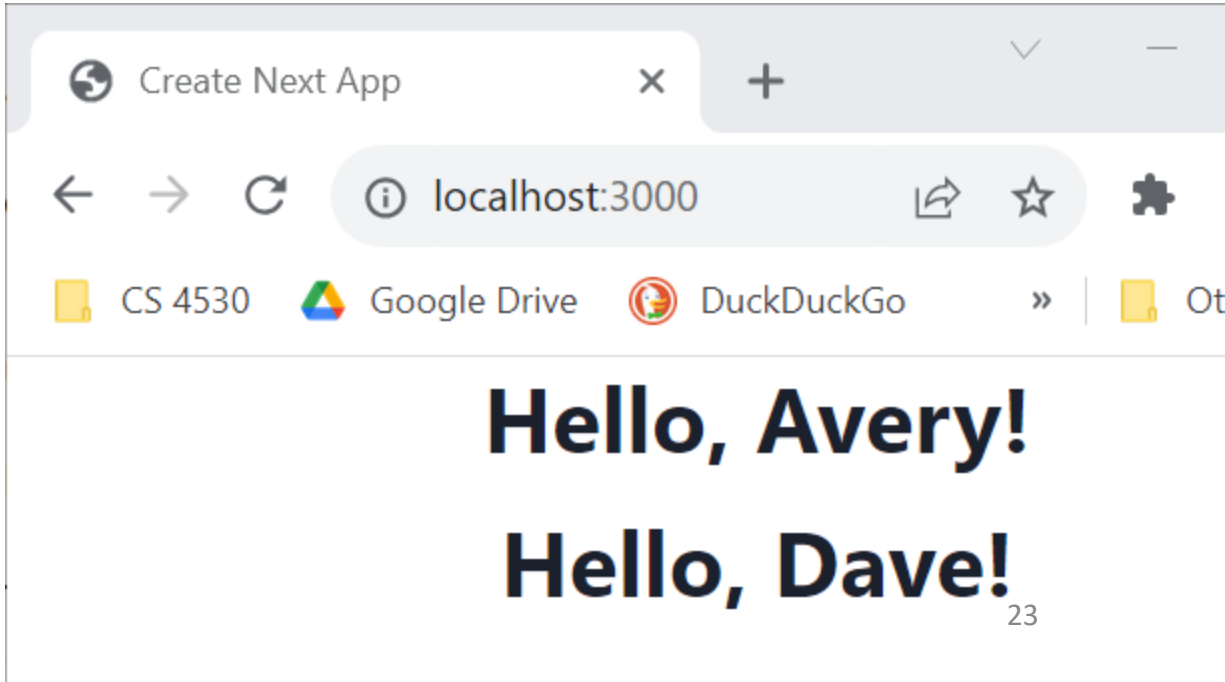
```
export function HelloMessage(){
  return <div>Hello, World!</div>
}
```

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>
    )
}
```



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

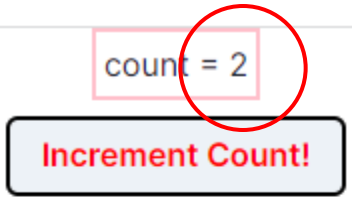
- ***A setter doesn't change the state immediately***: it is a request to REACT to update the state when this component is redisplayed.

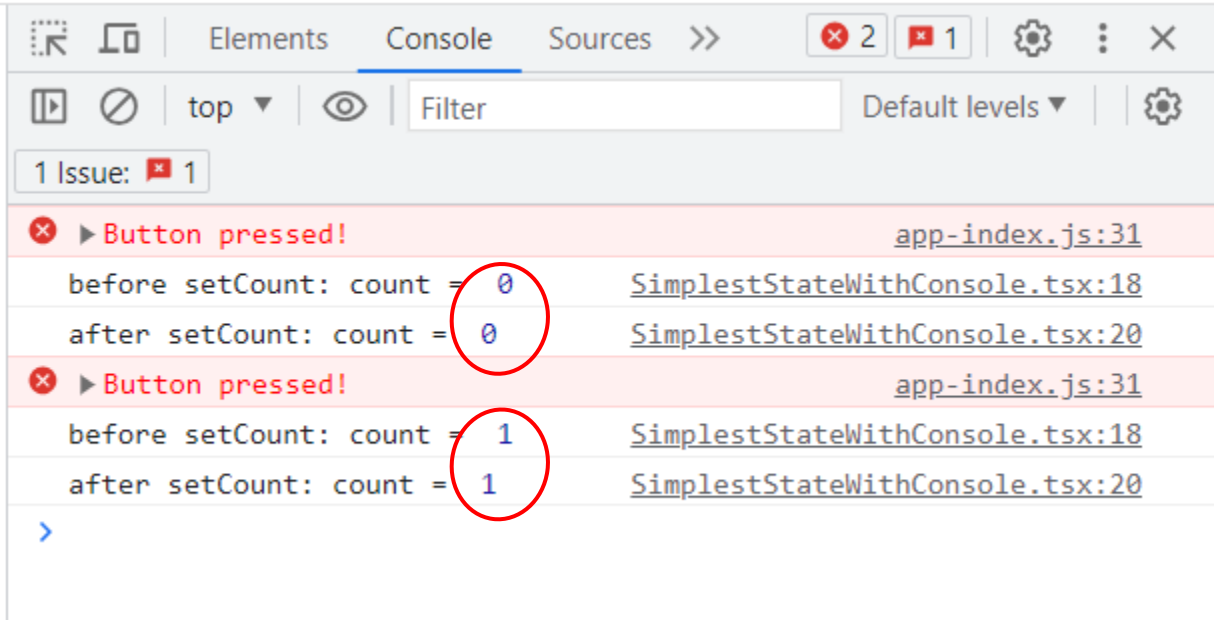
```
function handleClick() {
    console.error('Button pressed!');
    console.log('before setCount: count = ', count)
    setCount(count + 1)
    console.log('after setCount: count = ', count)
  }
```

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

app/Apps/SimplestStateWithConsole.tsx

Setters are asynchronous





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.}

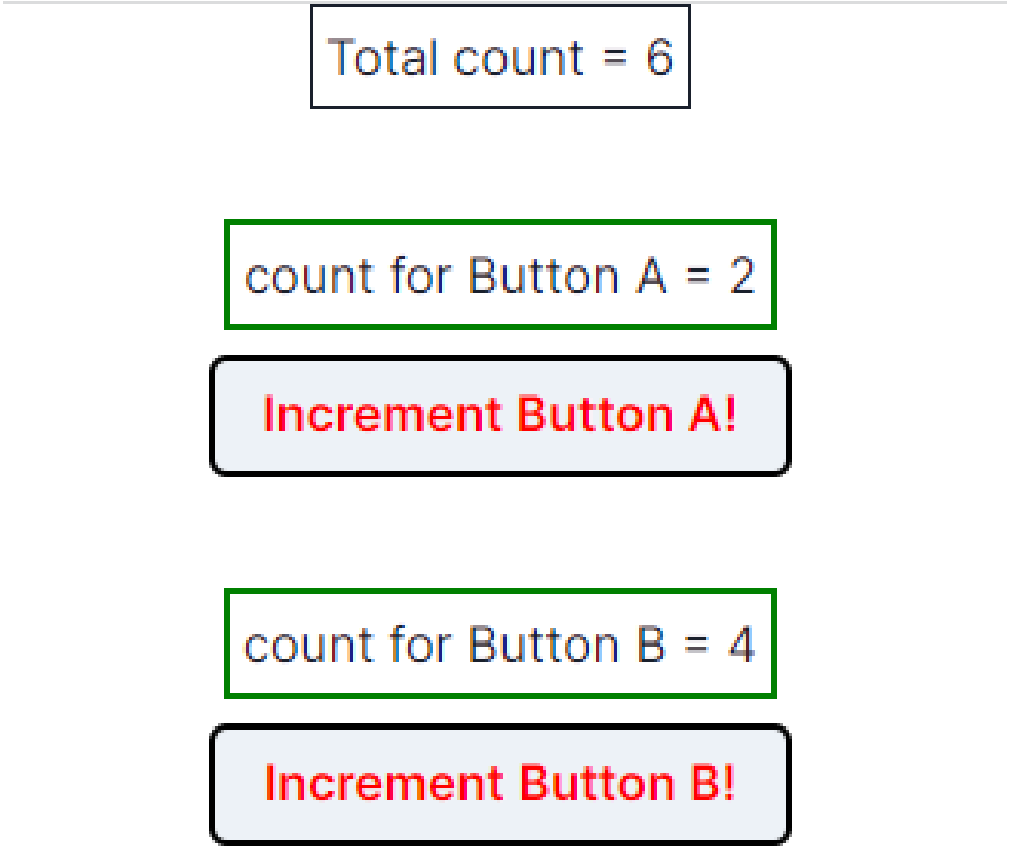
Nest Components, Passing State as Properties

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

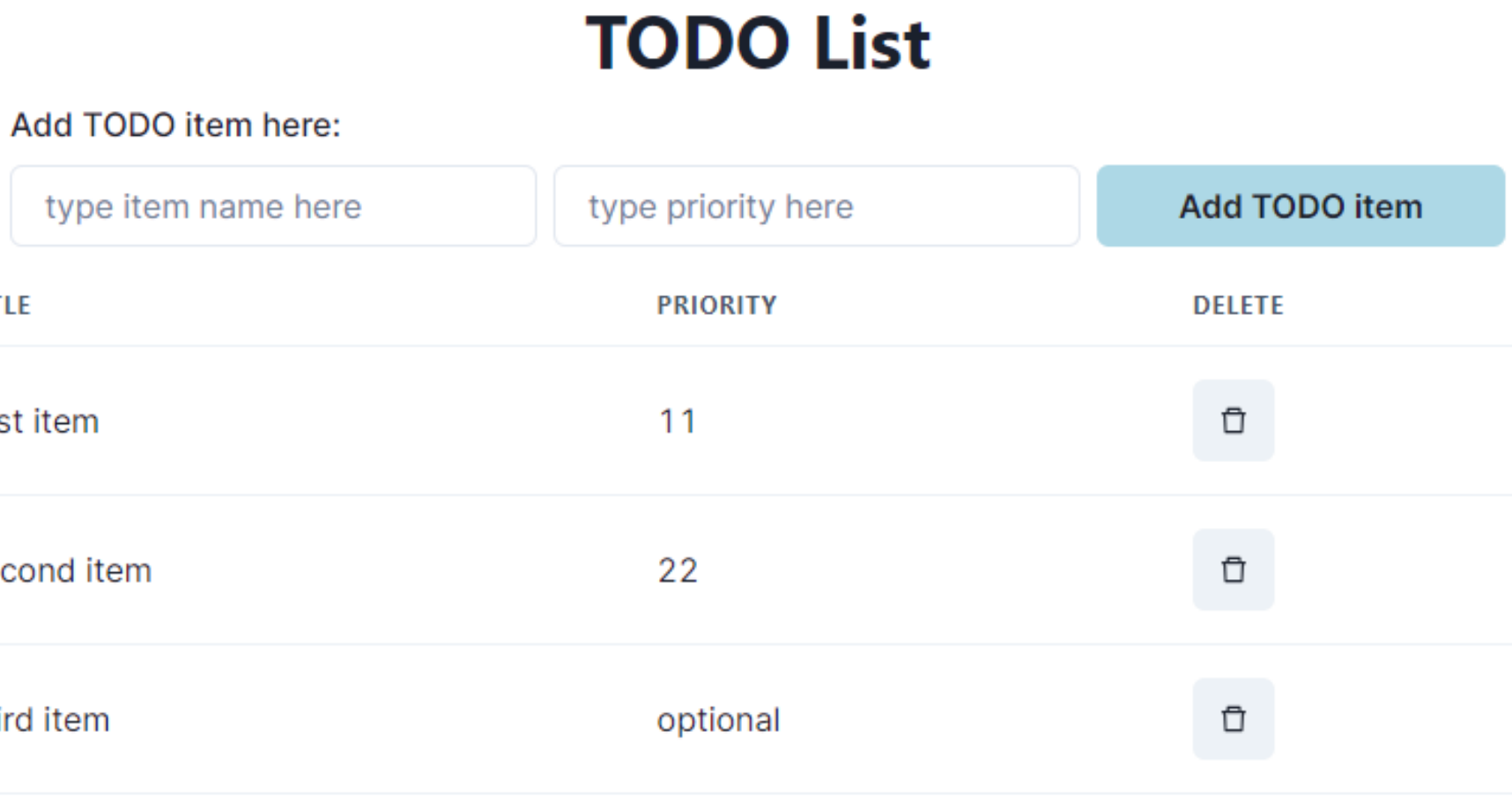


A ToDo App

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



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.