CS 4530: Fundamentals of Software Engineering

Lesson 6.2 Introduction to React

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Learning Goals

By the end of this lesson, you should…

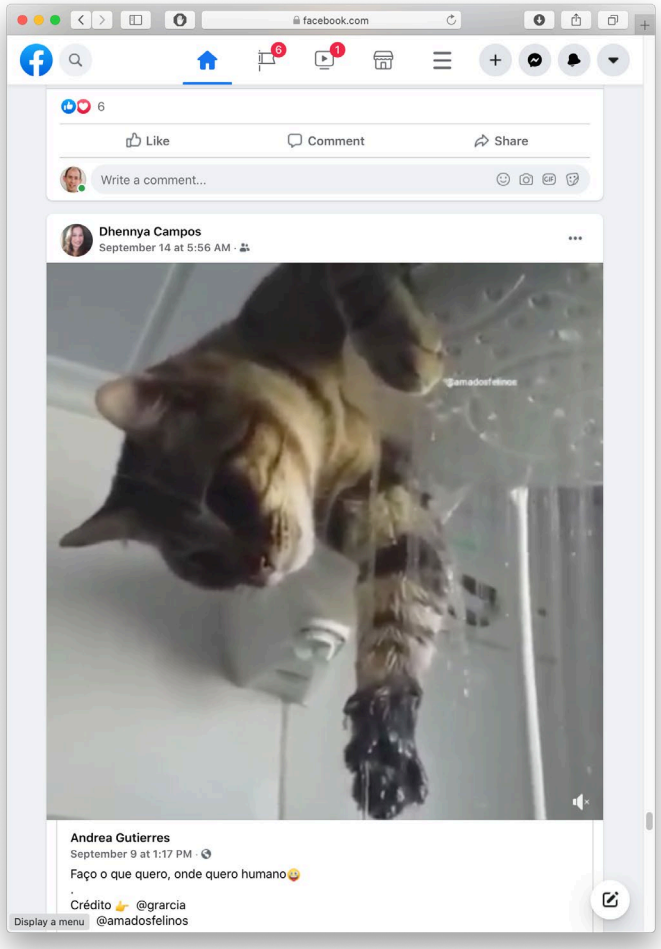
- Be able to explain how component reuse simplifies application development
- Understand how the React framework binds data (and changes to it) to a UI

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

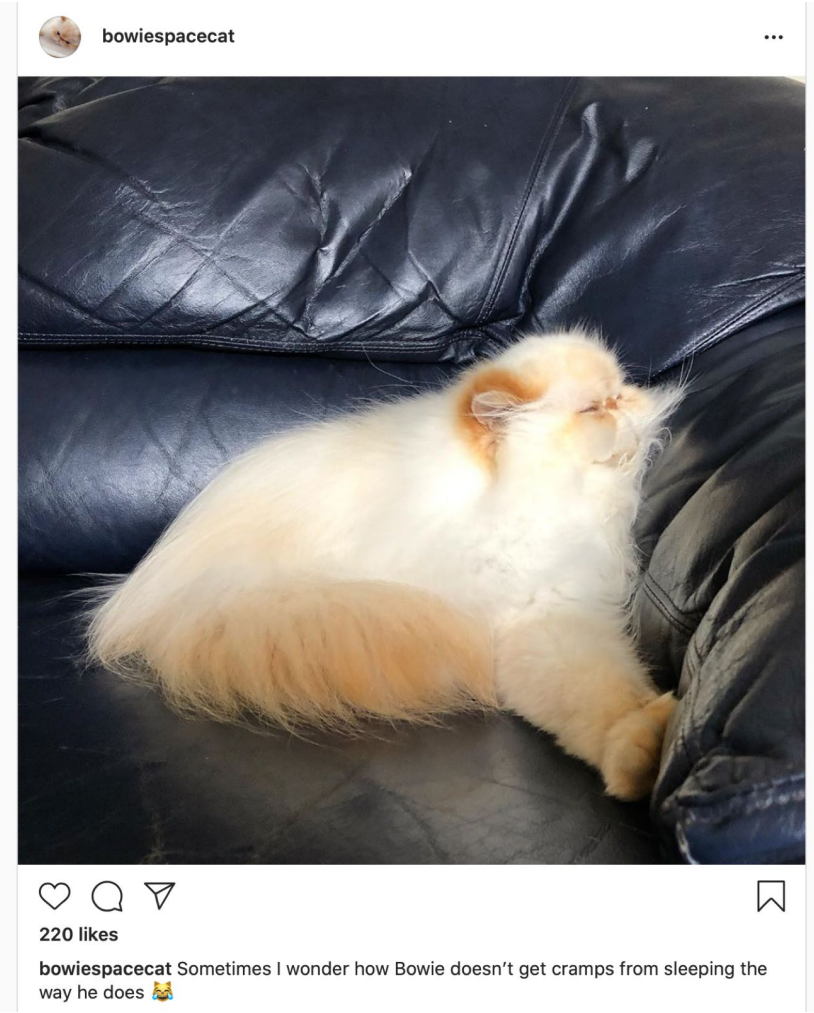
Infinite scrolling of cats



Typical properties of web app Uis

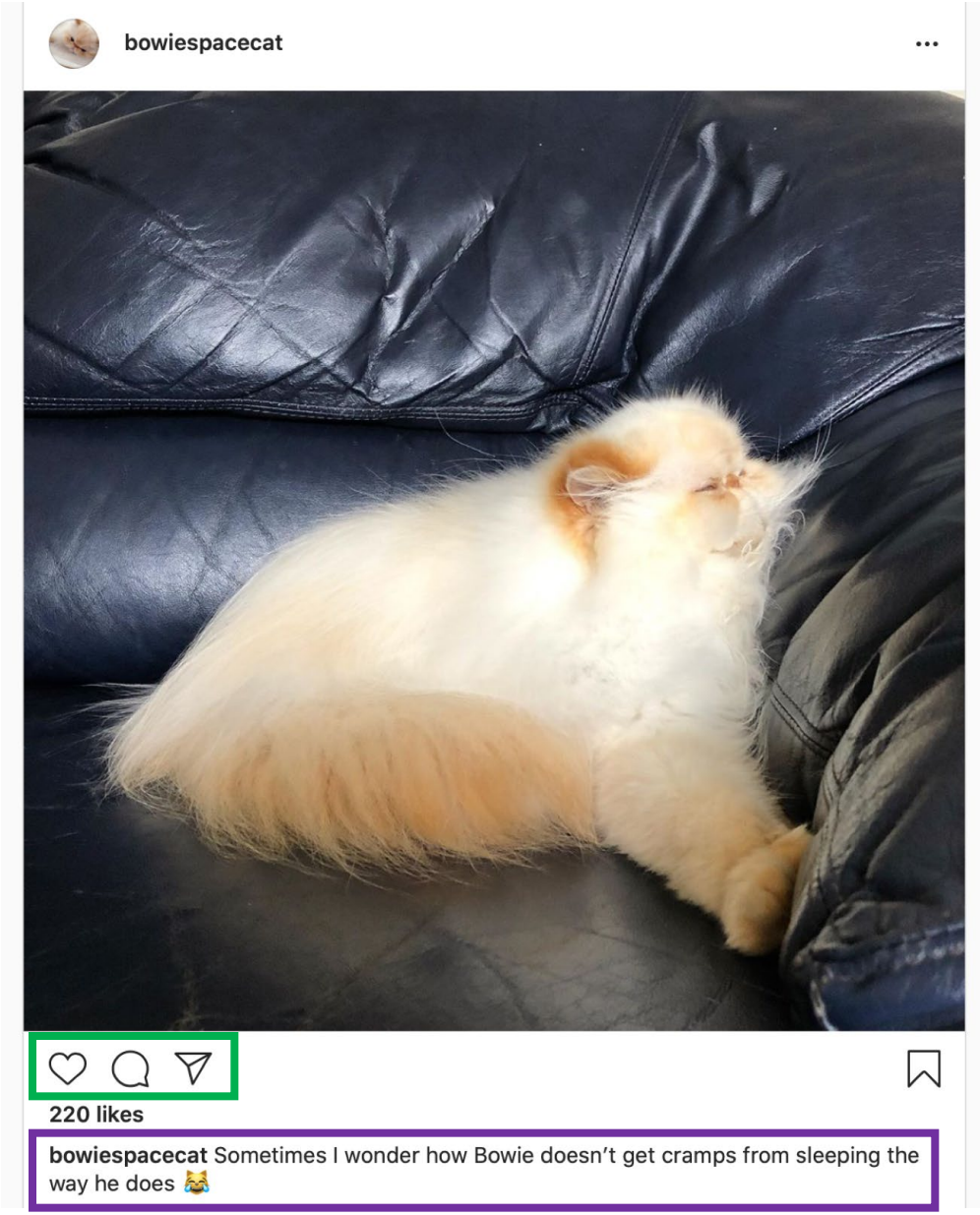
Building abstractions for web app development?

- Each widget has both visual presentation & logic
  - e.g., clicking on like button executes some logic related to the containing widget
  - Logic and presentation of individual widget strongly related, loosely related to other widgets
- 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



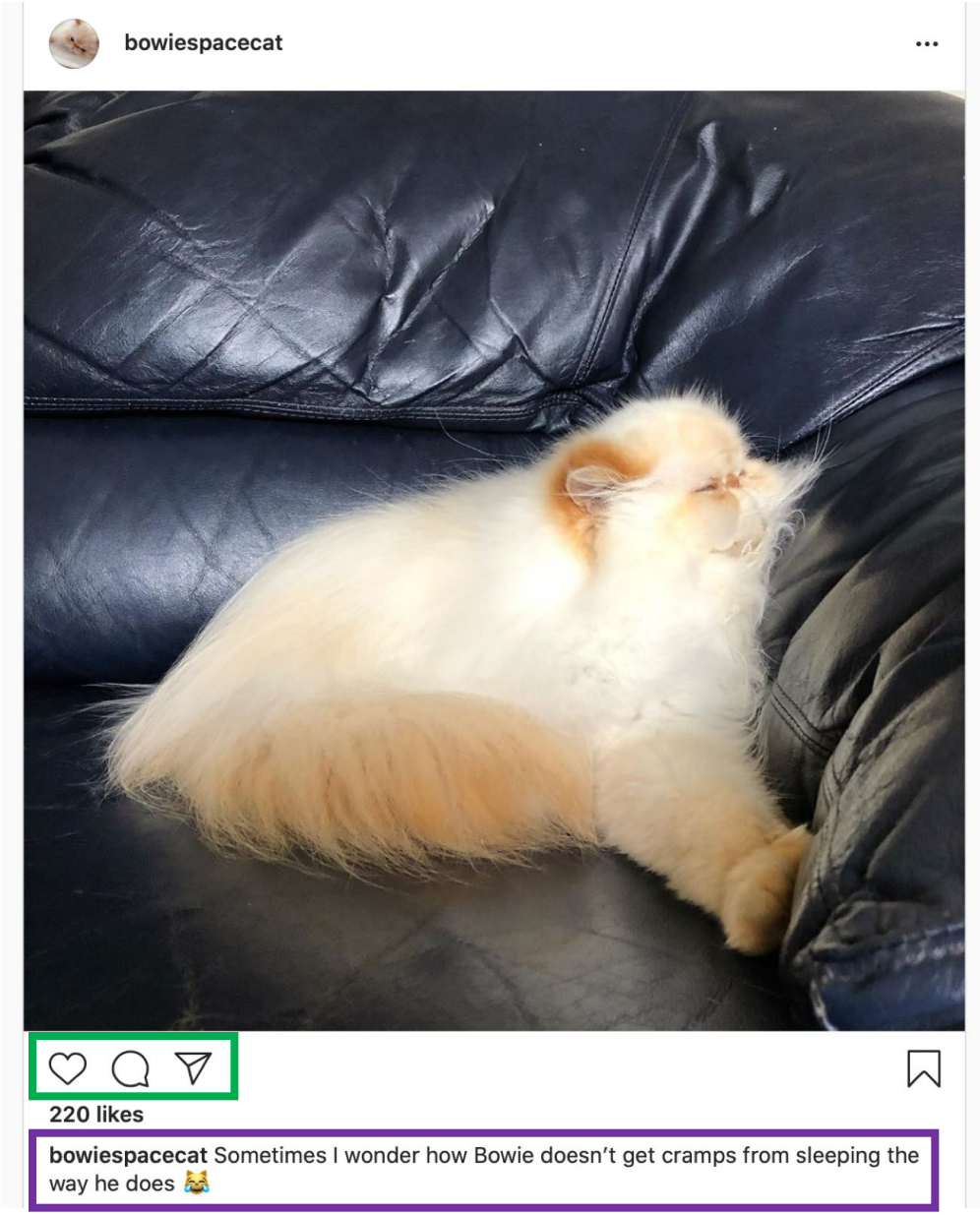
Key Idea: Components

- Web pages are complex, with lots of logic and presentation
- How can we organize web page to maximize modularity?
- Solution: Components - Easy to repeat, cohesive pieces of code (hopefully with low coupling)



Components

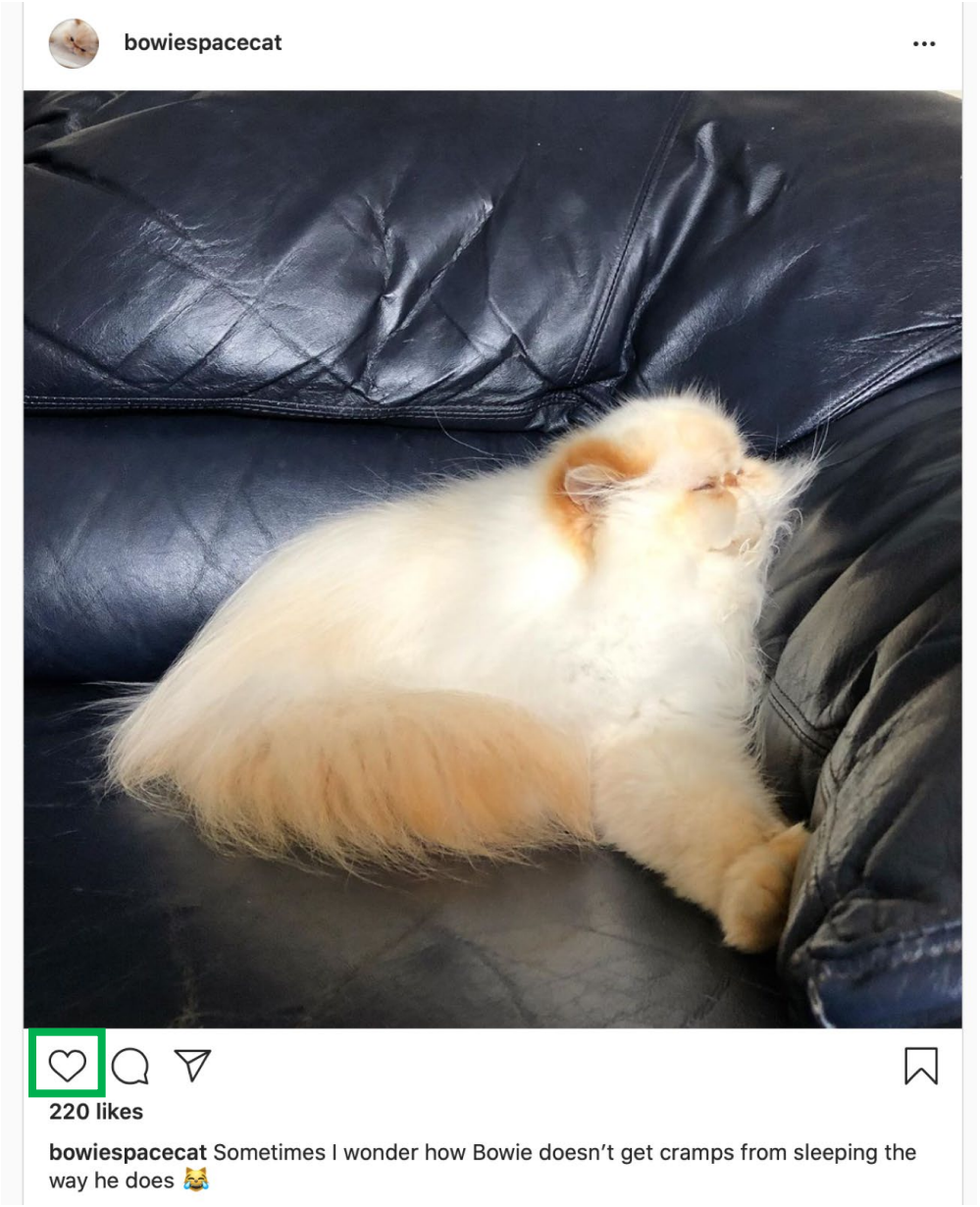
- Organize related logic and presentation into a single unit
  - Includes necessary state and the logic for updating this state
  - Includes presentation for rendering this state into HTML
- Synchronizes state and visual presentation
  - Whenever state changes, HTML should be rendered again



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')
);
```

React: Front End Framework for Components

- Created by Facebook
- Powerful abstractions for describing frontend UI components
- Official documentation & tutorials: https://reactjs.org/
- Key concepts:
  - Embed HTML in TypeScript
  - Track application “state”
  - Automatically and efficiently re-render page in browser based on changes to state

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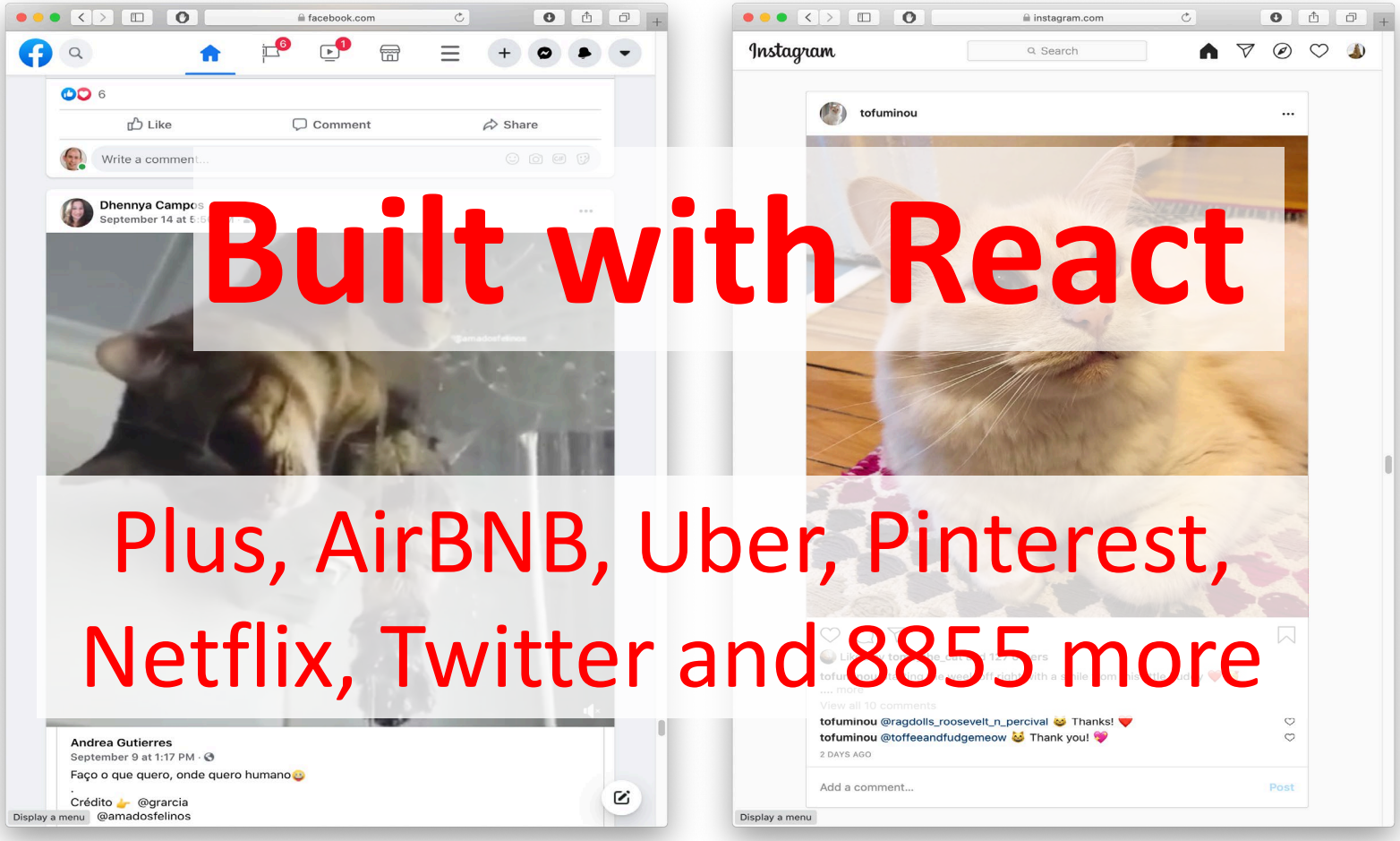
Infinite scrolling of cats



Built with React

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

React Evolution

From classes to functional components

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

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

- Hooks were added to functional components in React 16.8.
- Recommended using functional components instead of class components.
- Will have more features added.
- Neither approach is wrong.

Embedding HTML in TypeScript

```
return <div>Hello {name}</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() }
- Output of expression is HTML

Example Component

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

"Return the following HTML whenever the component is rendered"

The HTML is dynamically generated by the library.

"Declare a Hello component"

Declares a new component to which state and other functionality can be added.

Properties vs. State

- Properties should be immutable.
  - Created through attributes when component is instantiated.
  - Should never update within component
  - Parent may create a new instance of component with new properties

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

```
<HelloMessage name='Satya' />
```

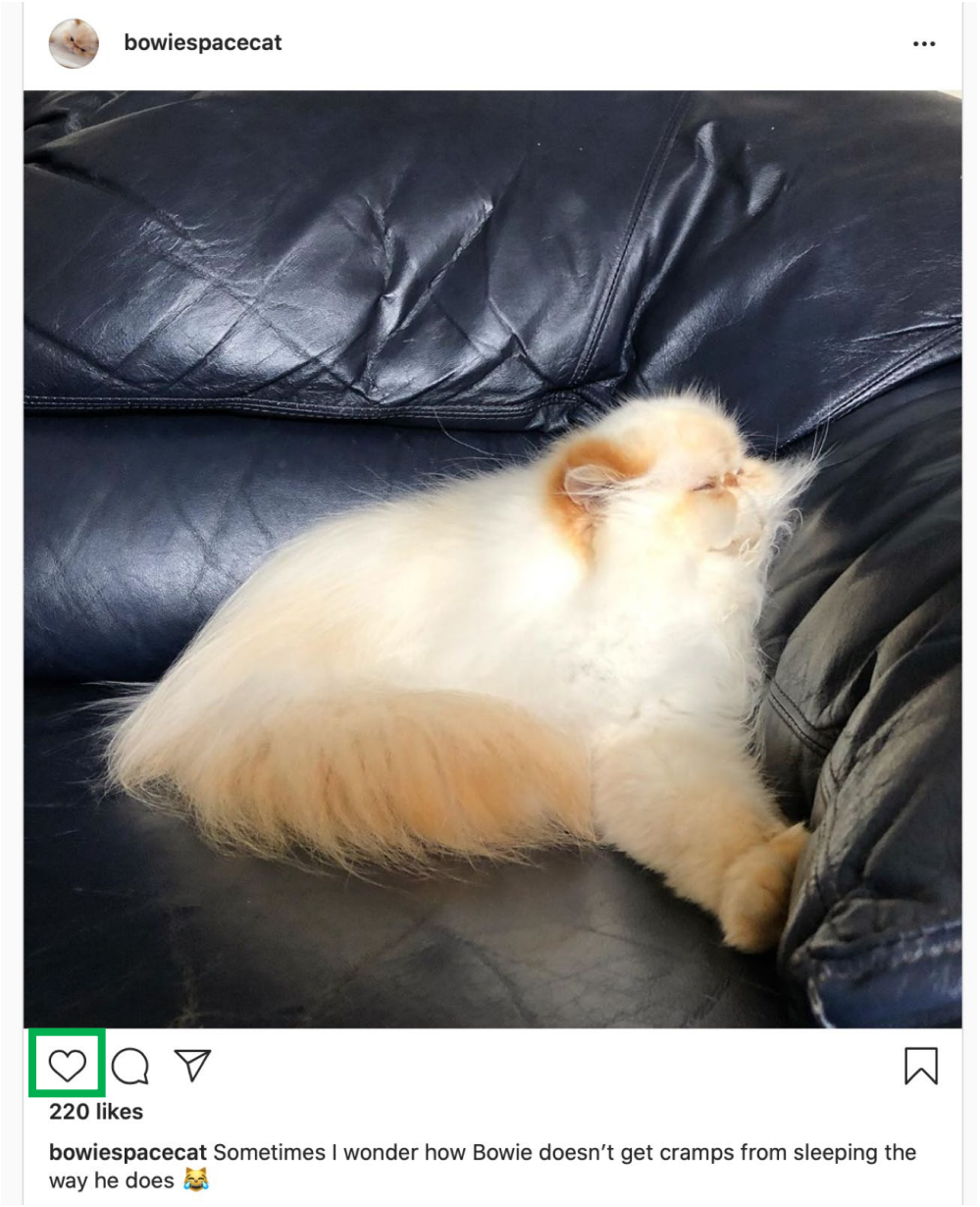
- State changes to reflect the current state of the component.
  - Can (and should) change based on the current internal data of your component.

Components

Example: Like button component

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

```
if(state.isLiked){
  return <HeartFilled onClick={toggleLike} />
  } else {
  return <HeartOutlined onClick={toggleLike} />
}
```



What is state?

- All internal component data that, when changed, should trigger UI update
  - Stored as state variables in the component
    - Created using useState(defaultValue)
    - E.g. let [state, setState] = useState({});
  - Only can set directly before a component is created (in useState()). Otherwise must call setState()
- Import useState from react

```
import { useState } from 'react';
```

Reacting to change

How does the page update automatically?

- Your code updates the state of component when event(s) occur (e.g., user enters data, get data from network)

- Updating state causes the html to be re-rendered by the framework (must call setter, not update variable directly)

- Reconciliation: Framework diffs the previously rendered DOM with the new DOM, updating only part of DOM that changed

Working with state

- useState() should initialize state of object inside component

```
let [date, setDate] = useState(new Date());
```

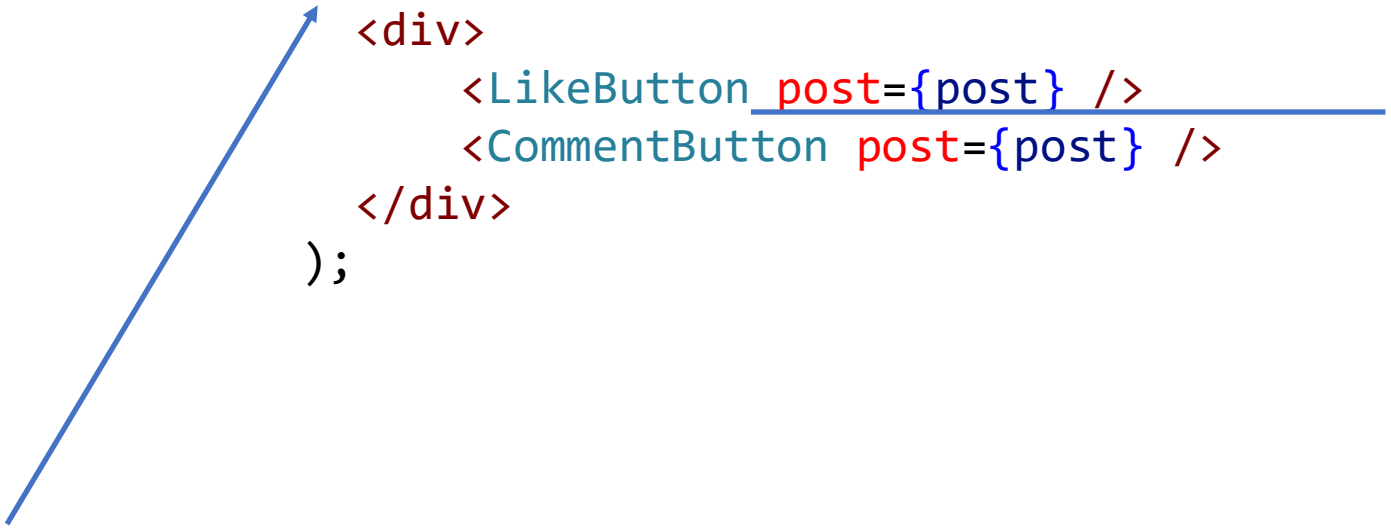
- Use setState to update state (setDate in example)

```
setDate(new Date());
```

- Doing this will (asynchronously) eventually result in render being invoked
- Multiple state updates can be automatically batched together and result in a single render call

Nesting components

```
return (
  <div>
      <LikeButton post={post} />
      <CommentButton post={post} />
  </div>
);
```



Establishes ownership by creating in returned template

Sets `post` property of child to value of `post` property of parent

The data flows down

- State that is common to multiple components should be owned by a common ancestor
  - State can be passed into descendants as properties
- When this state can be manipulated by descendants (e.g., a control), change events should invoke a handler on common ancestor
- Handler function should be passed to descendants

The data flows down

```tsx
export function Counter() {

  let [count, setCount] = useState(0);

  function incrementCount() {
    setCount(count + 1);
  }

  return (
    <div>
      <Display count={count} />
      <Button incrementCount={incrementCount} />
    </div>
  );

}
```

```tsx
export function Display(props: any) {
  return (
    <h1>Count: {props.count}</h1>
  )
}

export function Button(props: any) {
  return (
    <button onClick={props.incrementCount}>
      Increment Count
    </button>
  )
}
```

Component Lifecycle

- Traditionally, the React Component Lifecycle consists of 3 phases
  - Mounting: When a component first loads
    - componentDidMount()
  - Updating: When the component is updated
    - componentDidUpdate()
  - Unmounting: When the component is about to be removed
    - componentWillUnmount()

- In functional components, these are replaced by hooks.
  - Specifically, the useEffect() hook, imported from react

```
import { useEffect } from 'react';
```

Working with Hooks

Self incrementing timer

```
export function Timer() {

  let [seconds, setSeconds] = useState(0);

  function tick() {
    setSeconds((nrSeconds) => nrSeconds + 1);
  }

  // Some magic to make it work.

  return (

    <div>
      Seconds: {seconds}
    </div>

  );
}
```

Working with Hooks

Self incrementing timer

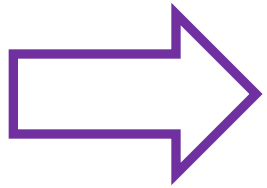
```
useEffect(() => {
  // set interval when component loads.
  let interval: NodeJS.Timeout = setInterval(tick, 1000);
  return () => {
    // clear interval when component is about to be removed.
    clearInterval(interval as NodeJS.Timeout);
  }
}, []); // Empty array to prevent execution when state is updated.

useEffect(() => {
  // Executes every time seconds is updated.
  console.log(seconds);
}, [seconds]); // will only run when seconds is updated.
```

Reconciliation

Efficiently updating browser's view of the app

```
<Card>
  <p> Paragraph 1 </p>
  <p> Paragraph 2 </p>
</Card>
```



```
<Card>
  <p> Paragraph 2 </p>
</Card>
```

- Process by which React updates the DOM with each new render pass
- Occurs based on order of components
  - Second child of Card is destroyed.
  - First child of Card has text mutated.

Reconciliation with Keys

- Problem: what if children are dynamically generated and have their own state that must be persisted across render passes?
  - Don’t want children to be randomly transformed into other child with different state
- Solution: give children identity using keys
  - Children with keys will always keep identity, as updates will reorder them or destroy them if gone

Reconciliation with Keys

```
export function NumberList(props: any) {
  const numbers = props.numbers;
  const listItems = numbers.map((number: any) =>
    <li key={number.toString()}>
      {number}
    </li>
  );
  return (
    <ul>{listItems}</ul>
  );
}

const numbers = [1, 2, 3, 4, 5];
ReactDOM.render(
  <NumberList numbers={numbers} />,
  document.getElementById('root')
);
```

Summary - React

- Component-based framework
- Automatically re-render components based on changes to data
- Maps each component to some HTML elements and efficiently updates them