CSE 331
Software Design & Implementation

Kevin Zatloukal

Spring 2022

Modern Web GUIs

Administrivia

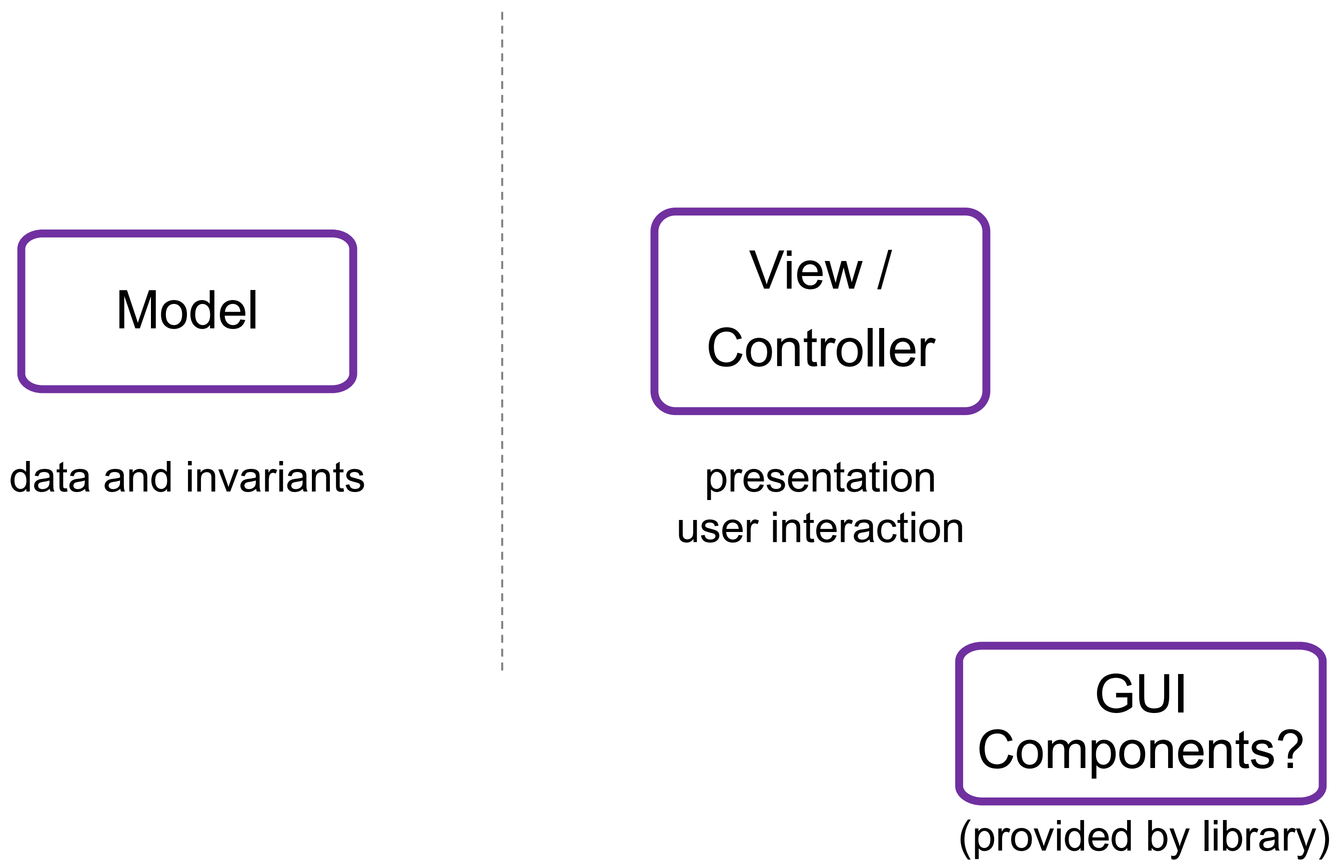
- Section tomorrow should be very useful
  - focus will be on homework prep as usual

Structure of a GUI Application

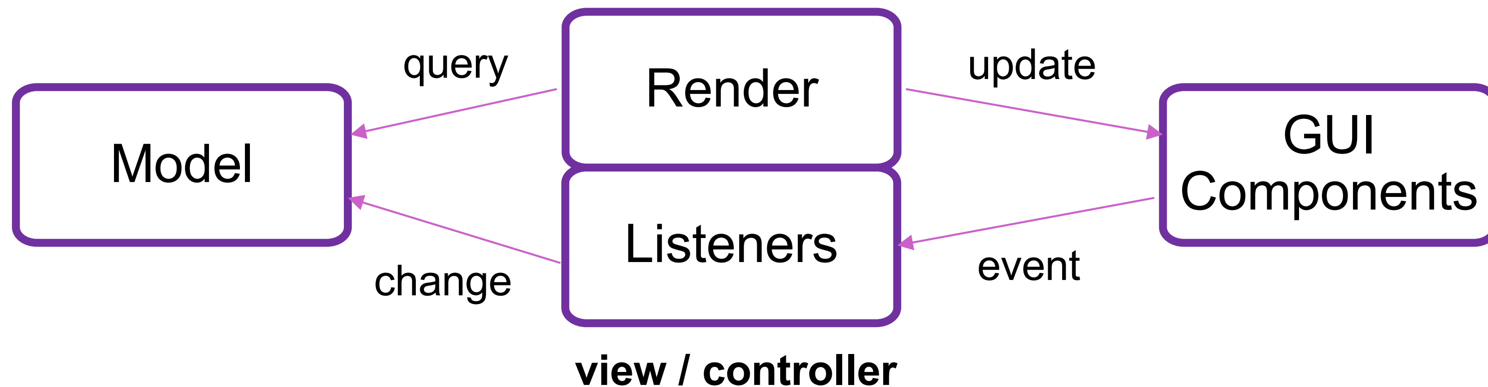
- Core parts of these applications:
  - stores some data for the user
  - displays that data for the user
  - allows the user to change the data
    - causes the app to re-display

- Library provides a set of ***components*** we can use

Structure of a GUI Application



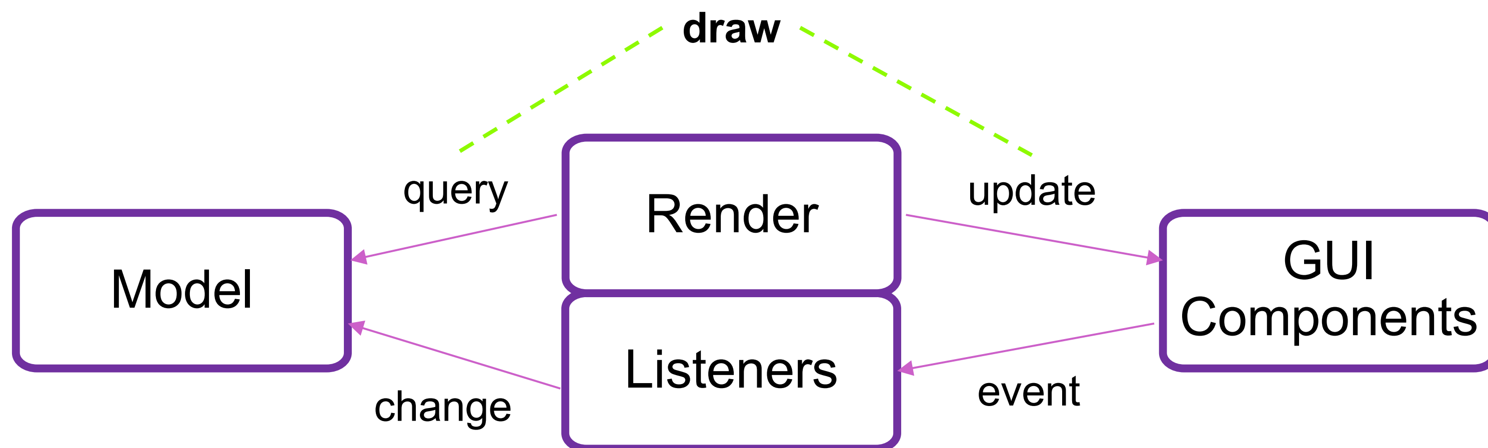
Structure of a GUI Application



View / Controller sits in between model and GUI components

- performs two key tasks…

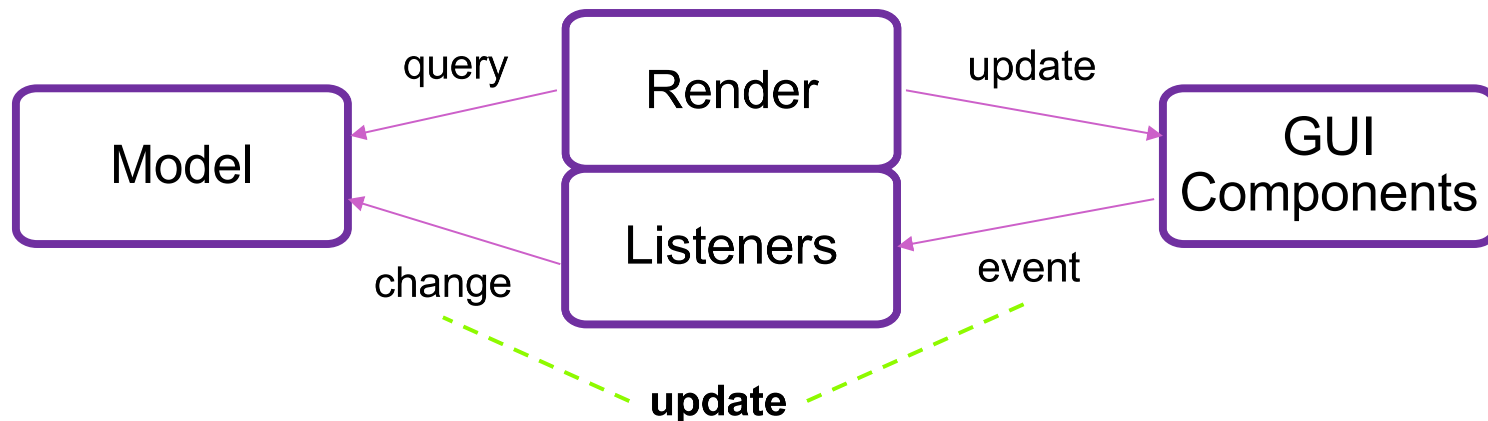
Structure of a GUI Application



View / Controller sits in between model and GUI components

1. Renders (“draws”) the model for the user via components

Structure of a GUI Application



View / Controller sits in between model and GUI components

1. Renders (“draws”) the model for the user via components
2. Updates the model based on user interaction
   – causes the app to draw again

JS Example

register-js/index.js

Remaining Problems

- ~~Code is extremely **verbose**~~
  - ~~can be improved using Lambdas~~

- Code is *not sufficiently* **modular**
  - one JS mixes data, display, interaction

- ~~**Too much work** involved with laying out elements~~

- Poor **tool support**
  - HTML is created in strings!
  - (and other issues not mentioned so far…)

ES6

From last time: Fake Classes

- JavaScript started as an OO language w/out classes

- Can do some of what we need already:

```
let obj = {f: (x) => x + 1};
console.log(obj.f(2));  // 3
```

- Use “**`this`**” to read fields of **`obj`** in **`obj.f`**

Classes

```
class Foo {
  constructor(val) {
    this.secretVal = val;
  }
  secretMethod(val) {
    return val + this.secretVal;
  }
}

let f = new Foo(3);    // {secretMethod: …, secretVal: …}
console.log(f.secretMethod(5));  // 8
```

Classes

- **`new Foo`** creates an object already containing methods
  - also calls the constructor

- Still has the same issue with this:

```
class Foo { … }

let f = new Foo(3);
let s = f.secretMethod;
console.log(s(5));                    // NaN

let t = (x) => f.secretMethod(x);
console.log(t(5));                    // 8
```

JS vs Java Classes

- JS method signatures are just the name
  - JS objects are just HashMaps
  - field names are the keys

```
obj.avg(3, 5)
```

- Java methods signatures are name + arg types
  - e.g., `avg(int,int)`
- JS has only one method with a given name
  - language allows different numbers of arguments
    - missing arguments are undefined
  - can strengthen a spec by accepting a wider set of possible input types

Modules

- Each file is a separate unit (“namespace”)
- Only exported names are visible outside:

```
export function average(x, y) { … }
```

- Others can import using:

```
import { average } from './filename';
```

  – file extension is sometimes not included

ES6 Example

register-js2/…

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TypeScript

TypeScript

- Adds type constraints to the code:
  - arguments and variables

```
let x: number = 0;
```

  - fields of classes (now declared)

```
quarter: string;
```

- **`tsc`** performs type checking
  - outputs version with type annotations removed

TypeScript Types

- Basics from JavaScript:
  number, string, boolean, string[], Object
- But also
  - specific classes `Foo`
  - tuples: `[string, number]`
  - unions: `string | number`
  - enums (as in Java)
  - allows `null` to be included or excluded (unlike Java)
  - `any` type allows any value
  - abbreviations: `type Point = [number, number]`
  - …

Simple Examples

`points1.ts`

`points2.ts`

UI Example

register-ts/…

TypeScript

- Type system is unsound
  - can't promise to find prevent all errors
  - can be turned off at any point with any types
    - `x as Foo` is an unchecked cast to `Foo`
    - `x!` casts to non-null version of the type (useful!)

- Full description of the language at `typescriptlang.org`

JSX

JSX

- Fix another problem by adding HTML as a JS type
- This is supported in `.jsx` files:

```
let x = <p>Hi, {name}.</p>;
```

- Compiler can now check that this is valid HTML
- {…} replaced with string value of expression

JSX Gotchas

- Put (..) around HTML if it spans multiple lines
- Cannot use `class="btn"` in your HTML
  - `class`, `for`, etc. are reserved words in JS
  - use `className=".."`, `htmlFor=".."`, etc.
- Must have a single top-level tag:
  - not: `return <p>one</p><p>two</p>;`
  - usually fixed by wrapping those parts in a `div`

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REACT

React

- Improve modularity by allowing custom tags

```
let app = (
    <div>
      <TitleBar name="My App"/>
      <EditPane rows="80" />
    </div>);
```

- `TitleBar` and `EditPane` can be separate modules
  - their HTML gets substituted in these positions

React

- Custom tags implemented using classes

```
class TitleBar extends React.Component {
```

- Attributes (`name="My App"`) passed in `props` arg
- Method `render` produces the HTML for component
- Framework joins all the HTML into one blob
  - can update in a single call to `innerHTML = …`

React Example

register-react/…

React Components

- Each React component renders into HTML elements

```
let app = (
    <div>
      <TitleBar name="My App"/>
      <EditPane rows="80" />
    </div>);
```

- React components corresponds to *portions* of the document
  - `TitleBar` is one subtree
  - `EditPane` is another subtree
  - `App` contains the two of those

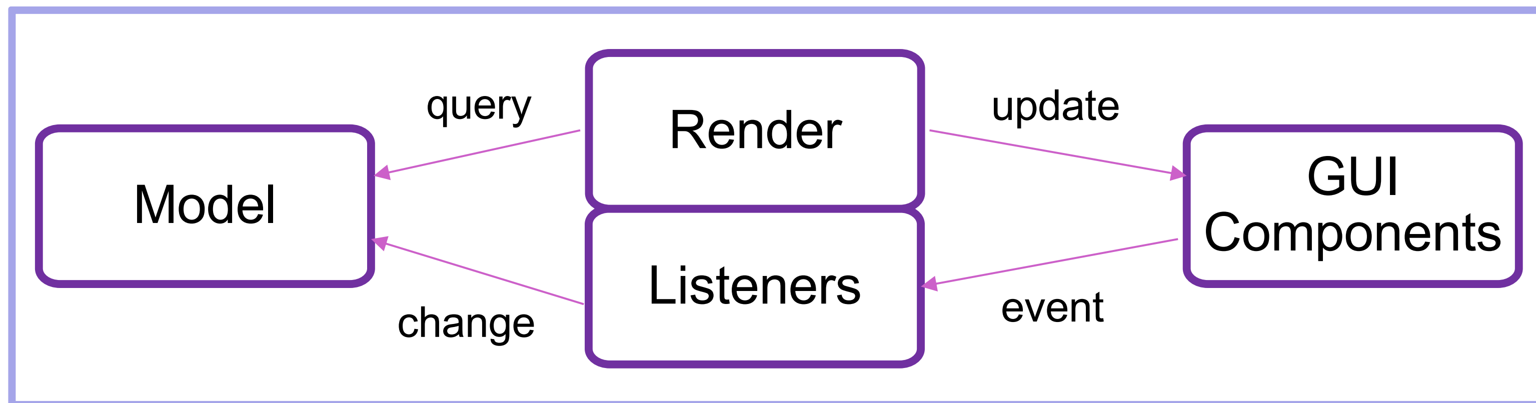
React State

- Last example was not dynamic
  - there was no model!

- Components become dynamic by maintaining state
  - stored in fields of `this.state`
  - call `this.setState({field: value})` to update

- React will respond by calling `render` again
  - will automatically update the live HTML to match
  - will only update the parts that changed

Structure of GUI Application

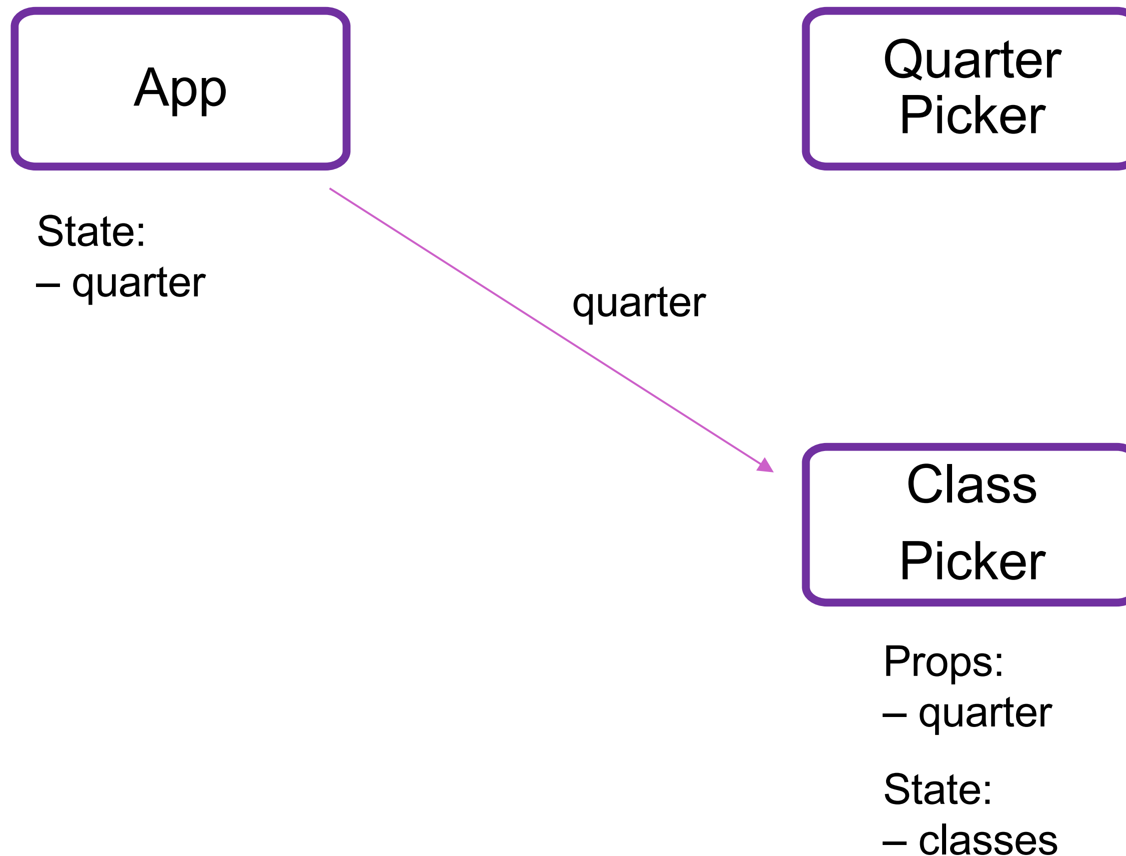


Each React component renders into HTML elements

Each React component includes

- **part** of the model
- **part** of the view (rendering of that data into components)
- **part** of the controller (listeners for interaction with that view)

Structure of Example React App



Example 5

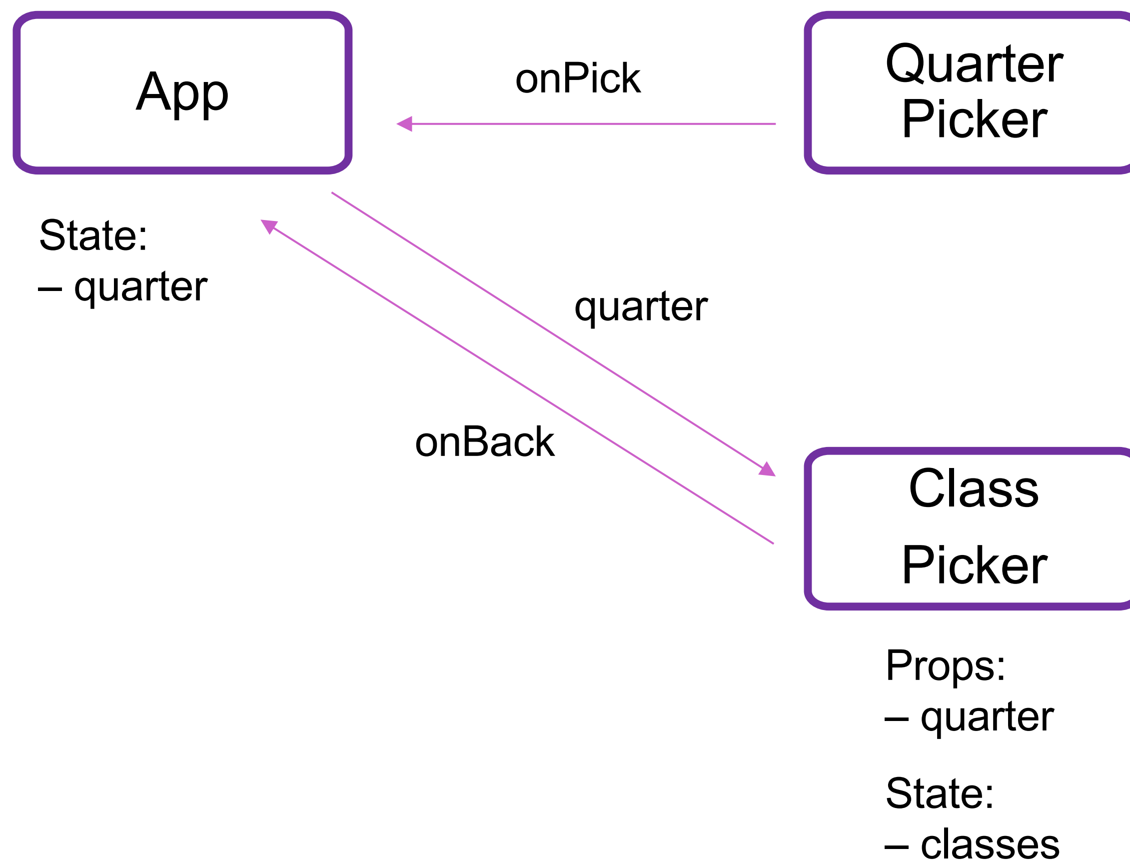
register-react2/…

React State

- Custom tag also has its own events

- Updating data in a parent:
  - sends parent component new data via event
  - parent updates state with `setState`
  - React calls parent's `render` to get new HTML
    - result can include new children
    - result can include changes to child props

Structure of Example React App



Splitting the Model

- State should exist in the **lowest common parent** of all the components that need it
  - sent down to children via *props*
- Children change it via *events*
  - sent up to the parent so it can change its state
- Parent's render creates new children with new props

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Event Listener Gotchas

- Recall the issue with "`this`" in JavaScript.
  - **do not** write `onClick={this.handleClick}`

- Three ways to do this properly:

  1. `onClick={(e) => this.handleClick(e)}`
  2. `onClick={this.handleClick.bind(this)}`
  3. Make `handleClick` a field rather than a method:

     ```
     handleClick: (e) => { … };
     ```

     Then `this.handleClick` is okay.

React setState Gotchas

- `setState` does not update state instantly:

```
// this.state.x is 2
this.setState({x: 3});
console.log(this.state.x); // still 2!
```

- Update occurs after the event finishes processing
  - `setState` adds a new event to the queue
  - work is performed when that event is processed
- React can batch together multiple updates

Other React Gotchas

- Model must store all data necessary to generate the exact UI on the screen
  - react may call `render` at any time
  - must produce identical UI

- Any state in the HTML components must be mirrored in the model
  - e.g., every text field's `value` must be part of some React component's state
  - render produces

```
<input type="text" value={…}>
```

Other React Gotchas

- `render` should not have side-effects
  - only *read* `this.state` in render
- Never modify `this.state`
  - use `this.setState` instead
- Never modify `this.props`
  - read-only information about parent's state
- Not following these rules may introduce bugs that will be hard to catch!

React Performance

- React re-computes the tree of HTML on state change
  - can compute a “diff” vs last version to get changes

- Surprisingly, this is not slow!
  - slow part is calls into browser methods
  - pure-JS parts are very fast in modern browsers
  - processing HTML strings is also incredibly fast

React Tools

- Use of compilers etc. means new tool set

- `npm` does much of the work for us
  - installs third-party libraries
  - runs the compiler(s)