Online Multimedia

Winter Semester 2019/20

Tutorial 06 – Front-end Tooling

Today's Agenda

- Testing
- Debugging & Benchmarking
- Roundup Quiz

Recap

Understanding JSX/TSX

- JSX/TSX is just a syntax sugar to eliminate cumbersome JS calls
- React transpiles this syntax to JS calls

```
export default class OmmCounter extends Component {
  …
  render() {
    return
    React.createElement('div', null,
      React.createElement('span', null, this.state.count),
      React.createElement('div', null,
        React.createElement('button', {onClick: this.inc}, '+'),
        React.createElement('button', {onClick: this.dec}, '-')))
  }
}
```

omm-counter.tsx

```
export default class OmmCounter extends Component {
  …
  render() {
    return (
      <div>
        <span>{ this.state.count }</span>
        <div>
          <button onClick={this.inc}>+</button>
          <button onClick={this.dec}>-</button>
        </div>
      </div>
    )
  }
}
```

omm-counter.tsx

Recap

Functional Components

- Class components ("stateful") was the only way to create an component
- However, building UI is very rare in designing a class system
- Functional components ("stateless") simply use JS functions to create an component:

```
const c: React.FC = () => {
   return (<div>TSX</div>)
}
```

```tsx
import React from 'react';
import './App.css';
import OmmCounter from './components/omm-counter/omm-counter'
const App: React.FC = () => {
  return (
    <div className="app">
      <div className="header"><h1>Counter - React
Hooks</h1></div>
      <OmmCounter />
    </div>
  );
}
export default App;
```

App.tsx

Recap

State Hook

- In functional components, there are no `state`, to manage states, we can involve `useState` hook:

```
const [currentState, setCurrentState] = useState('any data')
const F = () => { setCurrentState('new state') }
```

- `useState()` returns an array with exactly two elements:
  - Getter: Your current state value
  - Setter: A method to update your state value

Recap

Props

- `props` works like function parameters, which allows you pass data from a parent (wrapping) component to a child (embedded) component.
- Changes in props trigger React to re-render the components and potentially update the DOM in the browser.

```tsx
import React, { Component } from 'react';
import Child from './child'
export default class Parent extends Component {
  render() {
    return (
      <div><Child name={"Max"} age={18}/></div>
    )
  }
}
```

parent.tsx

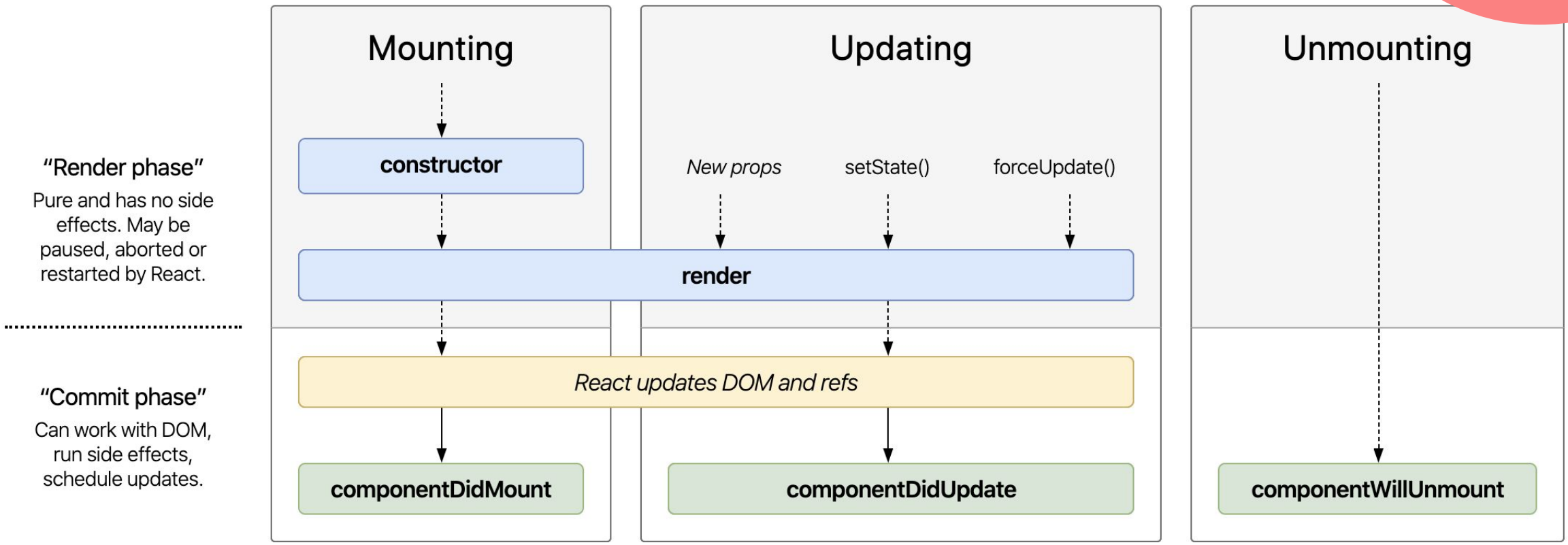
```tsx
import React, { Component } from 'react';
interface ChildProps { name: string, age: number }
export default class Child extends Component<ChildProps> {
  render() {
    return (<div>
        <div>name: {this.props.name}</div>
        <div>age: {this.props.age}</div>
        {/* <div>role: {this.props.role} </div> */}
    </div>)
}}
```

child.tsx

Recap

React Lifecycle Method Diagram

(only in class-based components)

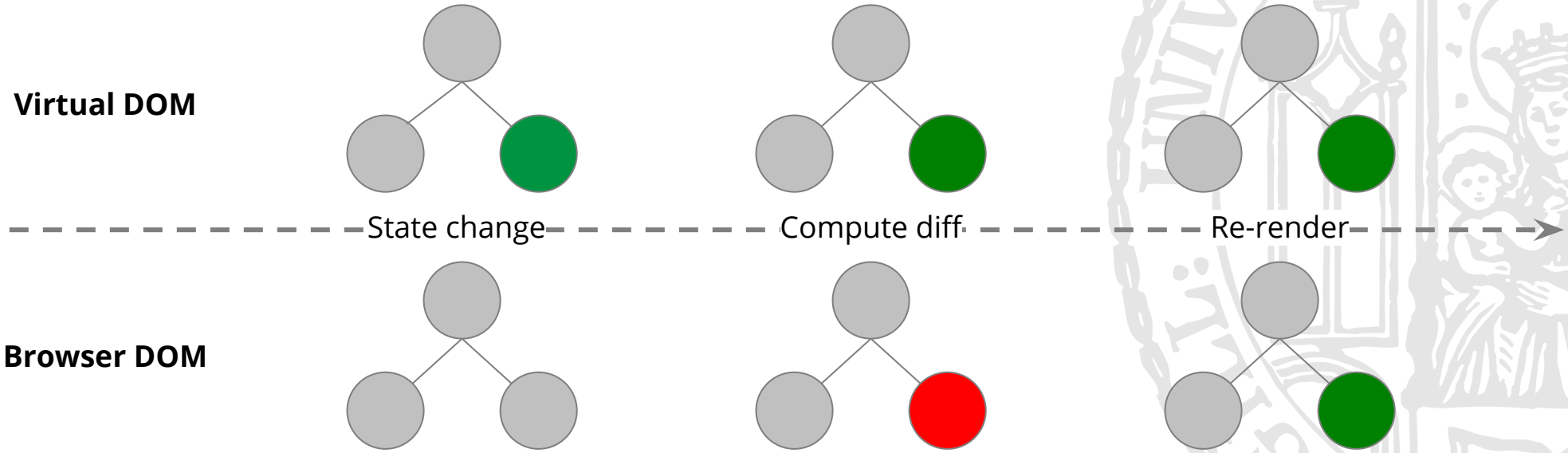


http://projects.wojtekmaj.pl/react-lifecycle-methods-diagram/

Recap

Reconciliation

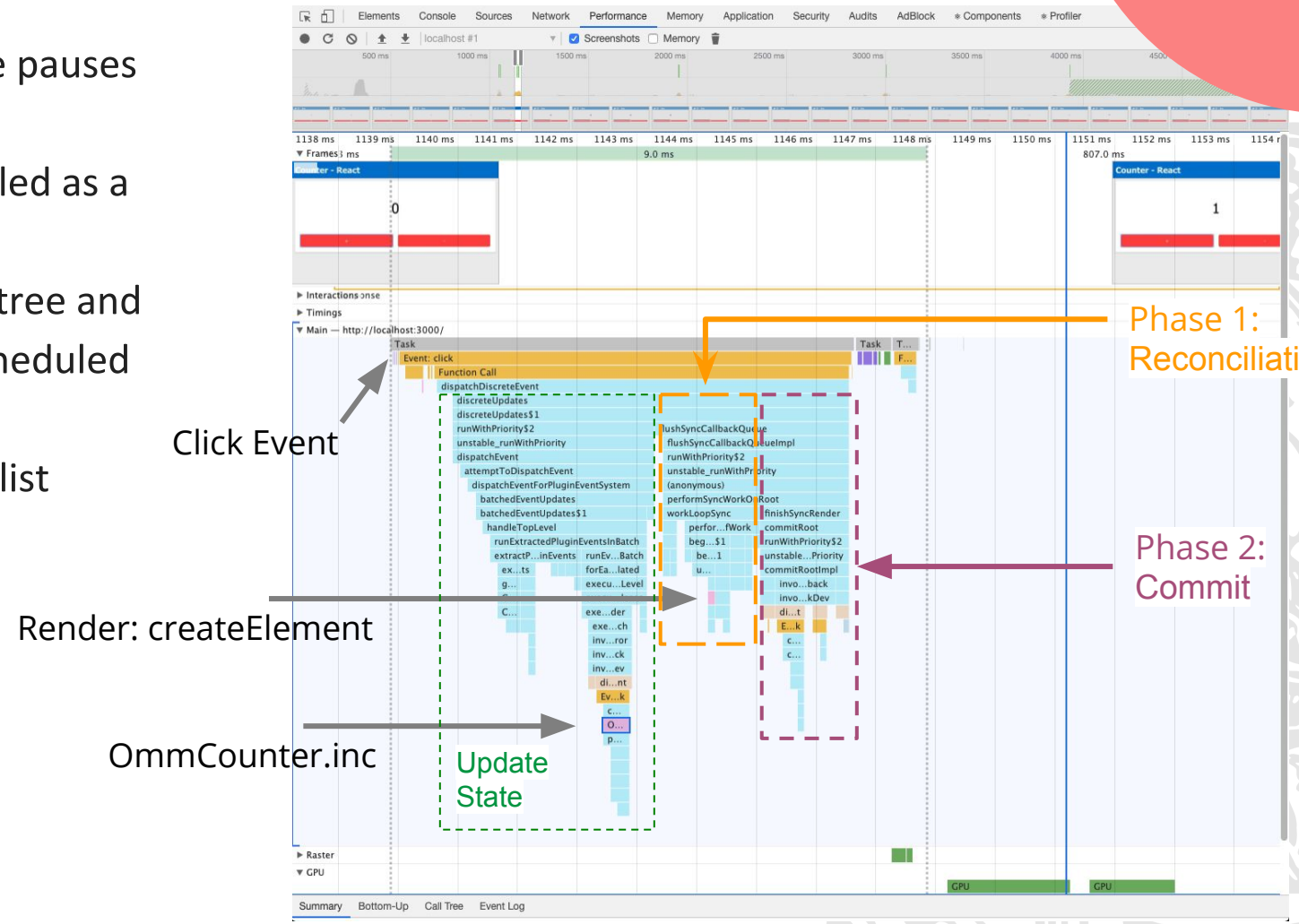
- React keeps a "virtual" representation (*Virtual DOM*) of a UI in memory and synced with the "real" DOM by `ReactDOM`. The process of synchronization is called reconciliation.
- When the component state is updated, the `ReactDOM.render` will be recalled and compares the "real" DOM to patch their diff.



Recap

Fiber Engine: Two-Phase Update Processes

- Traverse update a large DOM tree pauses main thread (recall event loop)
- Hence, an update patch is scheduled as a fiber node
- ***Reconciliation phase*** builds fiber tree and ensures higher priority tasks is scheduled after a timeslice (interruptible)
- ***Commit phase*** commits all effect list (uninterruptible)



Recap

Conditional and Repetitive Rendering

- Conditional:

```
if (condition) {
    optionalRender = (<div>render under a condition</div>)
}
return (<div>{optionalRender}</div>)
```

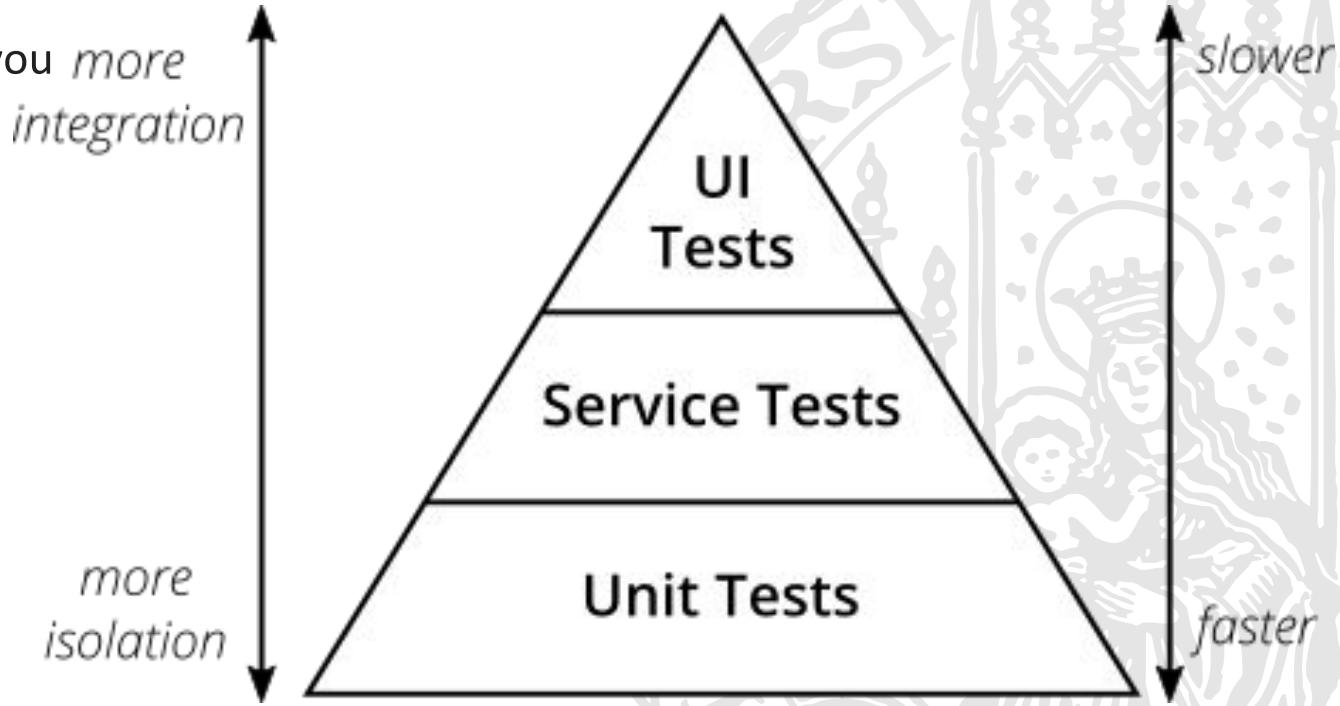
- Repetitive:

```
return (<div>{
    this.state.stateArray.map(item => {
        return <div key={item.id}>{item.property}</div>
    })
}</div>)
```

Testing in React

Test Pyramid

- Tests save yourself time maintaining application, but hard to
  - find a good amount of tests
  - avoid testing implementation details
- You should rarely have to change tests when you refactor code.
- UI Test
  - Usually performs End-to-End test
  - Test all parts of application
- Service Test (Integration Test)
  - Tests connectivity
  - E.g. web services - APIs
- Unit Test
  - Tests are local
  - Check if code works

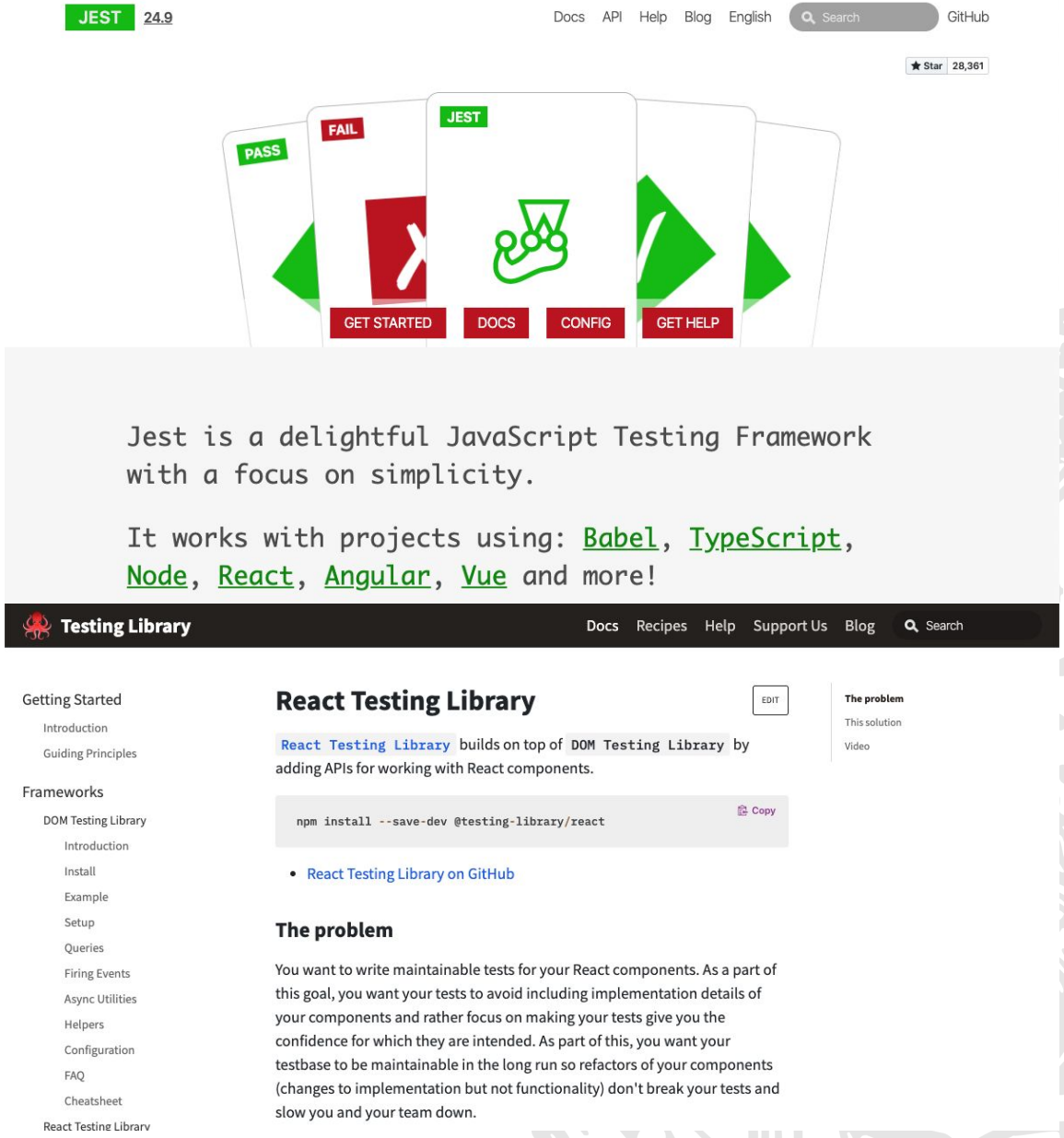


https://martinfowler.com/articles/practical-test-pyramid.html

Test Utilities in React

- **Jest** and **React Testing Library** are the two official recommended testing library for React
- **Jest** is a general purpose JavaScript testing library, e.g. `expect(val1).toBe(val2)`
- **React Testing Library** builds on top of DOM Testing Library, offers various rendering utilities for React components.

- APIs
  - https://jestjs.io/docs/en/api
  - https://testing-library.com/docs/react-testing-library/api



Test at Glance

- Create React App automatically gives a sample test in `src/App.test.tsx`
- Create React App provides the option to let you run your test: `npm test`

```
ou-lmu ❐ dev ● 1 zsh (tmux)                                    ⌥⌘1
Test Suites: 1 passed, 1 total
Tests:       1 passed, 1 total
Snapshots:   0 total
Time:        1.126s, estimated 2s
Ran all test suites related to changed files.

Watch Usage
 › Press a to run all tests.
 › Press f to run only failed tests.
 › Press q to quit watch mode.
 › Press p to filter by a filename regex pattern.
 › Press t to filter by a test name regex pattern.
 › Press Enter to trigger a test run.
```

```tsx
import React from 'react';
import ReactDOM from 'react-dom';
import App from './App';

it('renders without crashing', () => {
 const div = document.createElement('div');
 ReactDOM.render(<App />, div);
 ReactDOM.unmountComponentAtNode(div);
});
```

App.test.tsx

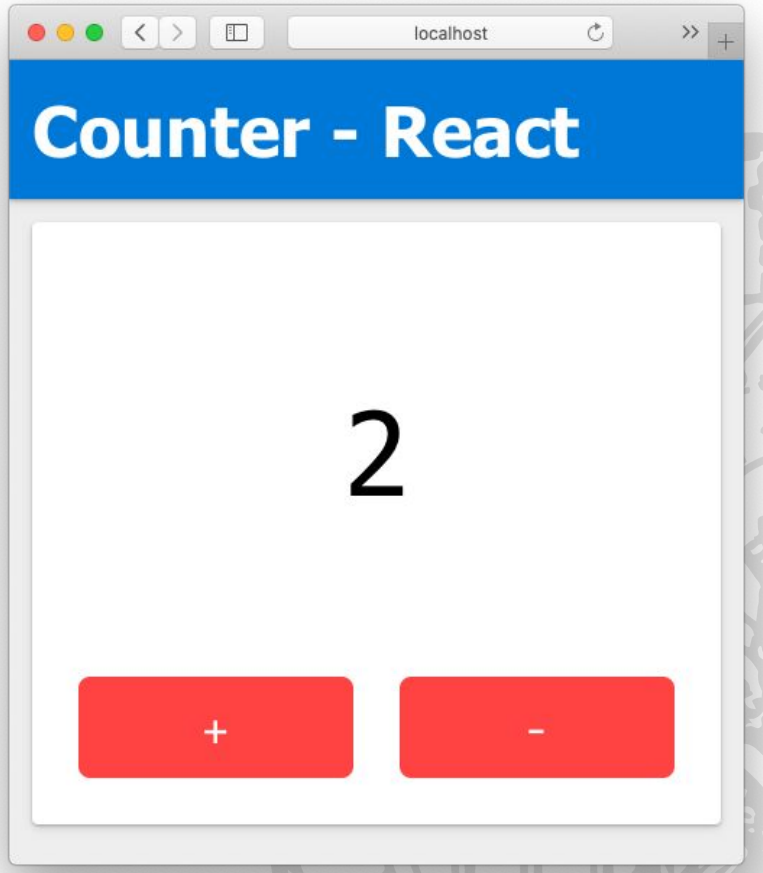
```
{
 ...
 "scripts": {
   ...
   "test": "react-scripts test",
   ...
 },
 ...
}
```

package.json

What to Test?

- Take the OmmCounter as an example
- Questions:
  - what are the most important features in OmmCounter?
  - what is a testable user flow?

- **Component renders without crash**
- **"+" button clicked → label = old label + 1**
- **"-" button clicked → label = old label - 1**



What to Test?

- **Component renders without crash**
- **"+" button clicked → label = old label + 1**
- **"-" button clicked → label = old label - 1**


```
import React from 'react';
import OmmCounter from './omm-counter';
import { render, fireEvent } from '@testing-library/react';

it('renders without crashing', async () => {
 const { getByText } = render(<OmmCounter />);
 const text = document.querySelector('.counter-state');
 expect(text!.innerHTML).toBe('0');
});

it('plus button works', () => {
 const { getByText } = render(<OmmCounter />);
 fireEvent.click(getByText('+'));
 const text = document.querySelector('.counter-state');
 expect(text).toBeDefined();
 expect(text!.innerHTML).toBe('1');
});

it('minus button works', () => {
 ... // similar to above
});
```

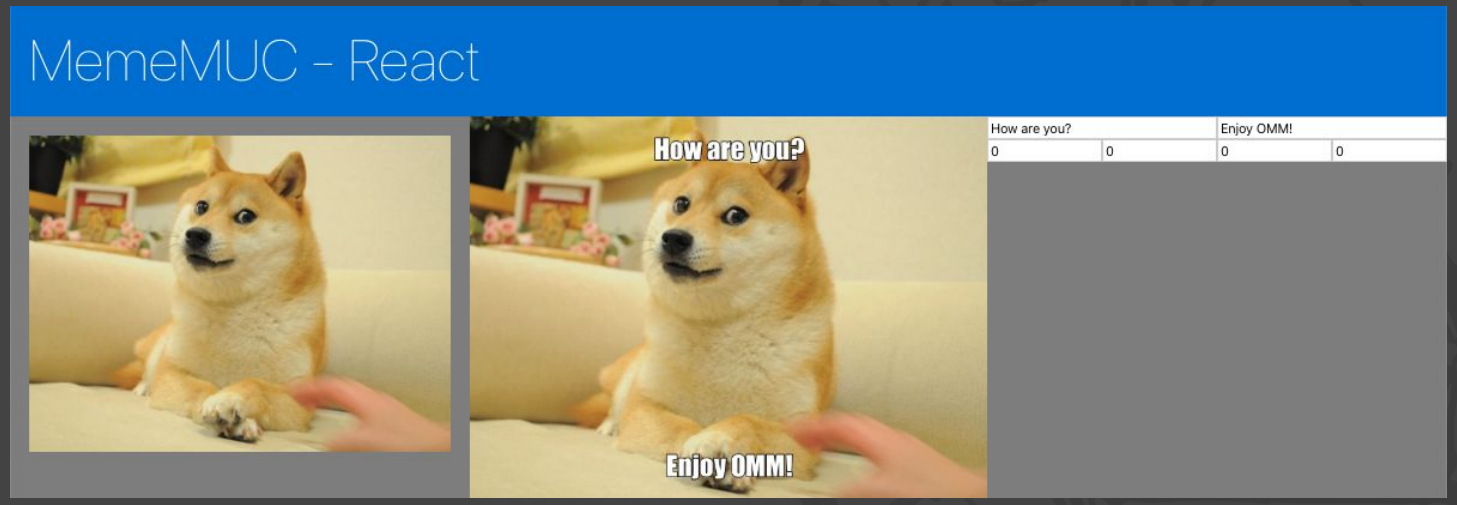
omm-counter.test.tsx

Breakout #1: Testing MemeMUC Component

Write tests to test the following aspects:

1. MemeMUC component renders without errors
2. The middle image shows correctly if user clicks images from the left
3. The middle image is rendered correctly if user inputs upper text or lower text

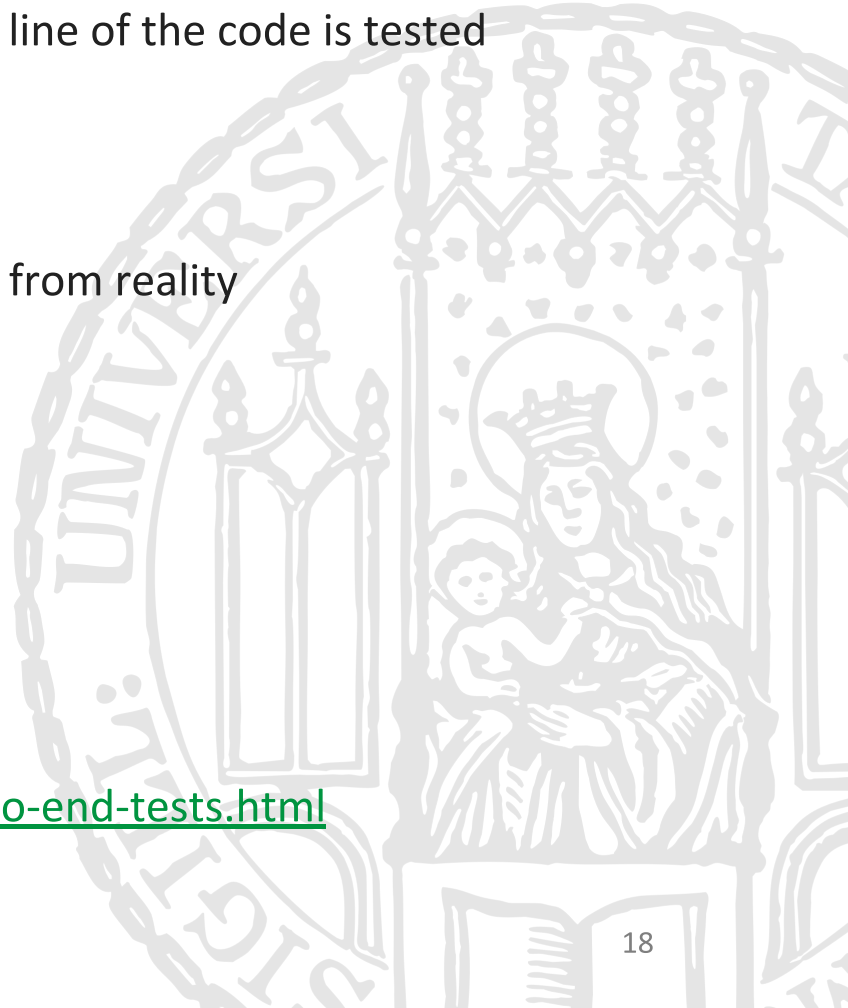
Timeframe: **20 Minutes**



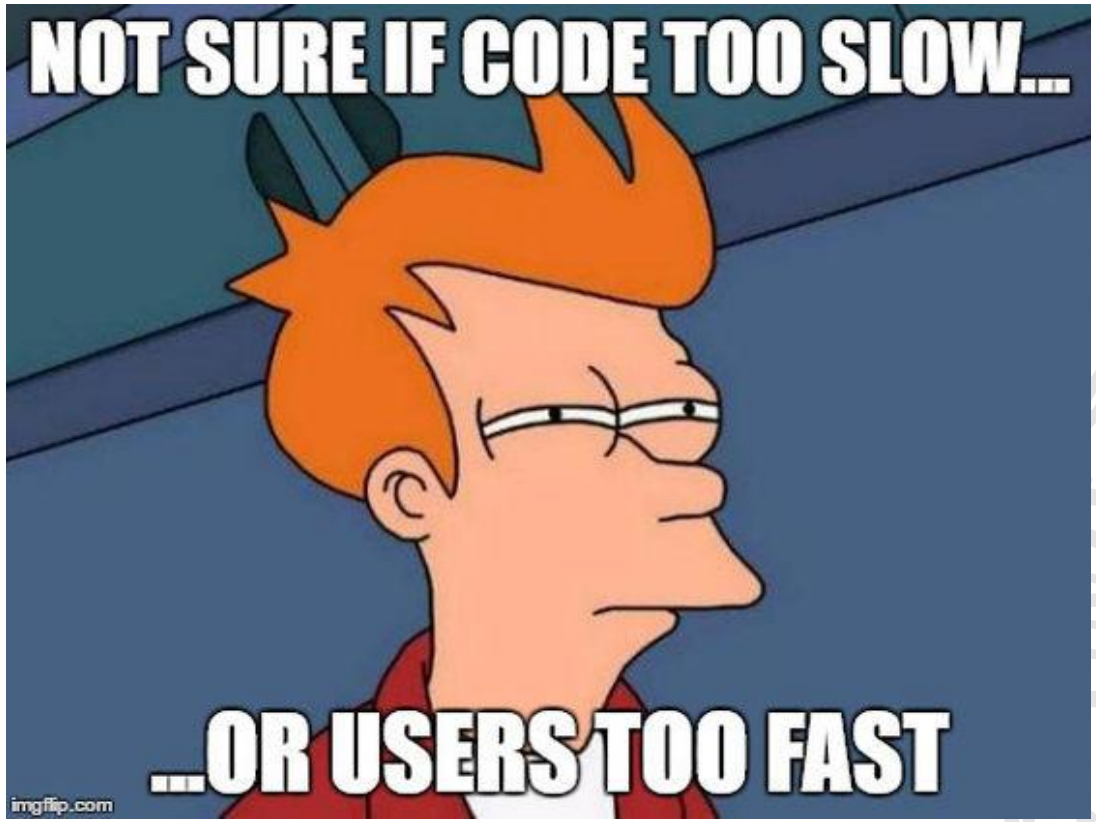
Testing is Hard

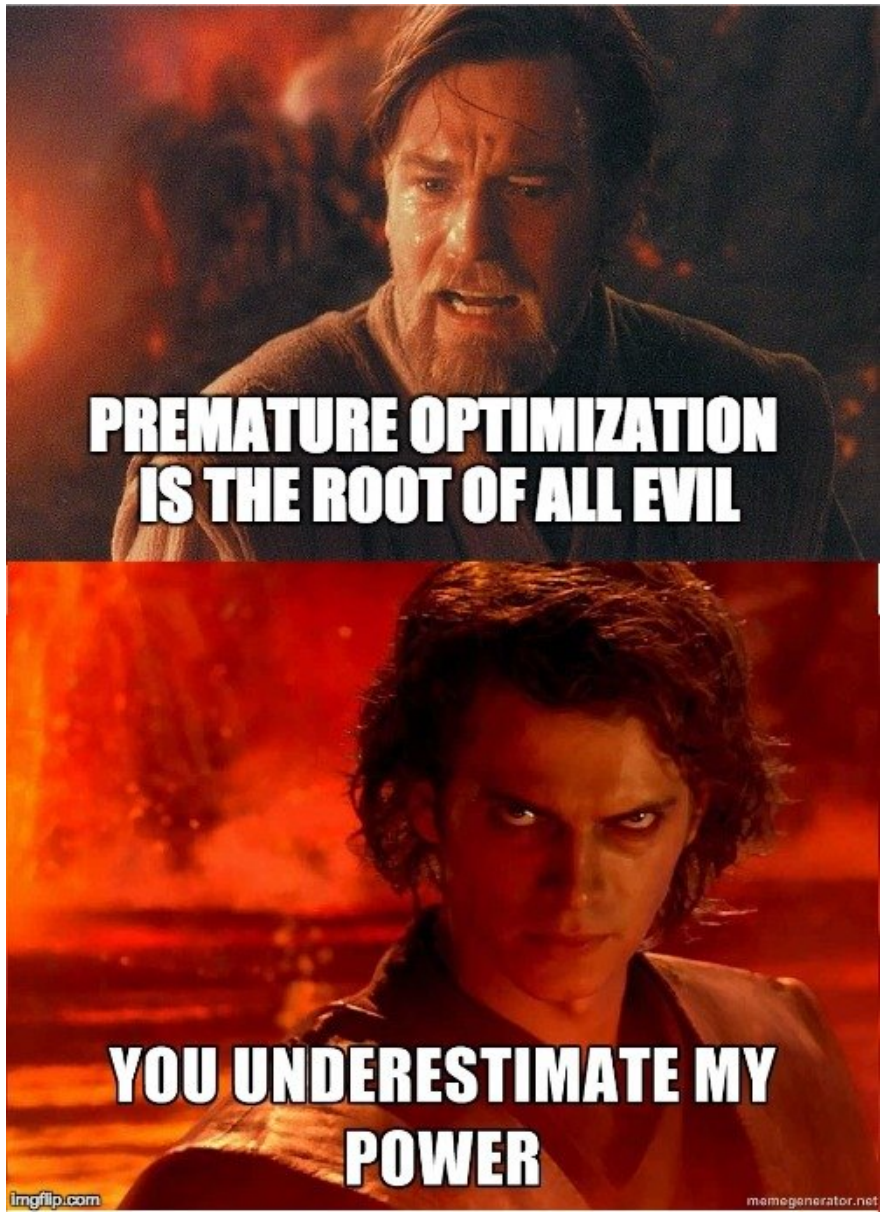
- Testing is hard and difficult because we need to test the code for both valid and **invalid inputs**
- Testing always need to give the inputs in such a way that each and every line of the code is tested efficiently, i.e. 100% coverage takes huge effort
- Non-deterministic code behavior is not deterministically triggered
- Some tests can only be tested in a simulated environment which is apart from reality

- Didn't cover:
  - (Expensive) End-to-end Testing
  - Just Say No to More End-to-End Tests
    https://testing.googleblog.com/2015/04/just-say-no-to-more-end-to-end-tests.html



Debugging & Benchmarking


NOT SURE IF CODE TOO SLOW...
...OR USERS TOO FAST
imgflip.com


PREMATURE OPTIMIZATION
IS THE ROOT OF ALL EVIL
YOU UNDERESTIMATE MY
POWER
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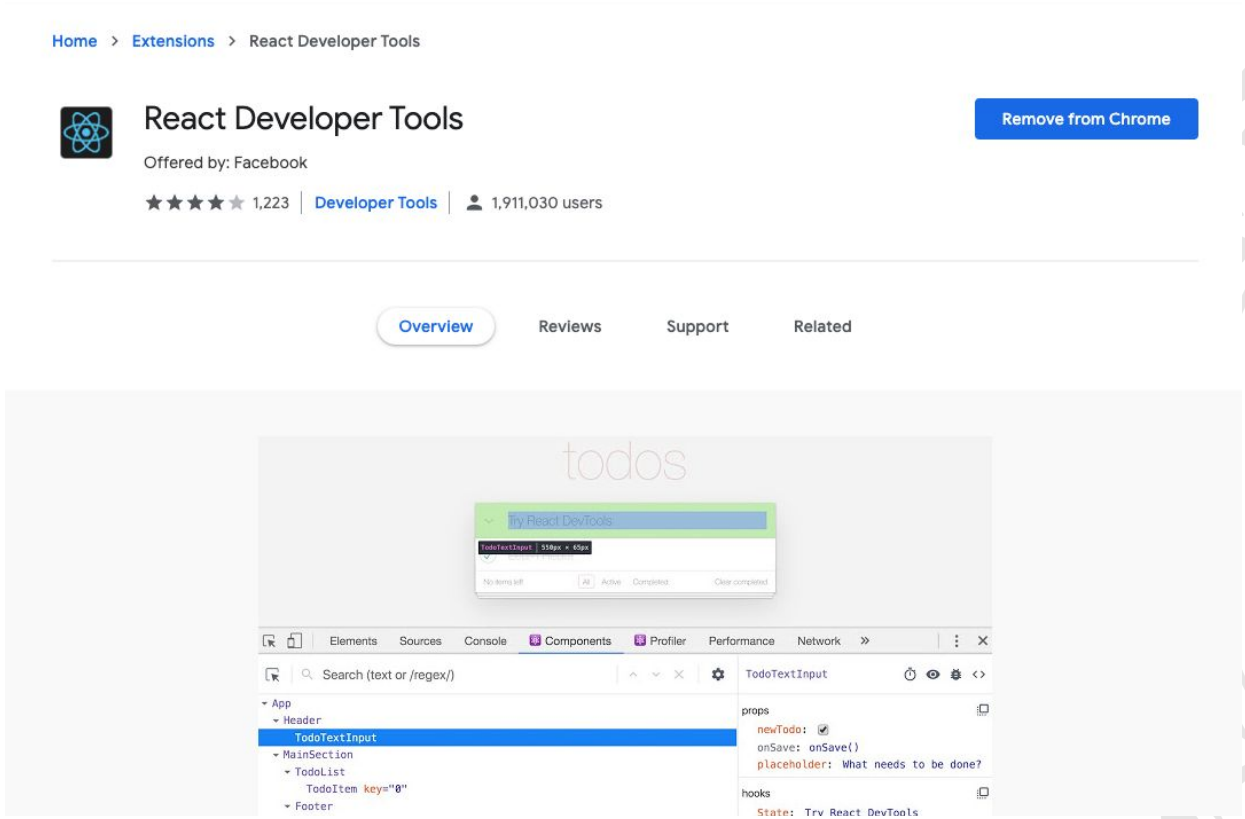
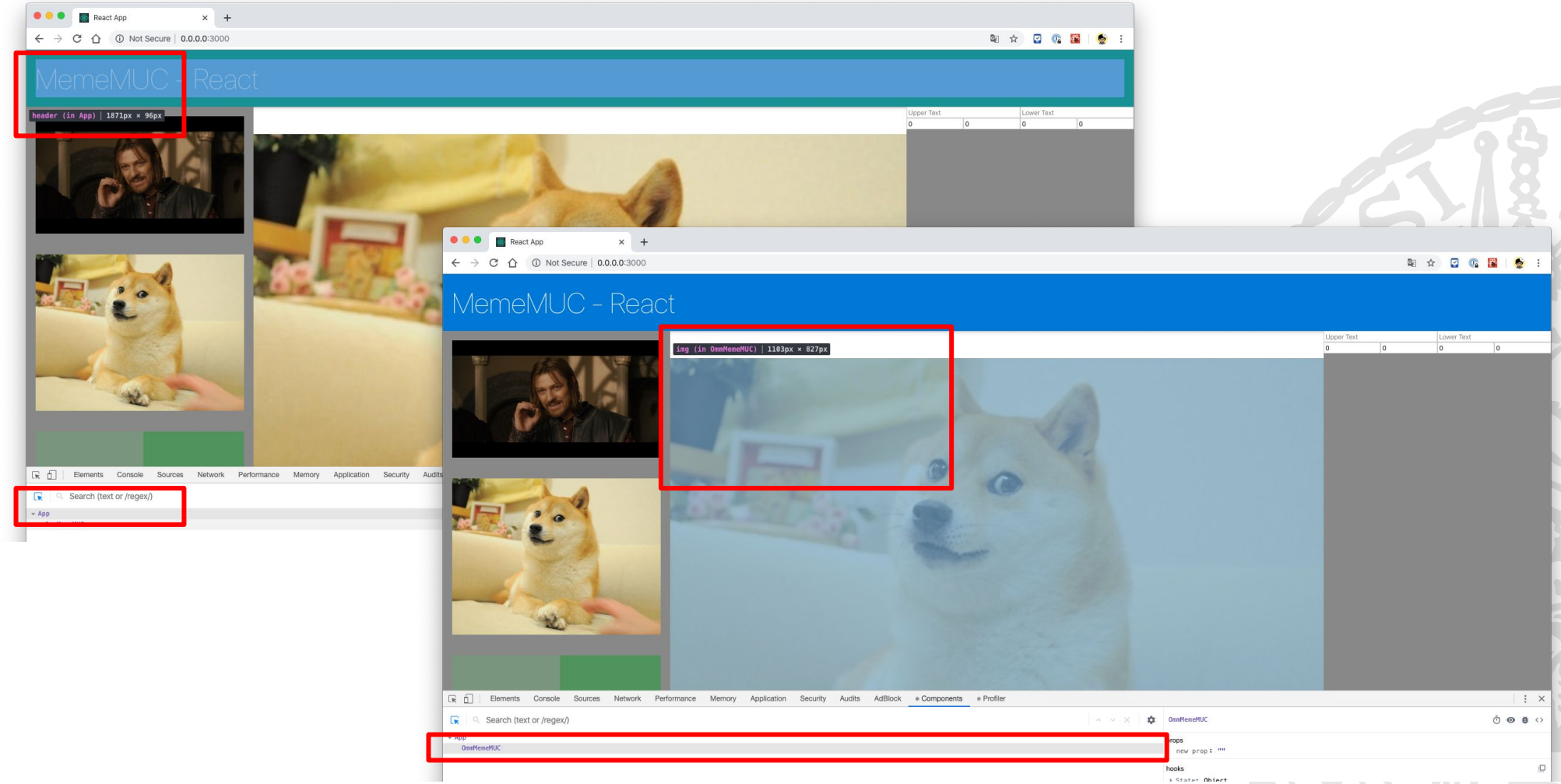
memegenerator.net

React DevTools

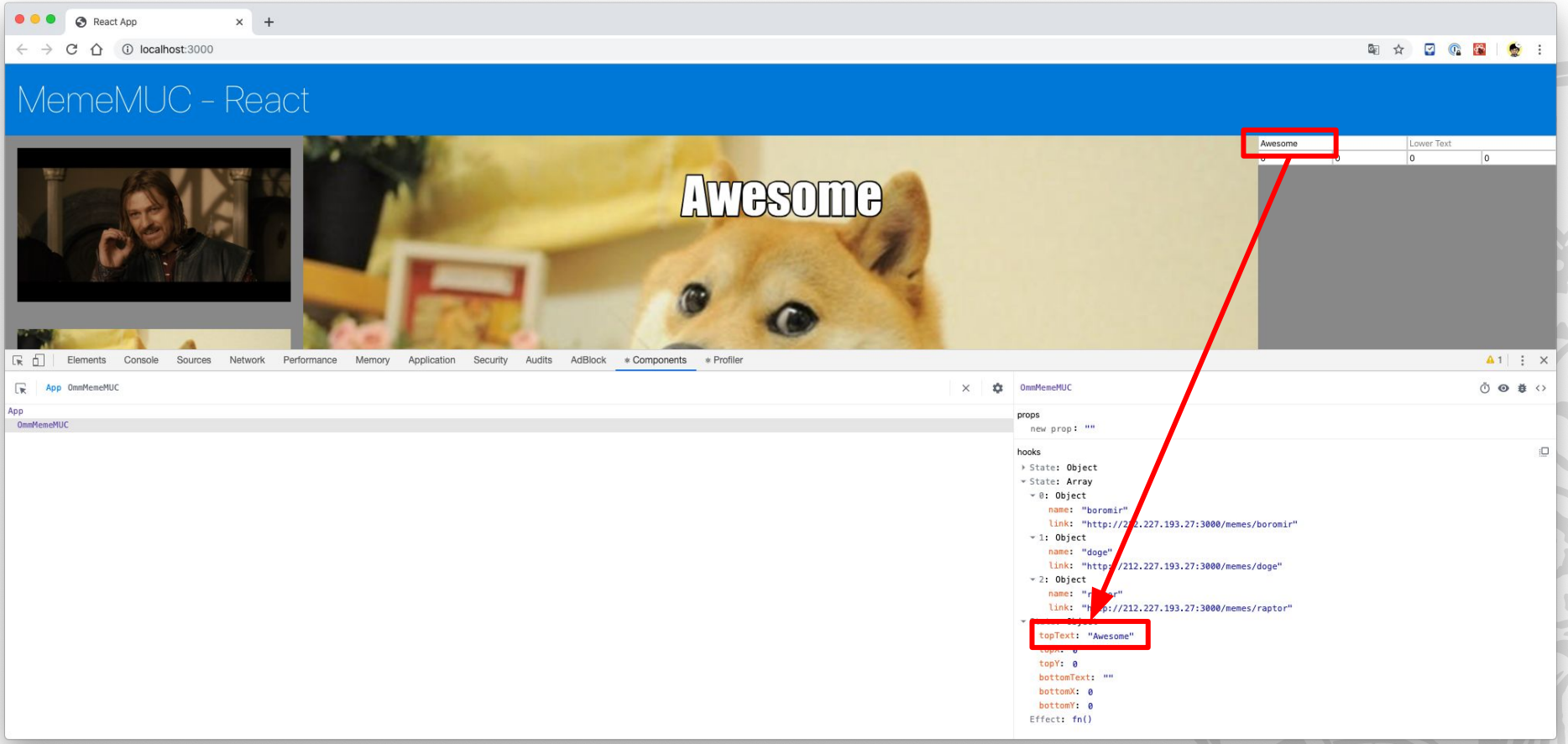
- Allow you debugging and benchmarking React apps per-component
- Interactive Tutorial: https://react-devtools-tutorial.now.sh/



React DevTools: Components

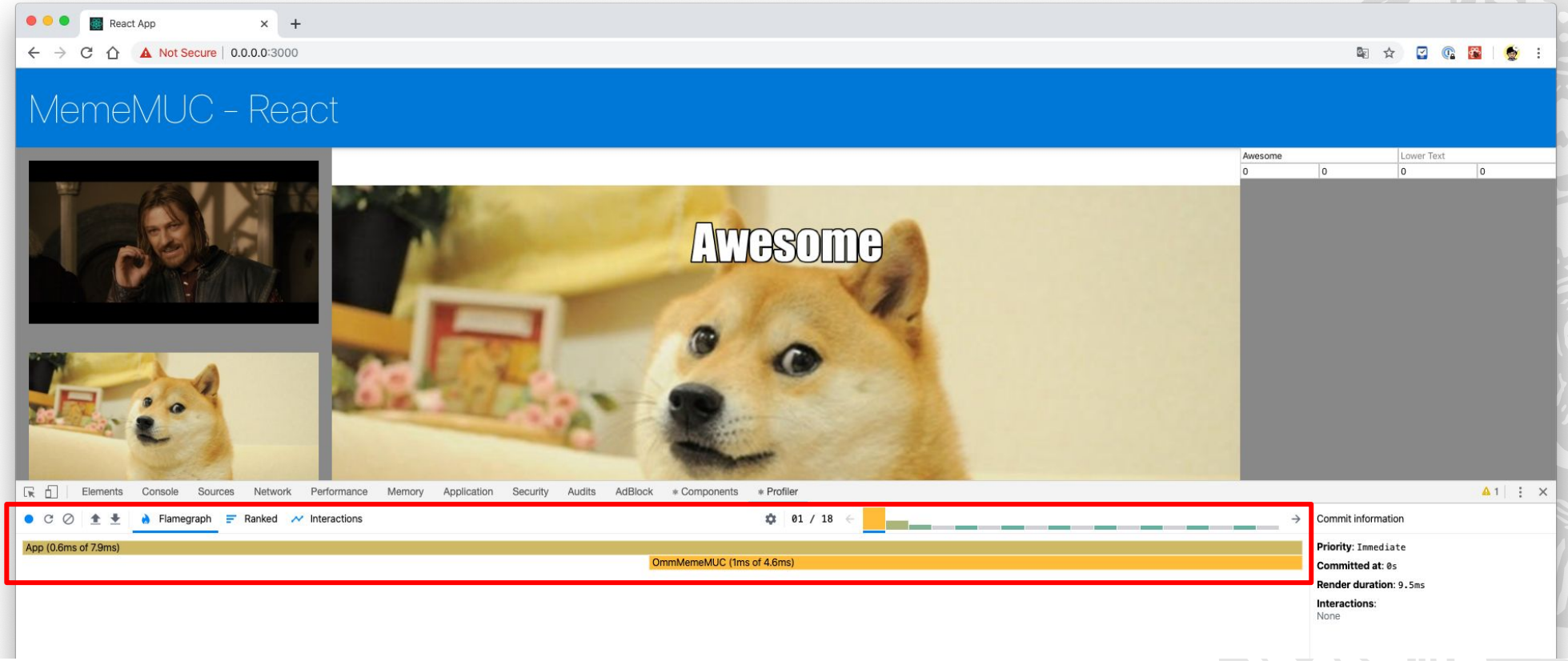


React DevTools: Components



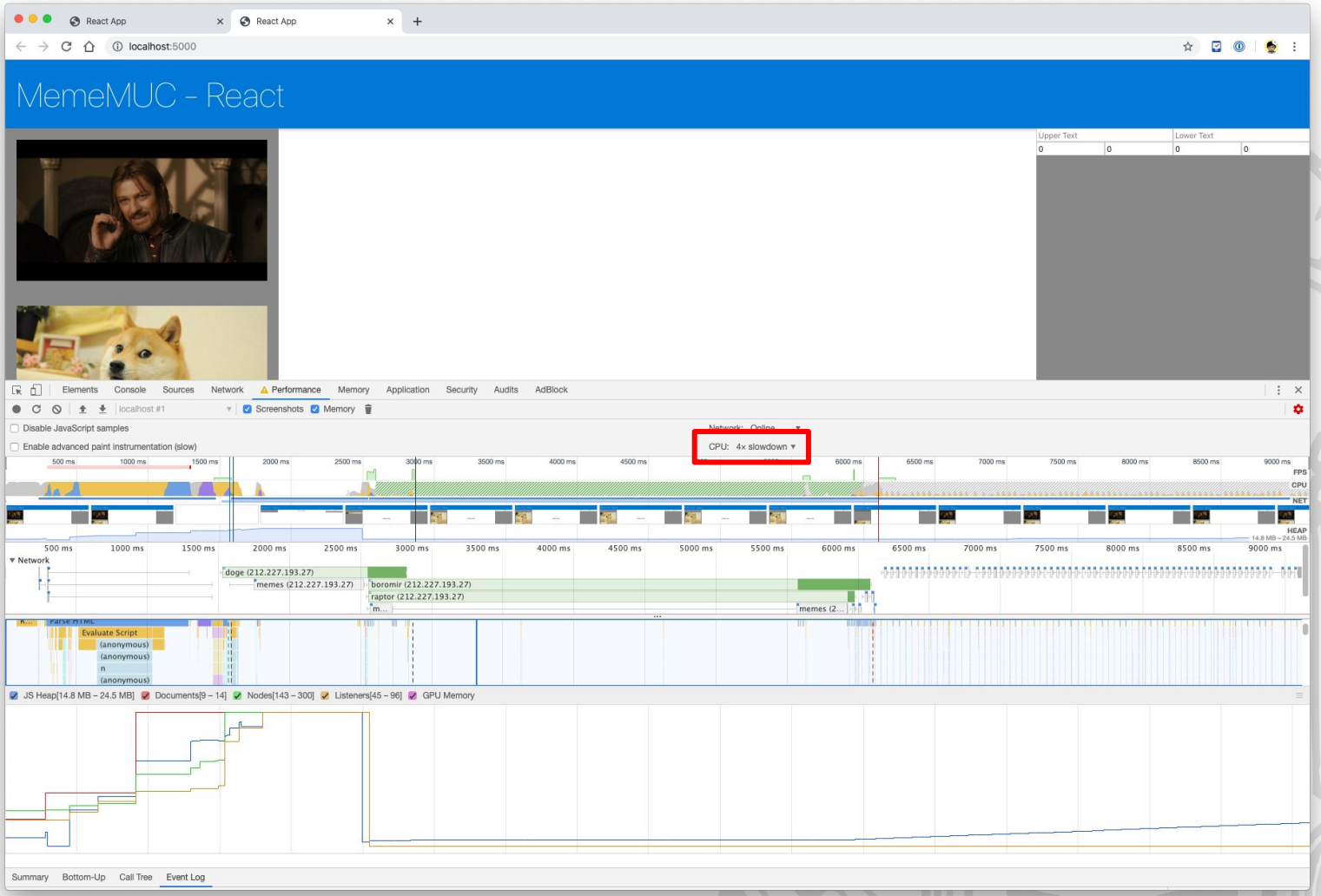
React DevTools: Profiler

- The App component is rendered in 7.9ms
- OmmMemeMUC consumes 4.6ms (58% of total rendering time)



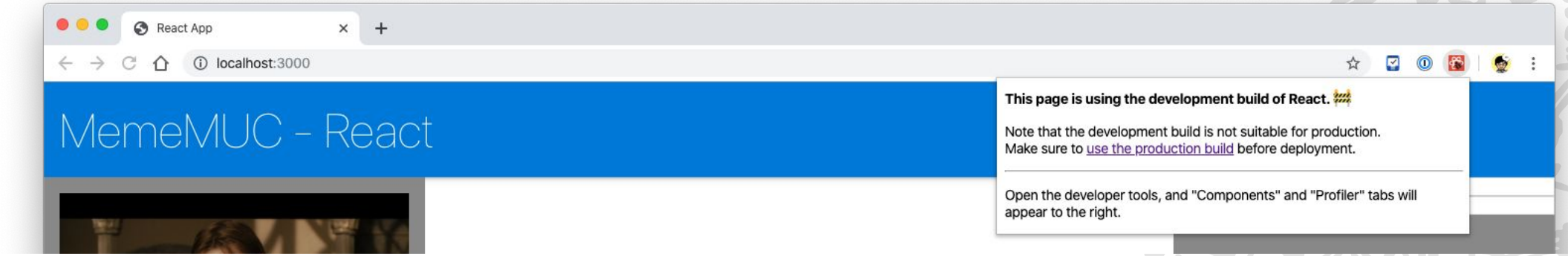
Performance Profiling

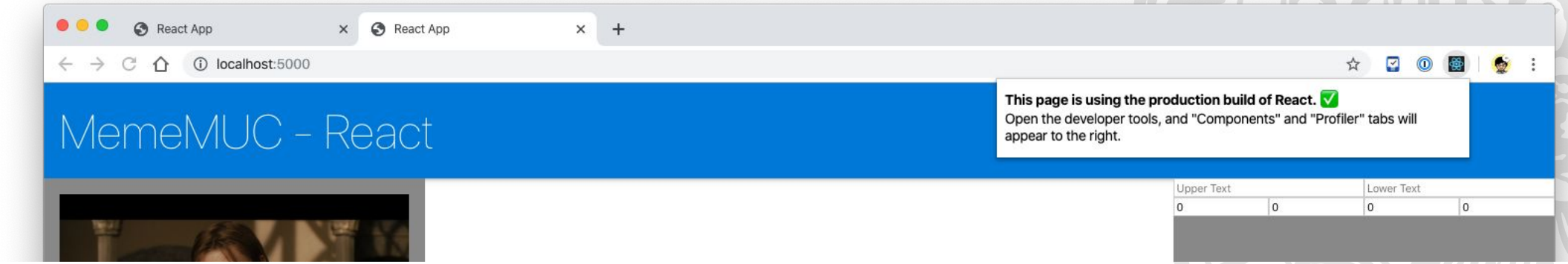
- Use Chrome Development Tool - Performance Tab
- Turn off React Developer Tools
- Make CPU 4x slowdown



Use the Production Build

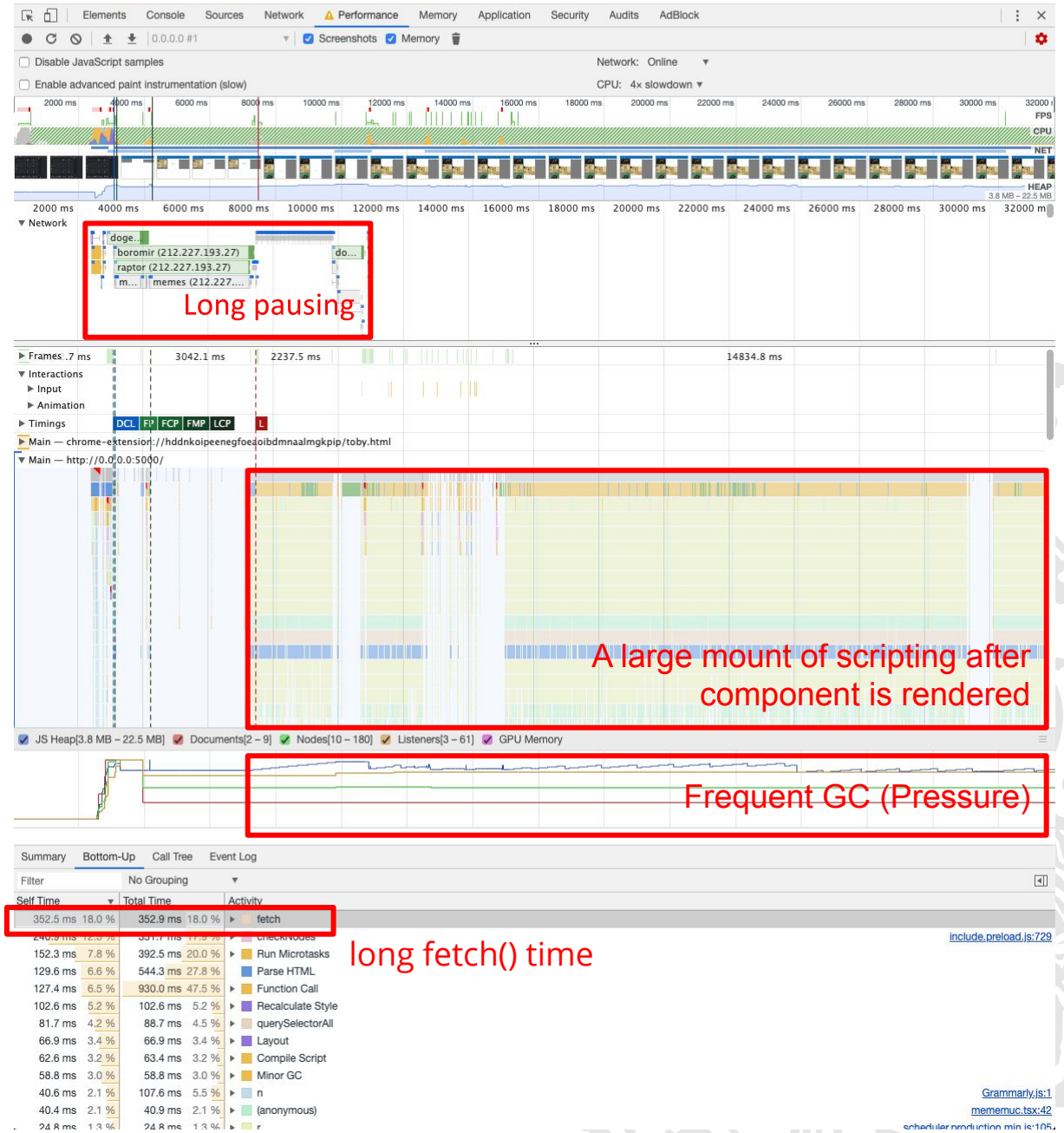
- Development builds include many debugging code which can influence profiling metrics
- Don't do any performance critical profiling under development mode.





Identifying Issues

- Why MemeMUC "feels" so slow?
- Try to recording performance from the page loading



→ Loading does not providing any feedbacks

→ There is a infinity calling in `useEffect()`

Breakout #2: Fixing Identified Issues

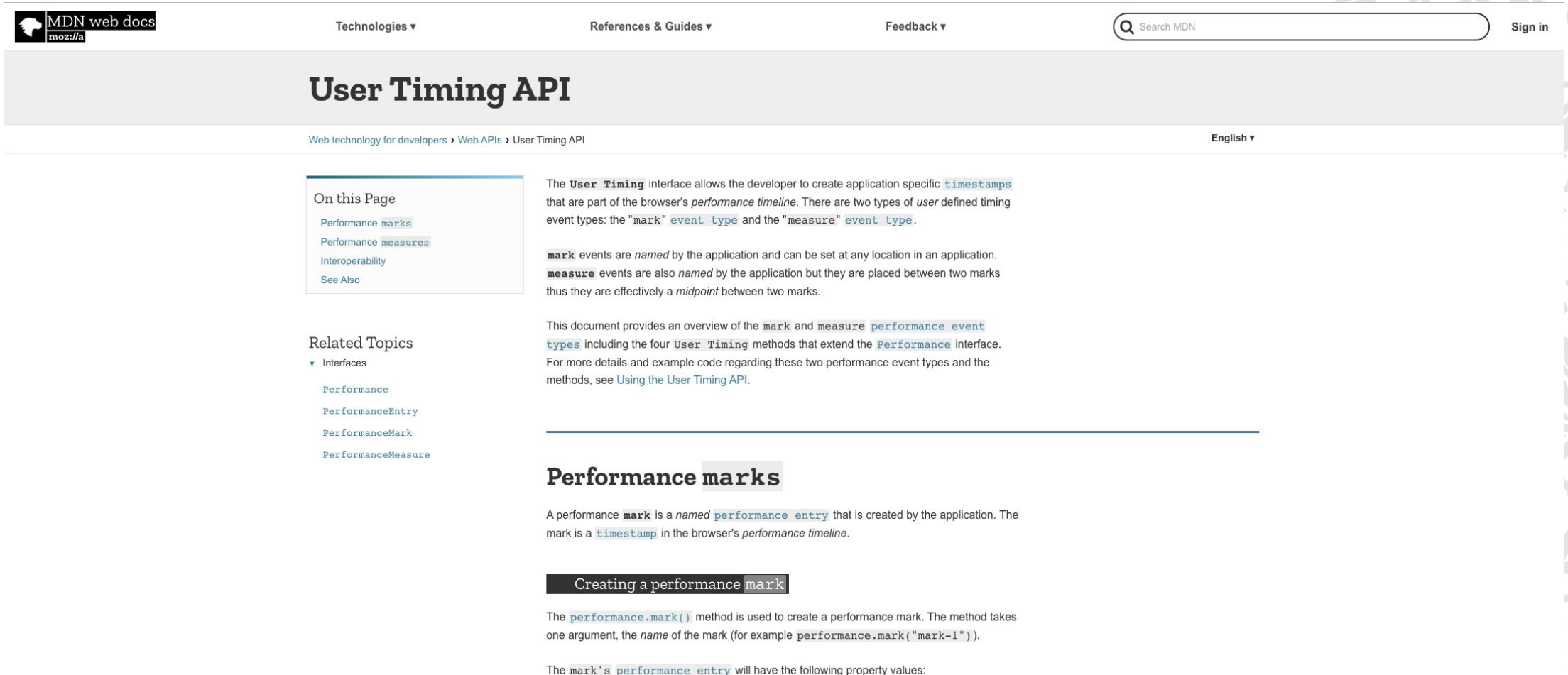
Please fixing the identified issues.

- Adding a load indicator to the MemeMUC,
  - you may want check this: https://material-ui.com/components/progress/
- Fix the infinity calling of `getMeme()`
  - Hint: update states only if states has changed

Timeframe: **15 Minutes**

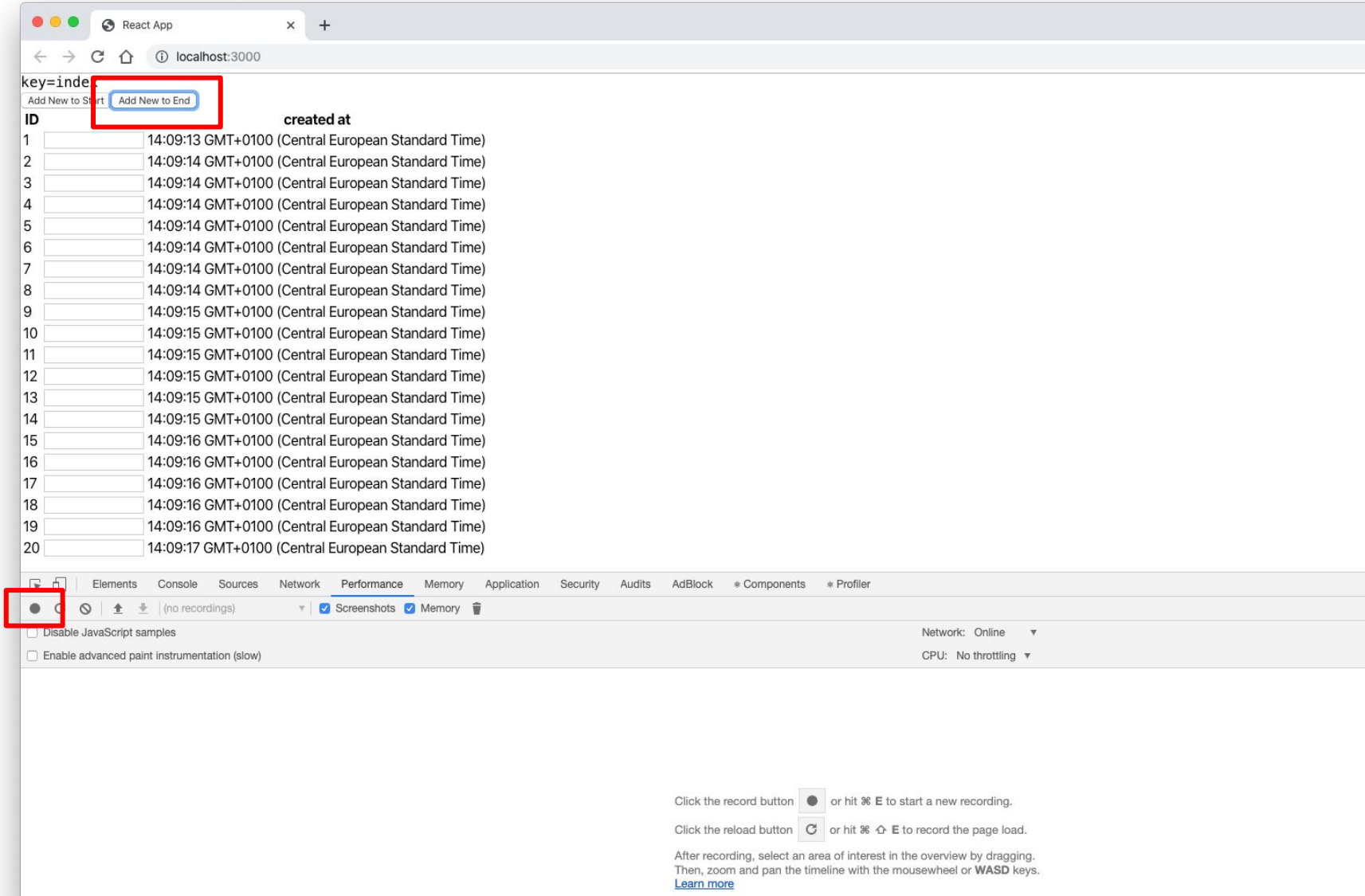
Native Web APIs for Benchmarking

- React uses standard Timing API for benchmarking



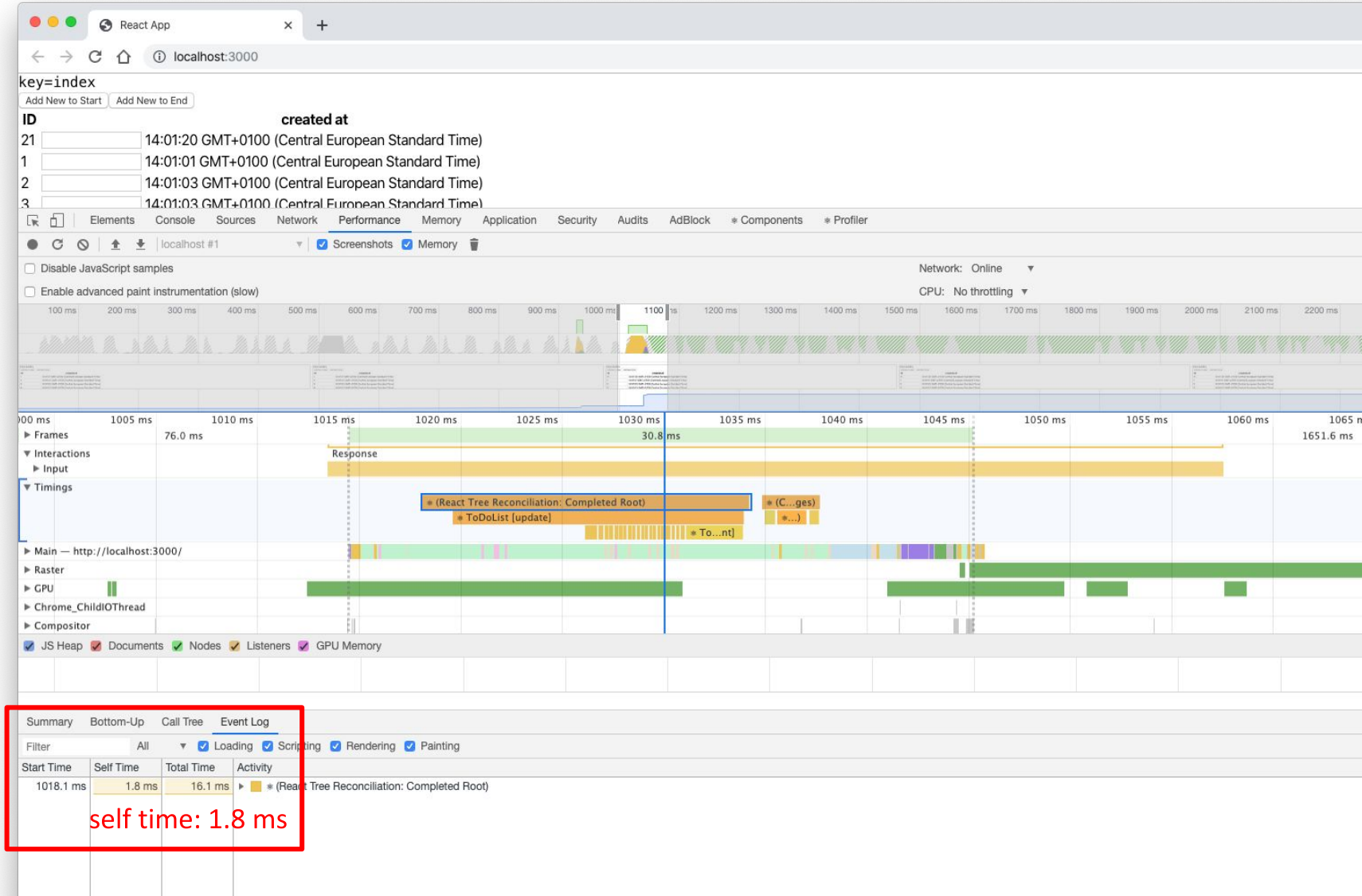
Reconciliation in Repetitive Rendering

1. Check out our ToDoList example
2. Prepare 20 ToDo
3. Click performance recording
4. Click "Add New to Start"
5. Stop performance recording



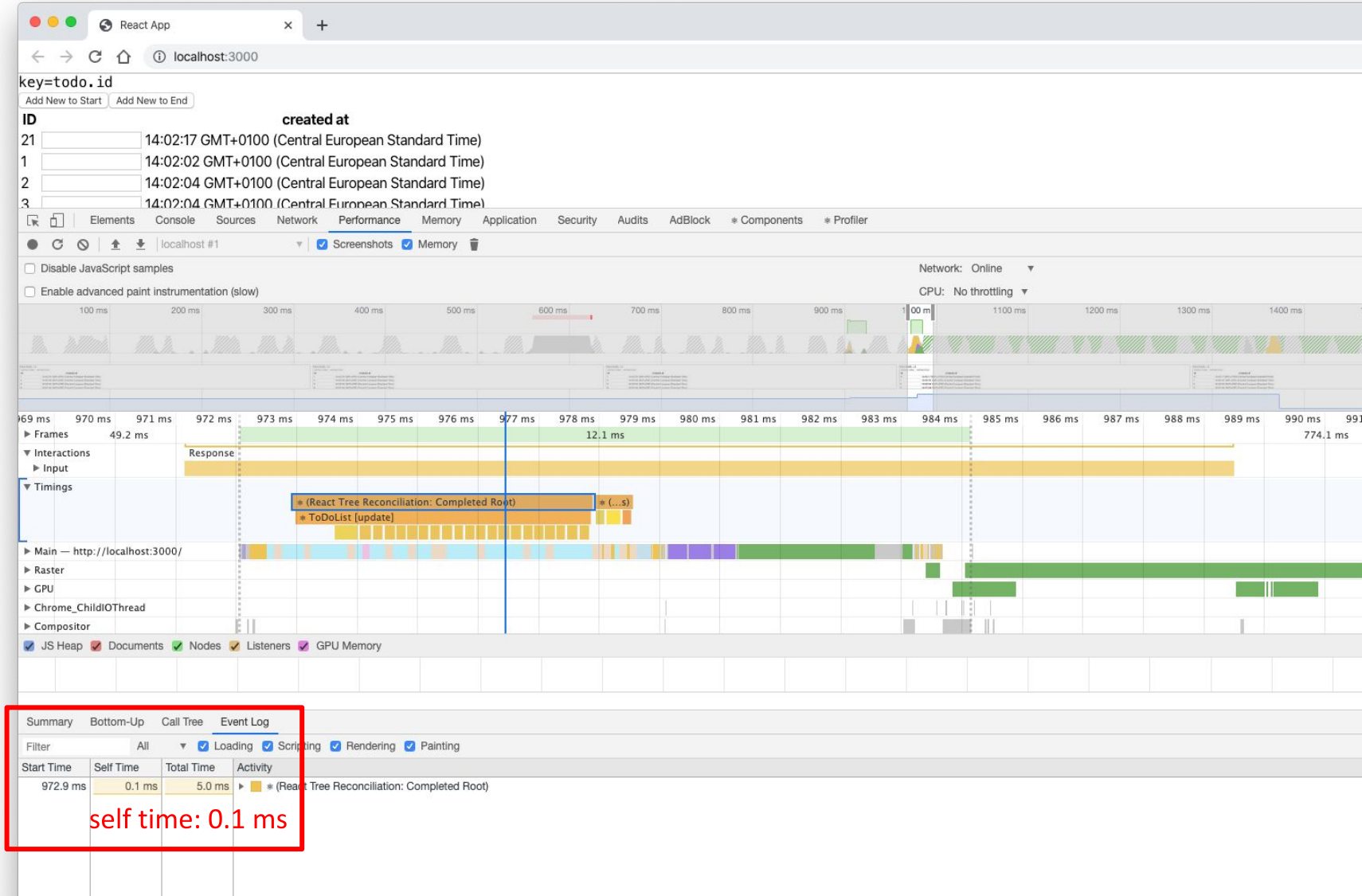
Reconciliation: Using unstable array index

- Checkout **Timings**
- Select "**React Tree Reconciliation: Completed Root**"
- The update time using array `index` is **1.8ms**



Reconciliation: Using self-defined unique ID

- Change ToDo component's key from `index` to `todo.id`
- Redo the measurement
- The update time using `todo.id` is **0.1ms**

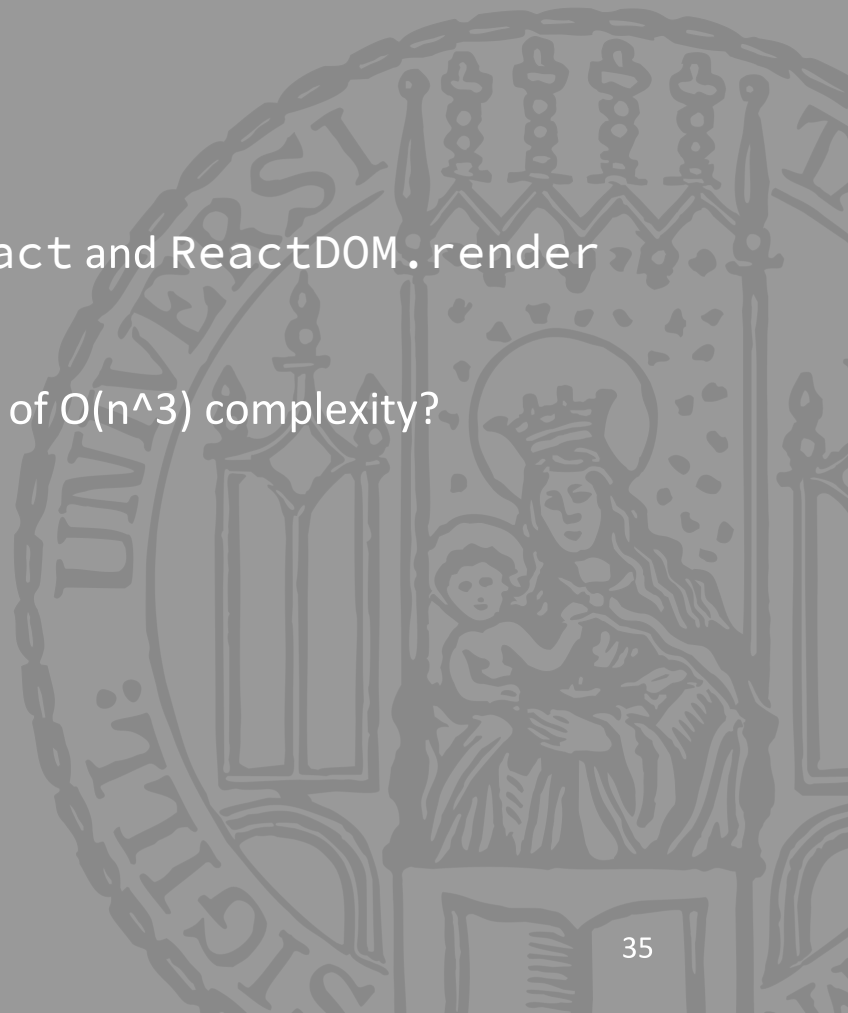


Reconciliation Performance

- When state or props update, `ReactDOM.render` returns a different DOM tree, reconciliation finds out the difference and update the browser DOM **efficiently**
- The generic state-of-the-art solution is O(n^3)
  - 1000 elements ⇒ 1,000,000,000 comparisons
- React reconciliation algorithm is O(n) under two assumption (perf critical)
  - **Two elements of different types will produce different trees**
    - React will not attempt to diff them, but rather replace the old tree completely
  - **Keys should be "stable, predictable and unique."**
    - Diffing of lists is performed using `key` prop

Round-up Quiz

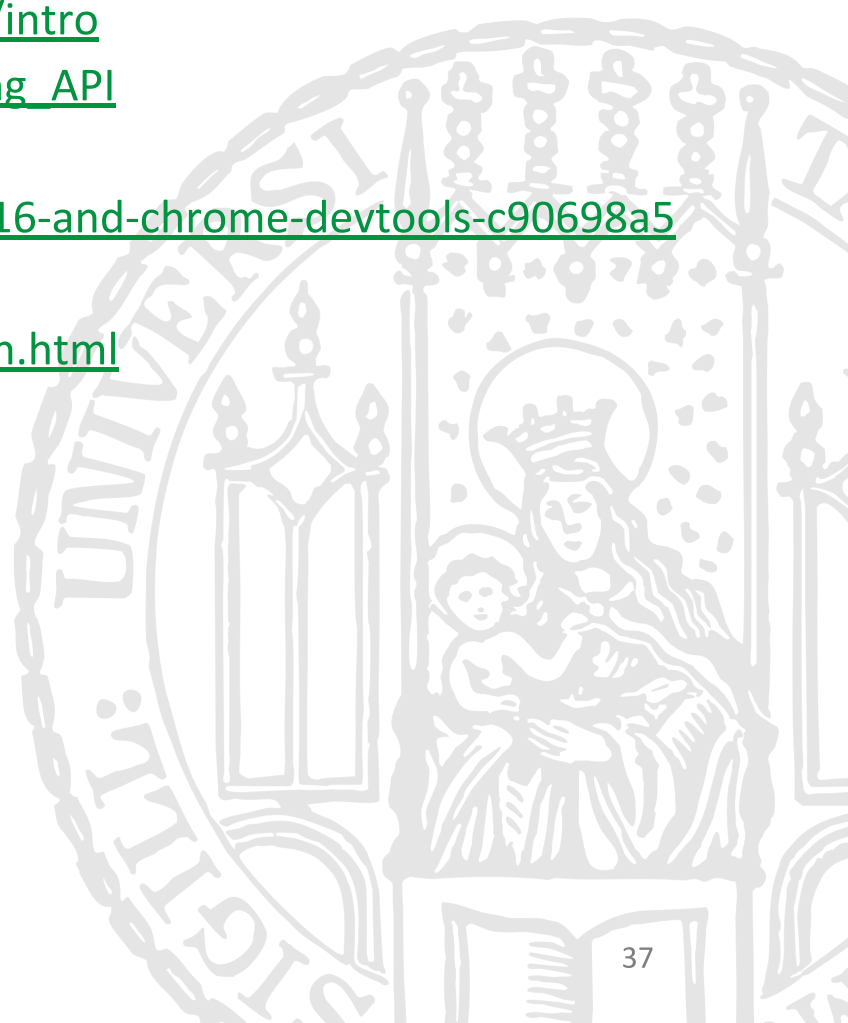
1. Name three types of test method.
2. How to test a function returns an expected value in Jest?
3. What is the name convention for the testing file name?
4. Name a difference between `render` from `@testing-library/react` and `ReactDOM.render`
5. Name a reason to use production mode in performance profiling
6. Under what assumption(s) that the React reconciliation is in O(n) instead of O(n^3) complexity?
7. Explain why key prop should be stable, predictable and unique.



Thanks!
What are your questions?

More Links about Tooling

- Jest https://jestjs.io/
- React Testing Library https://testing-library.com/docs/react-testing-library/intro
- Timing API https://developer.mozilla.org/en-US/docs/Web/API/User_Timing_API
- Profiling React performance with React 16 and Chrome Devtools https://building.calibreapp.com/debugging-react-performance-with-react-16-and-chrome-devtools-c90698a522ad
- Reconciliation and Diffing Algorithms https://reactjs.org/docs/reconciliation.html
- A survey on Tree Edit Distance and Related Problems https://grfia.dlsi.ua.es/ml/algorithms/references/editsurvey_bille.pdf



E2E Test with cypress

- Cypress is a Javascript End to End framework
- Install `npm install cypress --save-dev`
- Write your first e2e test:
  https://docs.cypress.io/guides/getting-started/writing-your-first-test.html#Add-a-test-file