<WA1/>

2020

Components, Elements, JSX

The Foundations of React

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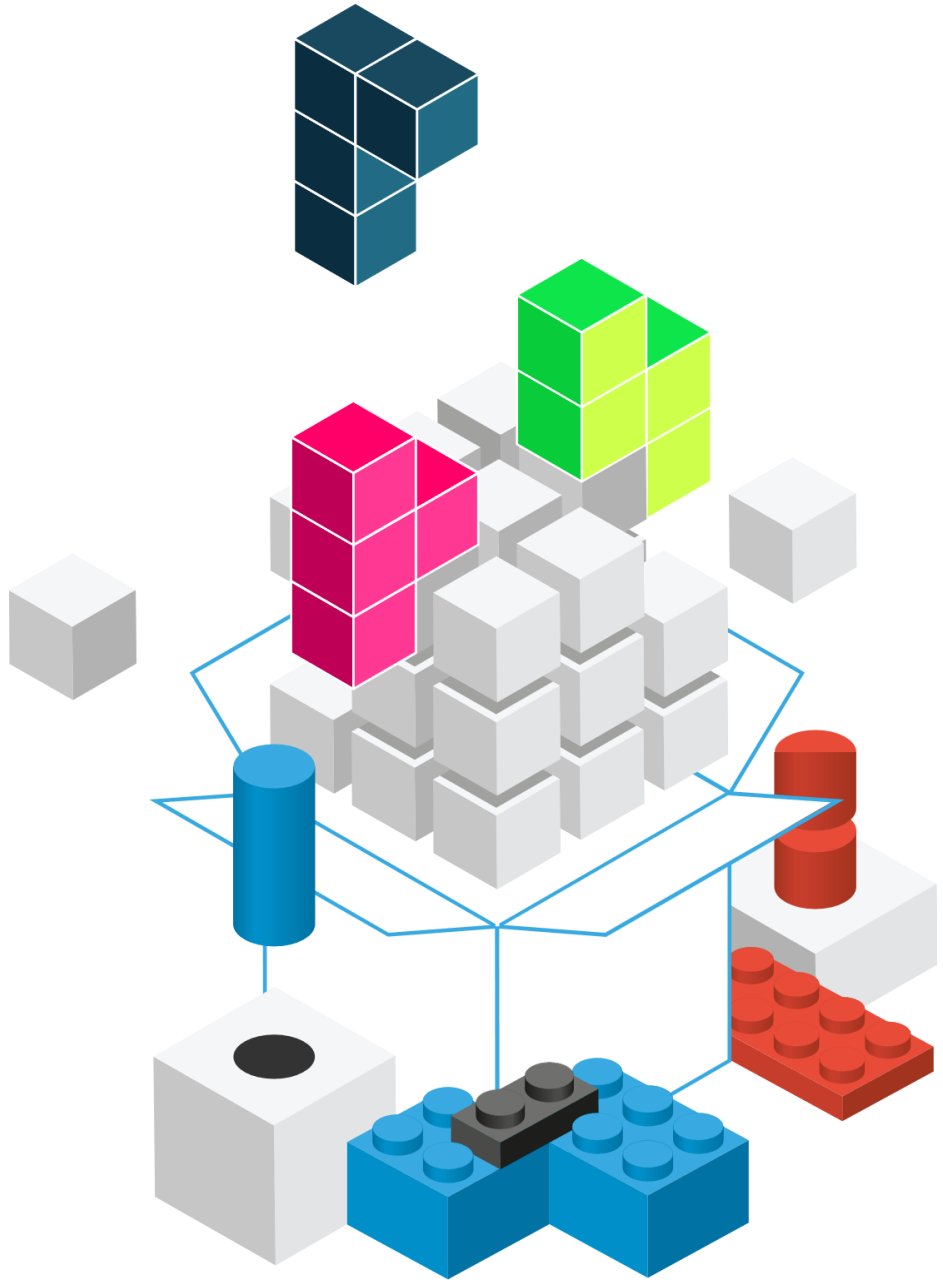


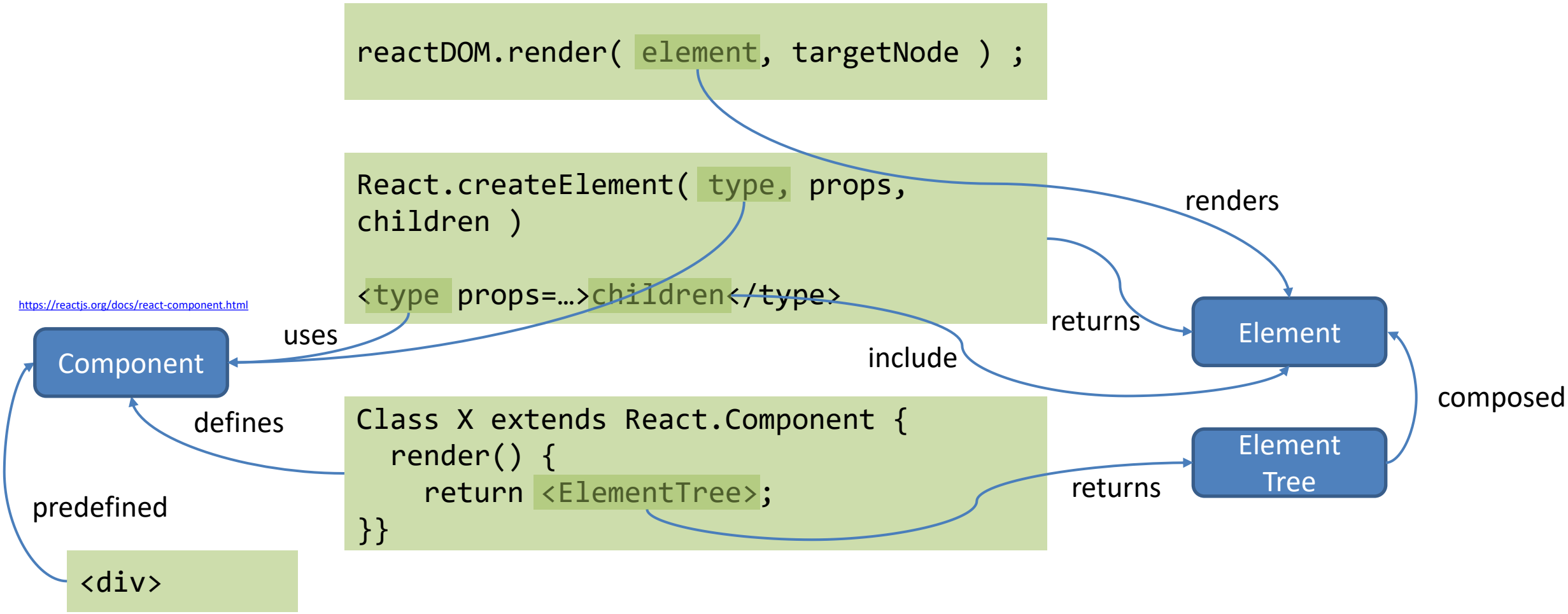
Outline

- React Elements
  - Creating
  - JSX language
- React Components
  - Defining
  - Props and State
  - Lifecycle
- React design process
  - Top-down information flow
  - Defining state
  - Adding Reverse flow

Part 1

Part 2

Conceptual Overview



https://reactjs.org/blog/2015/12/18/react-components-elements-and-instances.html

Full Stack React, Chapter “JSX and the Virtual DOM”

Building block for describing web page content

REACT ELEMENTS

React Element

- An element is a plain object describing a component instance or DOM node and its desired properties
- A ReactElement is a representation of a DOM element in the Virtual DOM.
- It contains only information about
  - the component type (for example, a Button)
  - its properties (for example, its color)
  - any child elements inside it.
- Not an *instance* of a part of a page, but a *description* about how to construct it.
- Elements offer no callable methods.

React.createElement (1/3)

- `React.createElement( type, props, children )`

- Type
  - String: a DOM node identified by the tag name (e.g., `'div'`)
  - React component class/function: a user-defined component

React.createElement (2/3)

- `React.createElement( type, props, children )`

- Props: a simple object {}, containing:
  - DOM attributes for DOM nodes (type, src, href, alt, …)
  - Arbitrary values for React components (even array- or object-valued)
    - Available as `this.props` in the Component body
  - Represented as object properties (not strings like HTML attributes)
    - Exceptions (reserved words): `class` → `className`, `for` → `htmlFor`

React.createElement (3/3)

- `React.createElement( type, props, children )`

- Children:
  - a ReactNode object, that may be:
    - A string or number: text content of the nodes
    - A ReactElement (that may contain a tree of Elements)
    - An array of ReactNodes
  - nested Elements to be rendered as children of the element

Element Objects

Element with DOM nodes

```
{
  type: 'button',
  props: {
    className: 'button button-blue',
    children: {
      type: 'b',
      props: {
        children: 'OK!'
      }
    }
  }
}
```

Elements with React Component

```
{
  type: Button,
  props: {
    color: 'blue',
    children: 'OK!'
  }
}
```

Note: we don't create elements as plain objects. We always use createElement or JSX

Rendering Element objects

Element with DOM nodes

```
{
  type: 'button',
  props: {
    className: 'button button-blue',
    children: {
      type: 'b',
      props: {
        children: 'OK!'
      }
    }
  }
}
```

```
<button class='button
button-blue'>
  <b>
    OK!
  </b>
</button>
```

Elements with React Component

```
{
  type: Button,
  props: {
    color: 'blue',
    ren: 'OK!'
```

Rendering Element objects

Element with DOM nodes

```
{
  type: 'button',
  props: {
    className: 'button button-blue',
    children: {
      type: 'b'
      props:
        child
      }
    }
  }
}
```

- Components encapsulate element trees (generated given their properties).
- React asks the Button component to render itself. It will generate a tree of elements, to replace this one.
- ↻ Repeat until only DOM nodes are present.

Elements with React Component

```
{
  type: Button,
  props: {
    color: 'blue',
    children: 'OK!'
  }
}
```

```
{
  type: 'button',
  props: {
    className: 'button
button-blue',
    children: {
      type: 'b',
      props: {
        children: 'OK!'
      }
    }
  }
}
```

Conventions

- DOM Elements are always lowercase
  - `div p li img …`
- React Components are always uppercase
  - `WarningButton LoginForm TaskList …`
- The two types of elements can be mixed, nested, combined in any way
  - React uses *composition* and not *inheritance*
- Element trees describe **portions of the Virtual DOM**

https://reactjs.org/docs/jsx-in-depth.html

Full Stack React, Chapter “JSX and the Virtual DOM”

React Handbook, Chapter “JSX”

A humane way of describing trees of ReactElements

JSX

JSX – JavaScript Syntax Extension

- Alternative syntax for React.createElement
- XML fragments inside the JS code
  - Syntax details: all tags must be </closed> or <selfclosing/>
- Transpiled by Babel into plain JS

```
<MyButton color="blue" shadowSize={2}>
  Click Me
</MyButton>
```

Element/Component name
Props
Children / Text content


```
React.createElement(
  MyButton,
  {color: 'blue', shadowSize: 2},
  'Click Me'
) ;
```

JSX Syntax

- May use <tag>…</tag> or <tag/> anywhere a JS expression is syntactically valid
  - Not only in Components
  - May also store in Arrays/Objects
  - After all, they are just ReactElements generated by React.createElement!
- May enclose in (…) for clarity

```
const element = <div className="main">Hello world</div>;
```

```
const element2 =  (<Message text="Hello world" />);
```

Note: use <tag/> if the component doesn't have any children

JSX Tag Name

- <Foo> is just React.createElement(Foo,…)
  - Foo must be in scope (imported or declared)
  - React must be in scope (even if it’s not visible in the code)

```
import React from 'react';
import CustomButton from './CustomButton';

function WarningButton() {
  return <CustomButton color="red" />;
}
```

Computed Tag Name

- The JSX Tag must be a valid identifier, can't be an expression
- If you want to select a component based on an expression, first assign it to a *capitalized* variable.

```
function WarningButton(props) {
  if(props.urgent)
    return <UrgentButton />;
  else
    return <NormalButton />;
}
```

```
function WarningButton(props) {
  const ThisButton = props.urgent ?
    UrgentButton : NormalButton ;
  return <ThisButton/>;
}
```

JSX Attribute Expressions

- Tag attributes are converted to props of the ReactElement
- String attributes become string-valued props
  - `color="blue" -> {color: 'blue'}`
- Other objects may be specified as a JS expression, enclosed in `{}`
  - `shadowSize={2} -> {shadowSize: 2}`
  - `log={true}`
  - `color={warningLevel === 'debug' ? 'gray' : 'red'}`
- Any JS expression is accepted

JSX Children

- The *content* between the tags <tag>*content*</tag> is passed as a special property `props.children`
- Such content may be:
  - A string literal
  - More JSX elements (nested components)

```
<MyComponent>Hello
world!</MyComponent>
```

```
<MyContainer>
  <MyFirstComponent />
  <MySecondComponent />
</MyContainer>
```

  - Any {JS expression}
  - A {JS expression} returning an array of JSX elements (they are inserted as siblings)
  - A JS function (may be used as a callback by the Component)
  - Anything that the Component may understand (and render properly)

JSX Child Expressions

- JS expressions in { } may be used to specify element children
- One child (or an array of children) are generated by an expression

```
const Menu = (<ul>{loggedInUser ? <UserMenu /> : <LoginLink />}</ul>)
```

  - <JSX> inside {JS} inside <JSX> inside JS. Totally Legit.
- `undefined`, `null` or Booleans (`true`, `false`) are not rendered
  - Useful for conditionally including children

```
return (<ul>
  <li>Menu</li>
  {userLevel === 'admin' && renderAdminMenu()}
</ul>)
```

Boolean HTML Attributes in JSX

- In HTML some attributes do not have a value. Their simple presence "activates" a behavior
  - HTML: `<option value='WA' selected>Washington</option>`
  - HTML: `<input name='Name' disabled />`
- In JSX, a Boolean value must be given
  - True, for the presence of the attribute
  - False (or nothing) for the absence of the attribute
  - JSX: `<option value='WA' selected={true}>Washington</option>`
  - JSX : `<input name='Name' disabled={true} />`

Comments in JSX

- There are **no** comments in JSX
- The HTML/XML comments syntax `<!-- … -->` does **not** work
- If you want to insert comments, you must do that in an embedded JS expression (using JS syntax inside `{}`)

  `{/* … */}`

- Yes, it's ugly

DOM attribute names

- When passing props to a DOM native node, some differences exist
- Attribute names are camelCase
  - HTML onchange → JSX onChange
- The style attribute accepts an object and not a string
  - `<div style={{color: 'white'}}>Hello World!</div>`
  - Object keys are CSS Properties, and are camelCase (e.g., `margin-top` → `marginTop`)
  - Object values are CSS values, represented as strings

JSX Spread Syntax

- Shortcut syntax for passing all properties of an object as props to a React Component

```
const welcome = {msg: "Hello", recipient:
"World"} ;

<Component
  msg={welcome.msg}
  recipient={welcome.recipient} />
```

```
const welcome = {msg: "Hello", recipient:
"World"} ;

<Component {...welcome} />

// properties of the welcome object
// are “spread” as individual props
// with the same name
```

JSX Spread example (property passthrough)

```
const Button = props => {
  const { kind, ...other } = props;
  const className = kind === "A" ? "ABtn" : "BBtn";
  return <button className={className} {...other} />;
};

const App = () => {
  return (
    <div>
      <Button kind="primary"
        onClick={() => console.log("clicked!")}>
        Hello World!
      </Button>
    </div>
  );
};
```

- The ‘kind’ property is “consumed” by <Button>
- All other properties (…other) are passed to the child <button>
- In this way, <App> can specify the kind to Button and all other properties to “pass through” down the hierarchy

JSX Syntax Reminders

- The HTML `class` attribute is called `className`
- The HTML `for` attribute is called `htmlFor`
- HTML entities (< & © ☆ etc…) are not supported in JSX
  - Use the corresponding Unicode character (< & © ☆) inside a string in JS `{'☆'}`
  - Alternatively, use a Unicode Escape sequence: `{'\u2606'}`
    - See: https://www.toptal.com/designers/htmlarrows/

Data properties in DOM nodes

- React Components accepy *any property name* you need
  - `<Message level='urgent' code={123}/>`
- DOM nodes have a predefined set of properties
  - `<button value='Press me' ~~urgency='high'~~>…</button>`
- You may add new “custom” properties by prefixing their name with ‘`data-`’
  - `<button value='Press me' data-urgency='high'>…</button>`

https://reactjs.org/docs/components-and-props.html

https://reactjs.org/docs/react-component.html

https://reactjs.org/blog/2015/12/18/react-components-elements-and-instances.html

Full Stack React, Chapter “Advanced Component Configuration with props, state, and children”

Putting together the building blocks

REACT COMPONENTS

Declaring components

Components as functions

```
const Button = ( props ) => (
  React.createElement( . . . )
     -or-
  <Element>...</Element>
);
```

Components as classes

```
class Button extends React.Component {
  render() {
    // receives this.props;
    return
      React.createElement( . . . ) ;
         -or-
      <Element>...</Element> ;
  }
}
```

Components:
Take props as their input
Return the elements as their output

Comparison

Components as functions

- Defined as function expressions or arrow expressions
- Receive (props) argument
- Must return a React Element tree
- The returned elements are function of the props
- Must be a pure function (no side-effects) and idempotent
- State and lifecycle may be managed with the recent Hooks, mechanism

Components as classes

- Must implement the render() method
  - Will return the React Element tree (same as function)
- Props are available as instance properties (this.props)
- May define other instance methods
- Local state may be defined
- Additional lifecycle events may be handled with custom logic

Top-Down Reconciliation

1. ReactDOM.render() or setState() is called for an element E
2. E() or E.render() is called, with the specified props, to obtain its representation as an Element tree ET (whose elements receive their props, as computed by E)
3. For each non-native element in ET, repeat steps 2-3 recursively
4. Stop when only native DOM elements are present in ET
5. The resulting ET is compared with the existing ET in the V-DOM, using an approximated $O(N)$ algorithm (https://reactjs.org/docs/reconciliation.html)
6. The differences are propagated to the browser's DOM

Tips for Creating Components

- It’s normal to create many different “small” components
- Each component is constructed by *composing* other components
  - Components may be repeated (with different props)
  - It’s up to the parent to determine the children’s props
- If a component becomes too complex, try to *extract small re-usable parts* as independent components

Lists and Keys (1/2)

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

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

- The `NumberList` component generates a `<ul>` containing `<li>` for each of the numbers in its `props.numbers`
- Whenever you construct a list of elements, you should pass a unique **key** attribute to identify each item
- Unique keys help React identify which items have changed, are added, or are removed. They are used in the Reconciliation algorithm heuristics

https://reactjs.org/docs/lists-and-keys.html

Lists and Keys (2/2)

- Assign to each item in the list a special 'key' attribute, with unique values
  - `<li key={number.toString()}>{number}</li>`
- Most likely, we may reuse unique IDs from the data itself
  - `<li key={todo.id}>{todo.text}</li>`
- Keys must be specified when building the array of components
  - Usually in the `.map()` call, in the 'container' component
  - Not needed within the component of the items
- Uniqueness is only required within *the same list*
  - *Not globally* on the page
- Keys are *not* available as `props` in the component

React Fragments

- `render()` should always return a tree of elements, with a single root.
- To return a list of elements, you must include them in some "container" (such a)
  - This generates an "extra" DOM node, and in some contexts it might be invalid
- The special node `<React.Fragment>` may be used to wrap a list of element into a single root.
  - React.Fragment will not generate any node at the DOM level
- A shortcut syntax for fragments is `<>…</>`

https://reactjs.org/docs/fragments.html

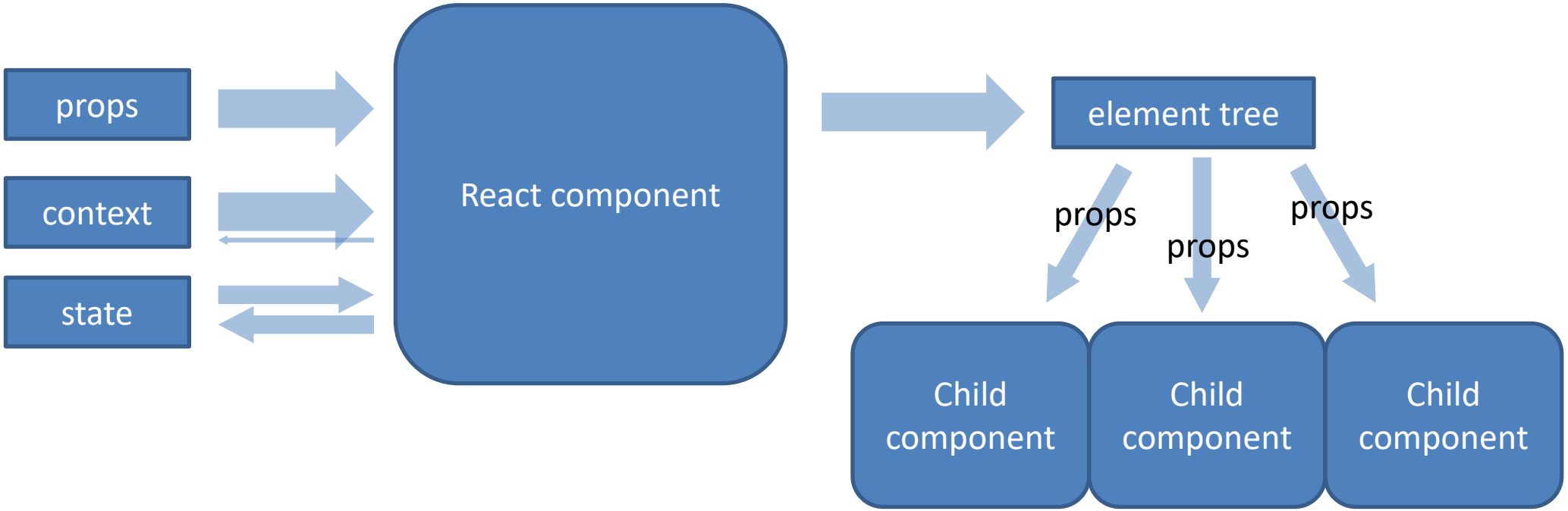
https://reactjs.org/docs/react-component.html

Full Stack React, Chapter “Advanced Component Configuration with props, state, and children”

React Handbook, Chapters “Props” and “State”

COMPONENTS: PROPS AND STATE

Props, state, context



Props, State, Context

- Props are immutable pieces of data that are passed into child components from parents
- State is where a component holds data, locally.
  - When state changes, usually the component needs to be re-rendered
  - State is *private* to the component and is *mutable* by component methods
- Context is a sort of “global” and “implicit” props, that are automatically passed to all components

Passing props

- In JSX, every attribute is converted to a prop
  - `<Header headerText='Hello'/>`
  - `this.props.headerText` -> string `"hello"`
- This.props collects all passed props
  - They are all read-only
- May be any JS object, or other React elements
  - `<UserError level={3}/>`
  - `<ResultsTable displayData={latestResults}/>`

PropTypes

- An *optional* mechanism for declaring the data types of props, that will be checked at run-time
  - npm install prop-types
- Create a static property `propTypes` in our component class
  - Maps every property name to a “type validator”
  - Validators check the props at run-time, only in development mode
  - Validation errors are shown in the JS console

https://reactjs.org/docs/typechecking-with-proptypes.html

PropTypes Example

```
import PropTypes from 'prop-types';

class Greeting extends React.Component
{
  render() {
    return (
      <h1>Hello, {this.props.name}</h1>
    );
  }
}

Greeting.propTypes = {
  name: PropTypes.string
};
```

```
import PropTypes from 'prop-types';

class Greeting extends React.Component
{
  render() {
    return (
      <h1>Hello, {this.props.name}</h1>
    );
  }

  static propTypes = {
    name: PropTypes.string
  };
}
```

PropTypes validators

- Optional props of pre-defined types
  - `PropTypes.array`
    - `PropTypes.arrayOf(PropTypes.number)`
  - `PropTypes.bool`
  - `PropTypes.funct`
  - `PropTypes.number`
  - `PropTypes.object`
    - `PropTypes.objectOf(PropTypes.number)`
    - `PropTypes.shape({…})`
  - `PropTypes.string`
- Rendering content
  - `PropTypes.node`: anything that can be rendered
  - `PropTypes.element`: any ReactElement
  - `PropTypes.MyComponent`
- Make a property required
  - `PropTypes.`*`type`*`.isRequired`
  - `PropTypes.any.isRequired`

Default Props Values

- We may specify default values
  - In case of missing properties
- Static property ‘defaultProps’
- If a prop is passed, the default is ignored
- Validation happens *after* default values are applied

```
class Counter extends React.Component {
  static defaultProps = {
    initialValue: 1
  };
  // ...
};
```

```
<Counter />
```

…equivalent to:

```
<Counter initialValue={1} />
```

State

- An object containing local data, private to a component, that may be mutated by the component itself
- To define state, simply assign an object to this.state in the class constructor
  - You need to define the component with the class syntax
  - You need to declare a constructor

State example

```
class WelcomeButton extends
React.Component {
  constructor(props) {
    super(props);
    this.state = { english: true };
  }

  render() {
    return <button>
      {this.state.english ?
          'Hello' : 'Ciao'}
    </button>
  }
}
```

- The constructor receives `props` and should call `super(props)`
- Assign to `this.state` the *initial version* of an object describing the component state
- Inside the component, you may refer to `this.state` to customize the result according to current state
- Never n-e-v-e-r modify `this.state` directly

State modifications

Merge: modifies (or adds) properties that you specify, leaves the others unchanged
Shallow: not recursive over nested objects

- `setState(updater, [callback])`
- **All** modifications to the state must be requested through setState()
- setState will apply the modification asynchronously (not immediately)
  - The callback will be executed after modification has been applied

- Updater as an object: it performs a *shallow merge* of the object's properties into the new state
  - `this.setState({num: 2});`
- Updater as a function
  - `(state, props) => updated_state`
  - Must return a **new** state object with the properties you want to modify
  - Must **not** mutate the passed-in state

https://reactjs.org/docs/react-component.html#setstate

Calling setState()

- State changes are usually determined by asynchronous events
  - DOM event handlers
  - Server responses (e.g., REST API calls)
- The event handler is a function that in turn calls setState

```
handleClick = () => {
  this.setState(
    {english: !this.state.english}
   );
};

render() {
  return <button
    onClick={this.handleClick}>
    {this.state.english ?
       'Hello' : 'Ciao'}
  </button>
}
```

Beware ‘this’: bind your functions

```
constructor(props) {
    super(props);
    this.state = { english: true };
    this.handleClick =
      this.handleClick.bind(this);
 }

 handleClick() {
    this.setState(
      {english: !this.state.english}
    );
 }
```

- When using class **methods** or function expressions, always bind the function in the constructor, or ‘this.state’ will fail
- When using **arrow** functions, it works because this is inherited from the class context

```
handleClick = () => {
    this.setState(
      {english: !this.state.english}
    );
};
```

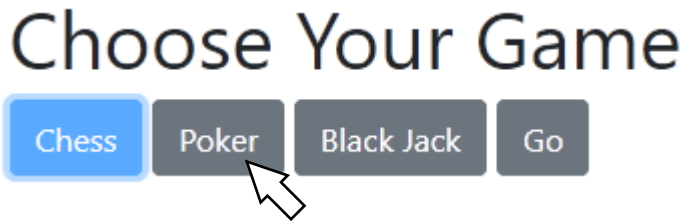
Function or Object in setState?

- If the logic for computing the next state depends on the current state, **always** use a function
- `setState({ counter: this.state.counter+1})`
  - `this.state.counter` is evaluated when `setState` **is called**
  - The new state will be assigned later, asynchronously
  - In case many asynchronous requests are made, some update may rely on out-of-date information
- `setState((state,props)=>({counter:state.counter+1}))`
  - `state.counter` will be evaluated when the async call is made: guaranteed to have the latest value

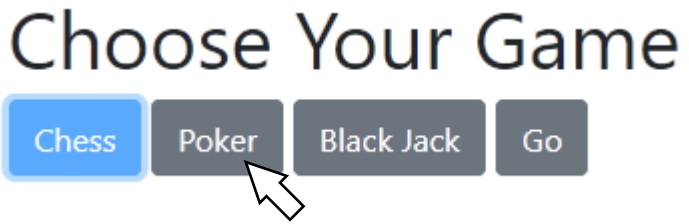
https://medium.com/@wisecobbler/using-a-function-in-setstate-instead-of-an-object-1f5cfd6e55d1

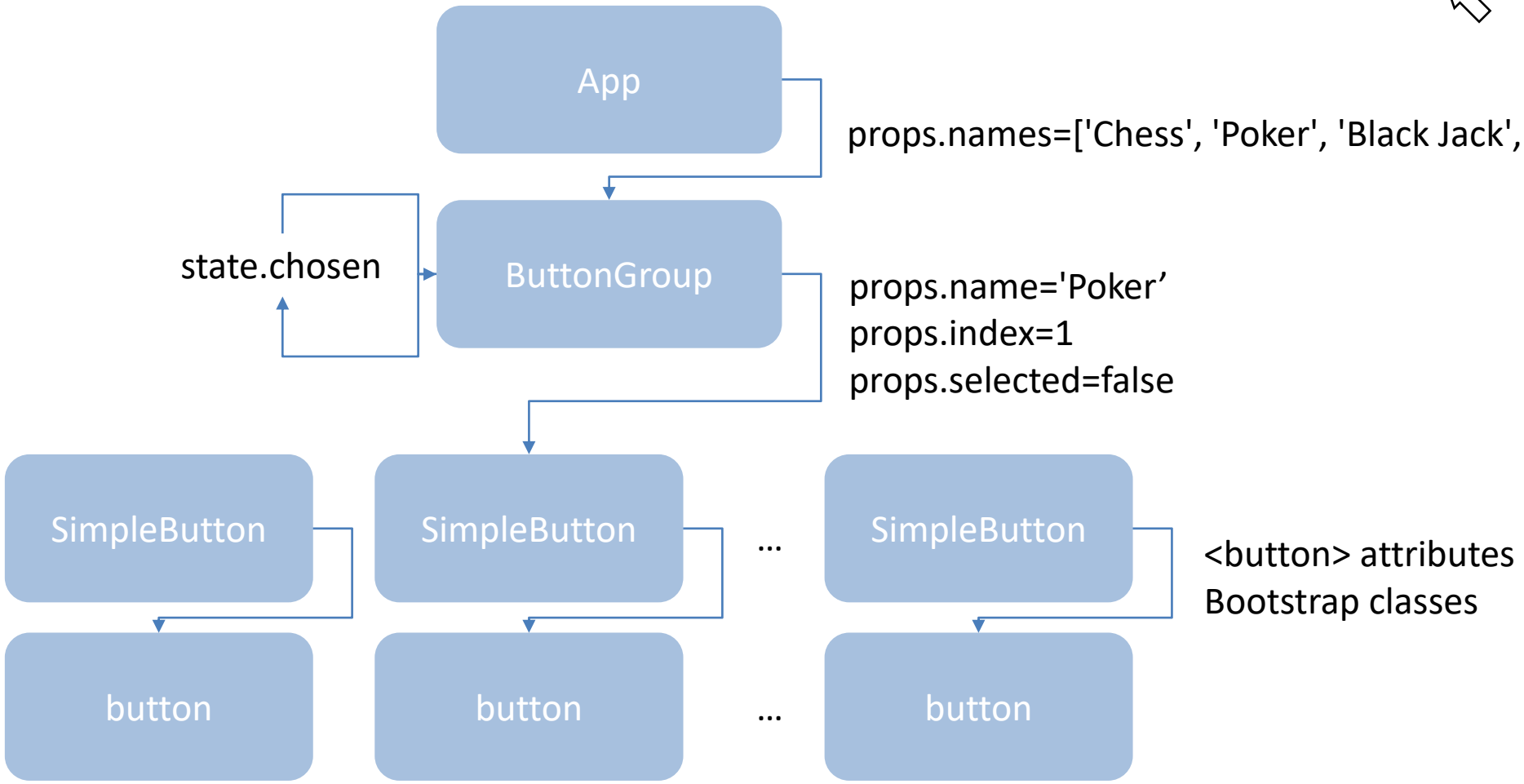
Can children mutate parent's state?

- Each button may be selected or not, but only one may be selected at a time
- The information about what button is selected may not be in the button
- It is a state of a container component for "button group"



Analysis

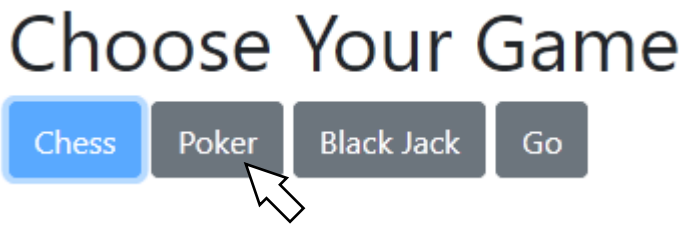

Choose Your Game
Chess
Poker
Black Jack
Go


App
props.names=['Chess', 'Poker', 'Black Jack', 'Go']
state.chosen
ButtonGroup
props.name='Poker'
props.index=1
props.selected=false
SimpleButton
SimpleButton
...
SimpleButton
<button> attributes
Bootstrap classes
button
button
...
button

How to change the chosen button?

- Handle onClick event from the button
- ButtonGroup must offer a method for changing the chosen option
  - Will call setState()
- The method reference must be passed down to SimpleButton, with all other props

Solution




```
changeSelected = (id)=>{
  this.setState(
    {chosen: id});
}
```

state.chosen

App

props.names=['Chess', 'Poker', 'Black Jack', 'Go']

ButtonGroup

props.name='Poker'
props.index=1
props.selected=false
props.changeSelected=this.changeSelected

SimpleButton

SimpleButton

...

SimpleButton

button

button

...

button

<button> attributes
Bootstrap classes
onClick={()=>props.changeSelected(props.index)}

React Design Hints

- Try to implement *stateless* components instead of *stateful* ones
  - Stateless components are more reusable
  - Stateless components are faster to execute
  - Stateless components may be declared as a simple function
- Move *state* to common ancestors (“state lifting”)
- Pass *state* down to the children using *props*
- Allow children to ask for state updates, by passing down callback functions

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