React Client-Components

Outline

1. Server vs Client Components
2. Component State
3. Components Communication
4. Common React Hooks
5. Interleaving Server and Client Components

Server vs Client Components

Server vs Client Components in Next.js

- **Server Components**
  - Run on the server. Great for:
    - Data fetching (from DB, API)
    - Static/SEO-friendly pages
    - Keep sensitive information on the server (access tokens, API keys, etc.)
    - Layouts and heavy logic

Use server components by default for performance and smaller bundle size (reduced client-side JavaScript)

Cannot use browser APIs or hooks such as useState, and useEffect

- **Client Components**
  - Run in the browser: support React hooks like useState, useEffect
  - While they execute on the client, **Next.js pre-renders their initial HTML** on the server for faster perceived load times and SEO
  - Needed for:
    - Adding interactivity and event listeners (onClick(), onChange(), etc)
    - Animations, modals, dropdowns
    - Access to browser APIs (localStorage, window)

Use client components only when **interactivity is required**

Decision Tree

- Does the component use React hooks (e.g., useState/useEffect)?

  └── Yes → Use Client Component

- Does it access browser-only APIs (e.g. window, localStorage)?

  └── Yes → Use Client Component

- Does it fetch data from a Database or a Web API?

  └── Yes → Use Server Component

- Is it interactive (e.g., handles client-side events such as click, mouseOver)?

  └── Yes → Use Client Component

- **Default to Server Components** for performance and enhanced security
- **Isolate interactivity** into **small Client Components** where needed

Component State

Component State

- A component can store its own local data (**state**)
  - Private and fully controlled by the component
  - Can be passed as **props** to children
- Use `useState` hook to create a ***state variable*** and an **associated *function*** to update the state

```
const [count, setCount] = useState(0);
```

`useState` returns a state variable ***`count`*** initialized with 0 and a function ***`setCount`*** to be used to update it

  - Calling ***`setCount`*** causes React to **re-render the app components** and **update the DOM** to reflect the state changes

Never change the state directly by assigning a value to the state variable => otherwise React will NOT re-render the UI

State

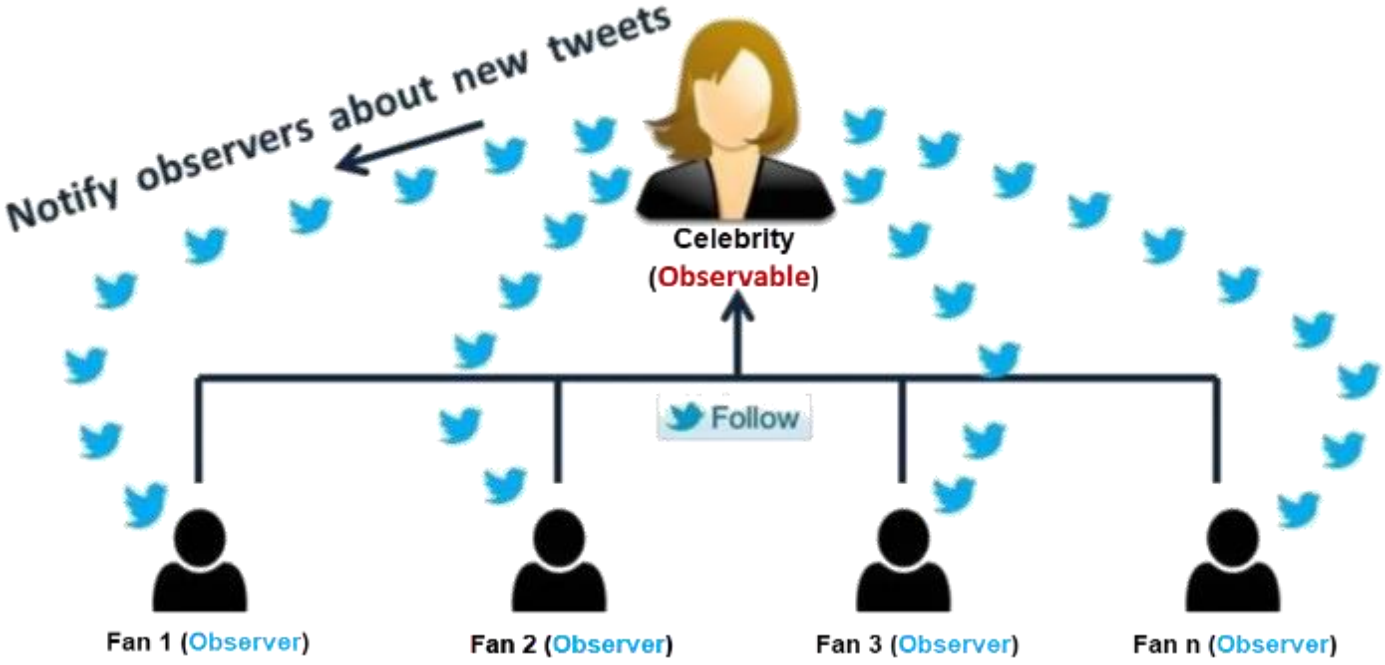
- State = any value that can change overtime
- State variable must be declared using **useState** hook to act as **Change Notifiers**
  - They **are observed** by the React runtime
  - **Persist** their values i.e., remembers the previously stored value (e.g., count = 5) across re-renders
  - Any change of a state variable will trigger the **re-rendering** of any functions that **reads** the state variable
  - Both props and state changes trigger a render update

=> UI is **auto-updated** to reflect the updated app state

Observer Pattern at the heart of Jetpack Compose

Observer Pattern Real-Life Example: A celebrity who has many fans on Tweeter

- Fans want to get all the latest updates (posts and photos)
- Here fans are **Observers** and celebrity is an **Observable** (analogous **state variable in React**)
- **A State variable** is an **observable data holder**: React runtime **observes its changes** and updates the Ul accordingly



Imperative UI vs. Declarative UI

- Imperative UI – manipulate DOM to change its internal state / UI

```
document.querySelector('#bulbImage').src = 'images/bulb-on.png';
document.querySelector('#switchBtn').value = "Turn off";
```

UI in React is immutable

- In react you should NOT access/update UI elements directly (as done in the imperative approach)
- Instead update the UI is by updating the state variable(s) used by the UI elements – this triggers automatic UI update
  - E.g., change the bulb image by updating the ***isBulbOn*** state variable

```
<input type="button"
       value= {isBulbOn ? "Turn off" : "Turn on"}
       onClick={() => setIsBulbOn(!isBulbOn)} />
```

useState: creates a state variable

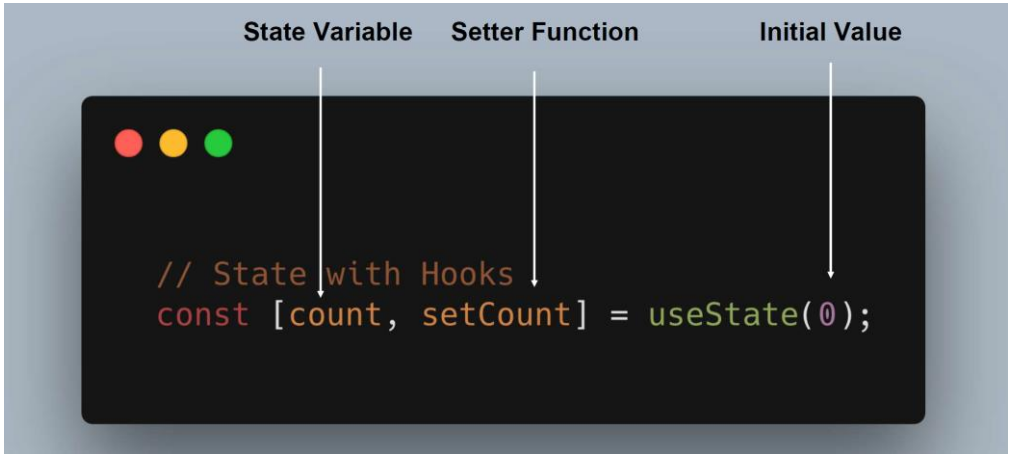
- Used for basic state management inside a component

const [state, setState] = useState(initialState)

The name of your state

The function you'll eventually use to change the value of this state

The initial value of your state



Component with State + Events Handling

```
import React, { useState } from "react";

function Counter({ startValue }) {
    const [count, setCount] = useState(startValue);
    const increment = () => { setCount(prev => prev + 1); };

    const decrement = () => { setCount(prev => prev = - 1); };

    return <div>
            Count: {count}
            <button type="button" onClick={increment}>+</button>
            <button type="button" onClick={decrement}>-</button>
        </div>
}
export default Counter;
```

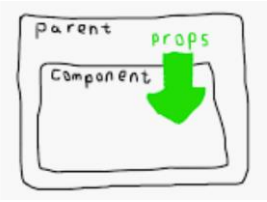
Count: 4 + -

Handling events is done the way events are handled on DOM elements

- Use the **Counter** component

```
<Counter startValue={3}/>
```

Uni-directional Data Flow: Props vs. State



- **Props** = data passed to the child component from the parent component

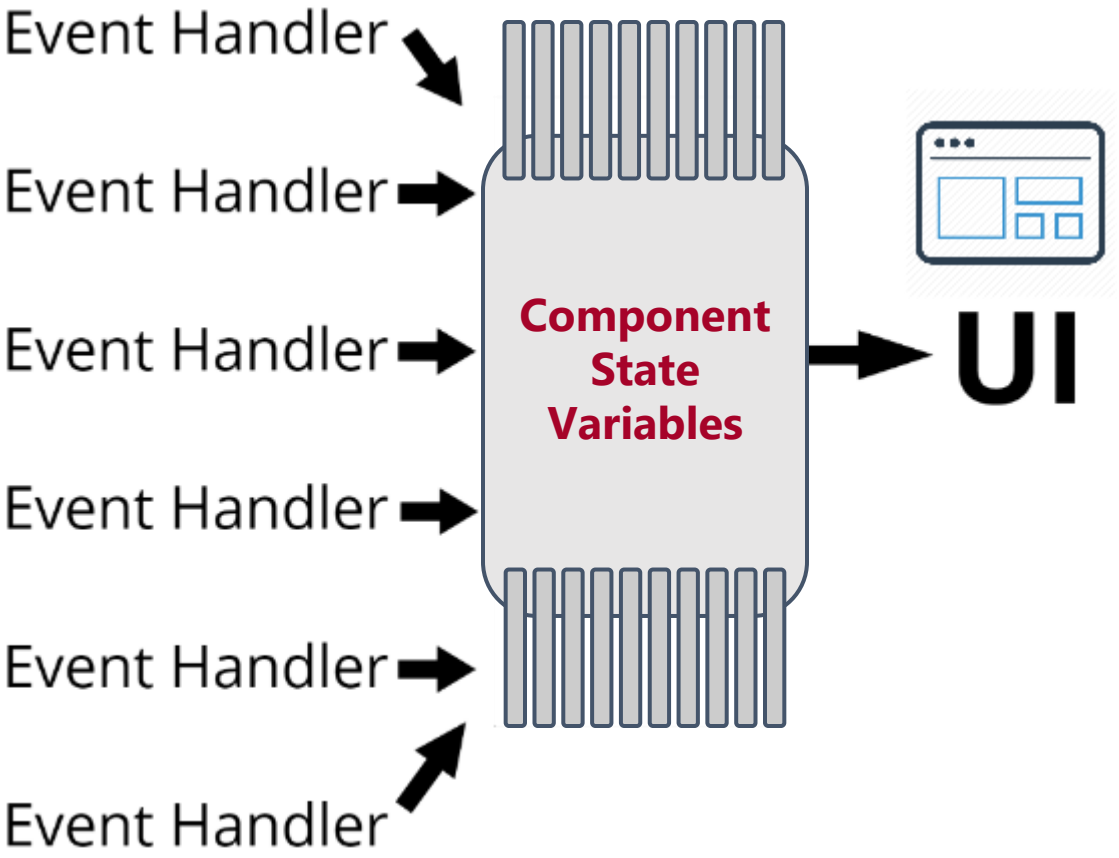
- **Props** parameters are **read only**

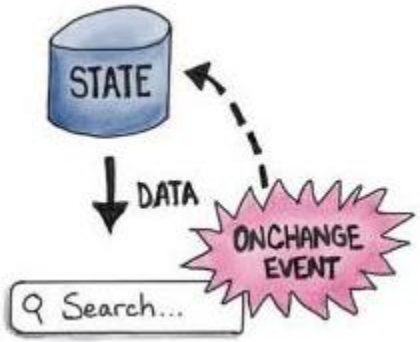
- **State** = internal data managed by the component (cannot be accessed or modified outside of the component)

- **State** variables are **Private** and **Modifiable** inside the component only (through **set** functions returned by useState)

👍 **React automatically re-render the UI whenever state or props are updated**

Event Handlers update the State and React updates the UI

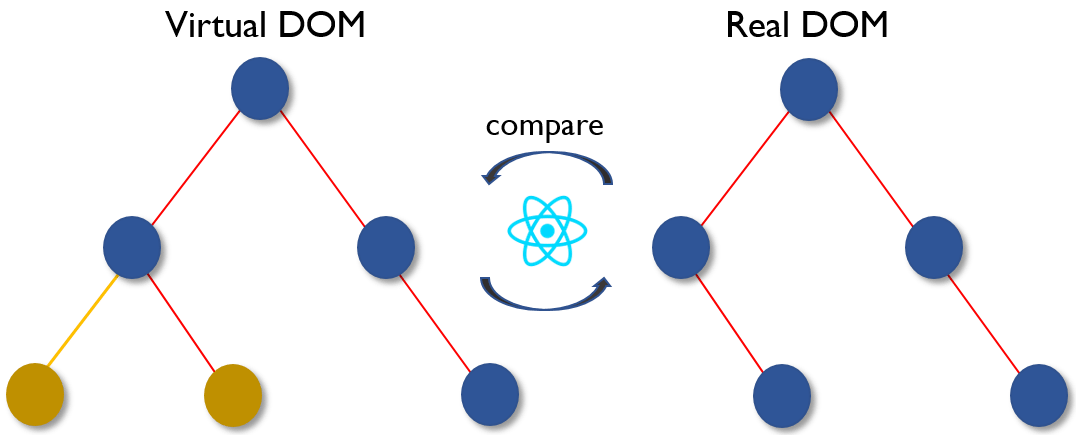




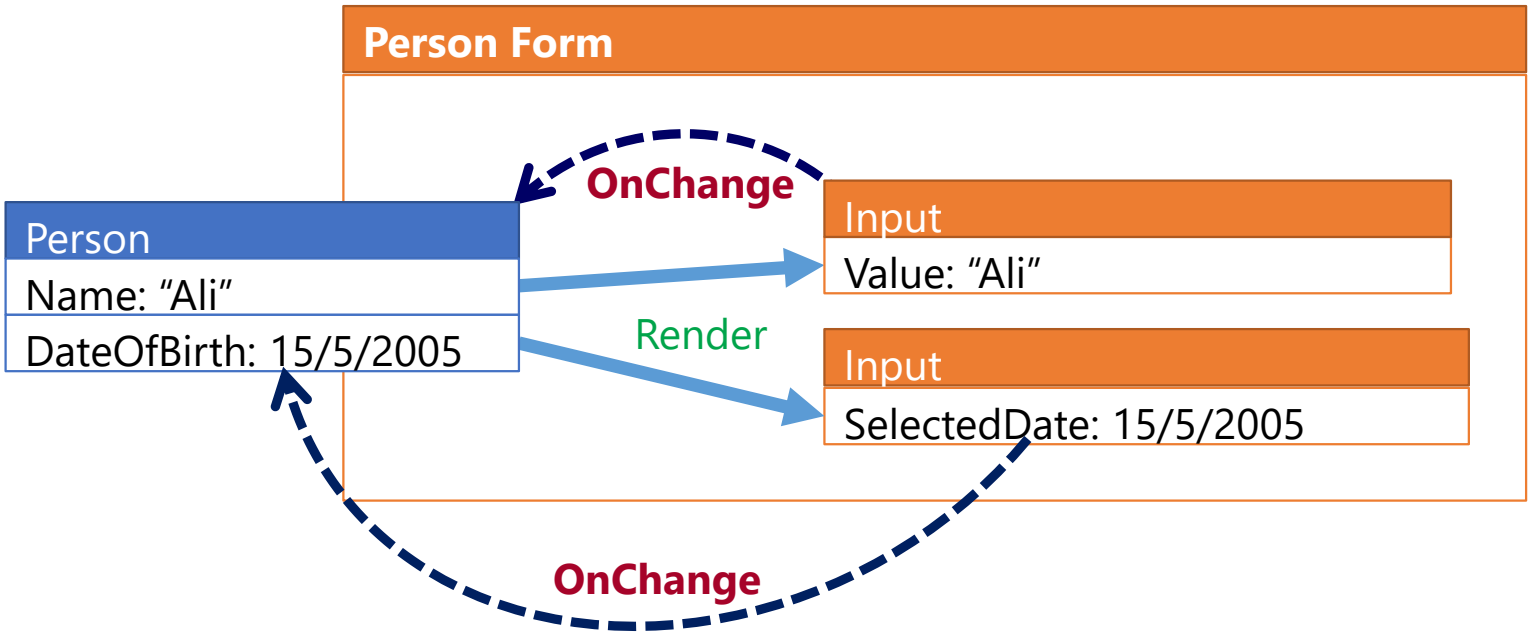
Every place a state variable is displayed is guaranteed to be auto-updated

Virtual DOM

- Virtual DOM = Pure JavaScript lightweight DOM, totally separate from the browser's slow JavaScript/C++ DOM API
- Every time the component **updates its state** or **receives new data via props**
  - A new virtual DOM tree is generated
  - New tree is **diffed** against old…
  - …producing a minimum set of changes to be performed on real DOM to bring it up to date



Unidirectional Data Flow in Forms



Common Events: `onClick - onSubmit – onChange`

Forms with React

Form UI

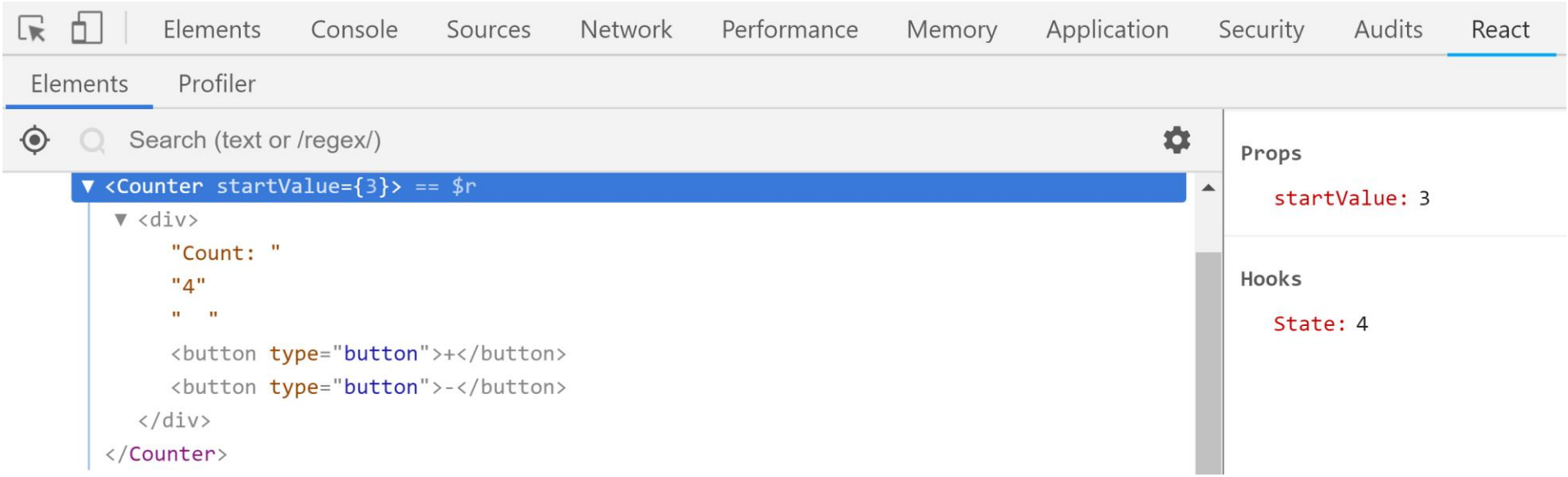
```
<form onSubmit={handleSubmit}>
    <input
        name="email"
        type="email" required
        value={state.user}
        onChange={handleChange} />
    <input
        name="password"
        type="password" required
        value={state.password}
        onChange={handleChange} />
    <input type="submit" />
</form>
```

Form State and Event Handlers

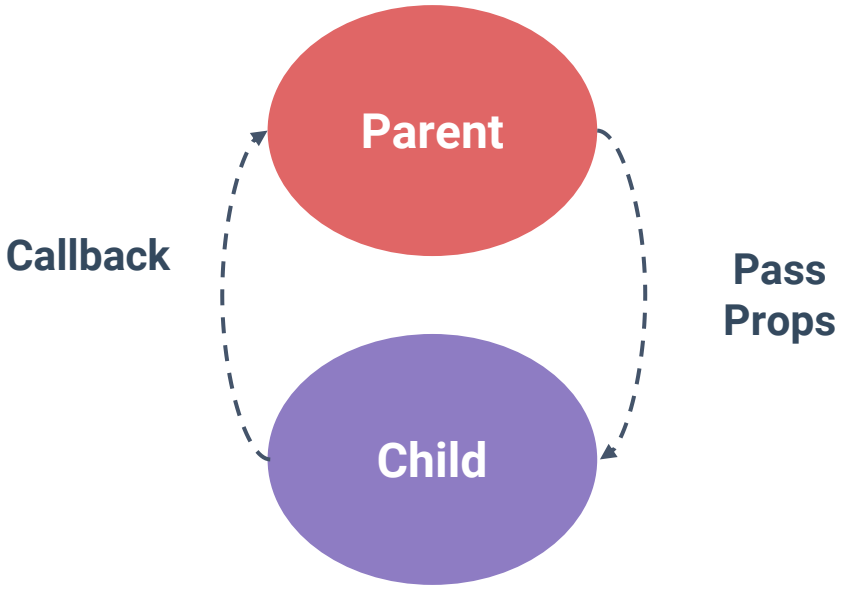
```
const [state, setState] = useState({ email: "", password: "" });

const handleChange = e => {
    const name = e.target.name;
    const value = e.target.value;
    //Merge the object before change with the updated property
    setState({ ...state, [name]: value });
};

const handleSubmit = e => {
    e.preventDefault();
    alert(JSON.stringify(state));
};
```

React Dev Tools

- React Dev Tools
  https://chrome.google.com/webstore/detail/react-developer-tools/fmkadmapgofadopljbjfkapdkoienihi?hl=en

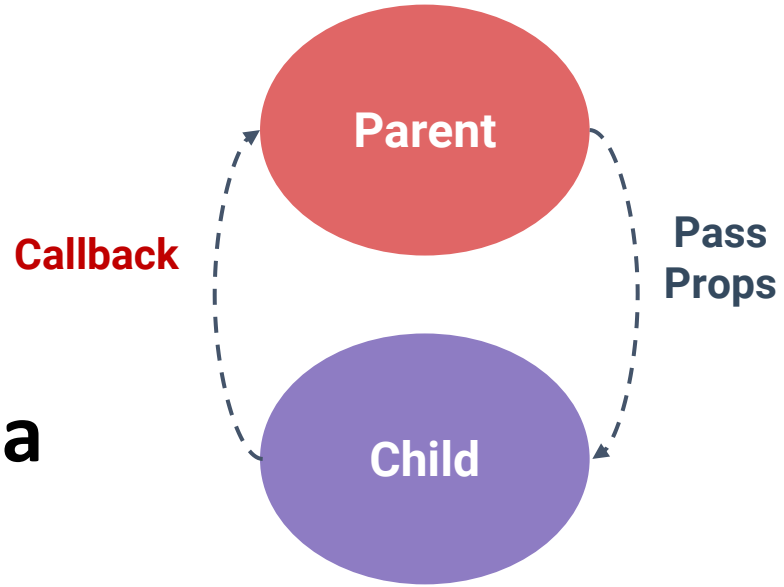


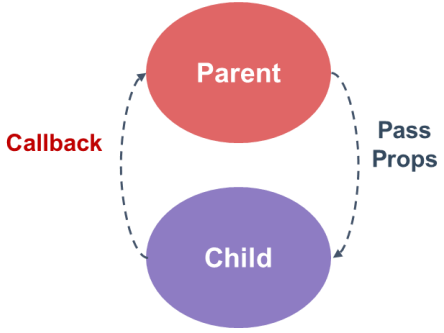
Components Communication



Composing Components

- Components are meant to be used together, most commonly in parent-child relationships
- Parent passes data down to the child via **props**
- The child notify its parent of **a state change via callbacks** (a parent must pass the child a callback as a parameter)





Parent-Child Communication

Parent

```
function Main => <Counter startValue={3}
        onChange={count => console.log(`Count from the child component: ${count}`)}/>
```

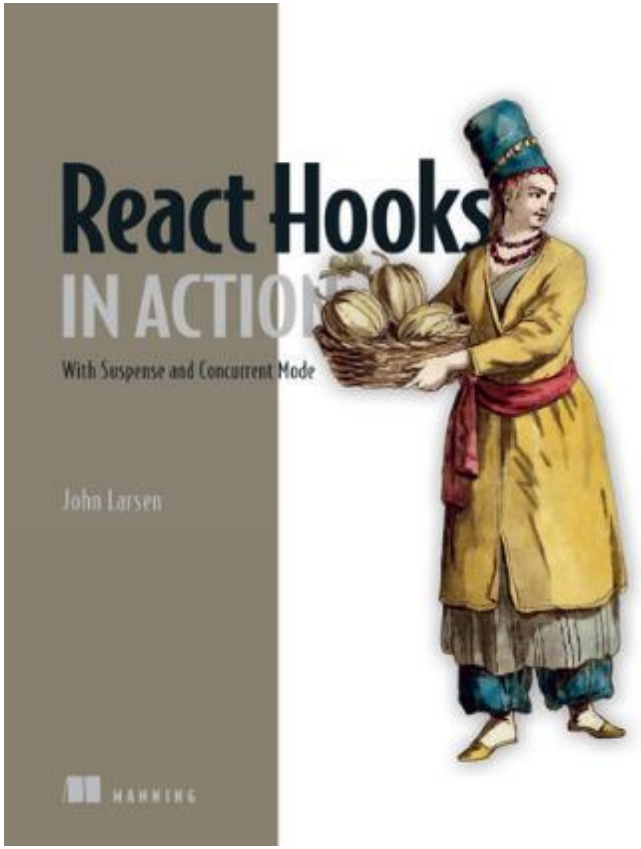
Child

```
function Counter({startValue, onChange}) {
    const [count, setCount] = useState(startValue);

    const increment = () => {
        setCount(prev => prev + 1);
        onChange(count);
    };

    return <div>
        Count: {count}
        <button type="button" onClick={increment}>+</button>
    </div>
}
```

Common React Hooks

React Hooks

1. useState
2. useEffect
3. useRef
4. useContext
5. useRouter
6. useActionState
7. useOptimistic



Some of the slides are based on
https://learning.oreilly.com/library/view/react-hooks-in/9781617297632/

What is Hook?

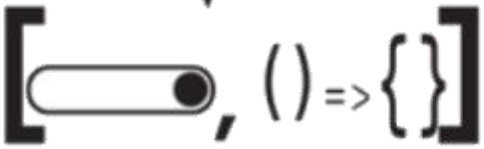
- React Hooks: Functions enabling the use of React state and lifecycle features within functional components. E.g.,
  - useState: adds and manages local state within a component
  - useEffect: enables running code such as fetching data after a component mounts
- Rules of Hooks:
  - Call at Top Level: Only call Hooks at the very top level of the React function, not inside loops, conditions, or nested functions
  - Don't Call Conditionally: (Implicit in Rule 1) Avoid calling Hooks inside conditional (if/else) blocks

useEffect

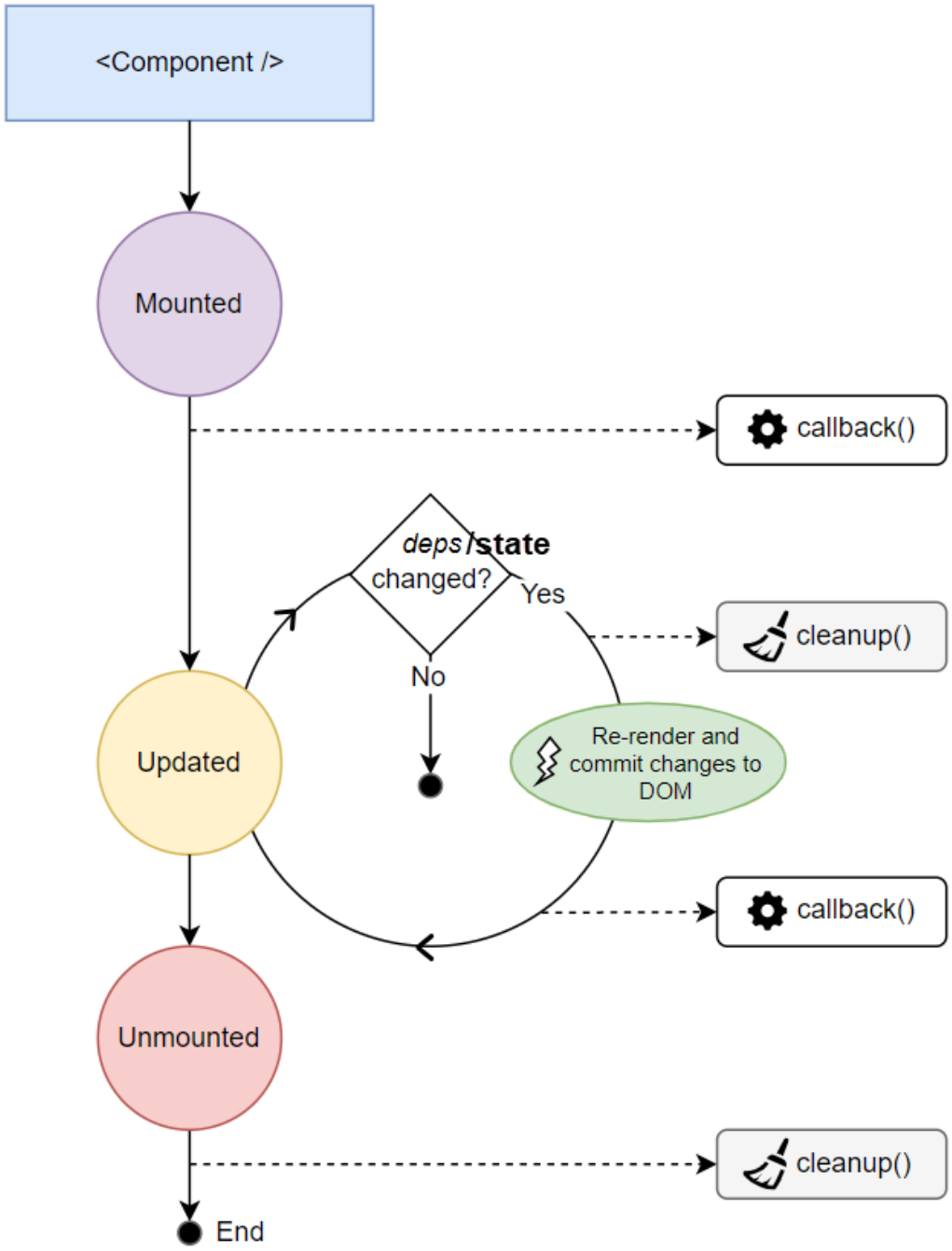
- For doing stuff when a component is mounts/unmounts/updates
- Ideal for fetching data when the component is mounted

```
useEffect( () => {

  // do something with dep1 and dep2

  return () => { /* clean up */ };

}, [dep1, dep2] );
```

Cleanup function:
Return a function to clean up after the effect (e.g., unsubscribe, stop timers, remove listeners, etc.).



Dependency list:
Run the effect only if the values in the array change.



1) After Initial Render: React runs the effect callback function after the component first mounts

2) After Subsequent Renders (if dependencies change):
- React first runs the cleanup function (if provided)
- Then, React runs the effect callback function

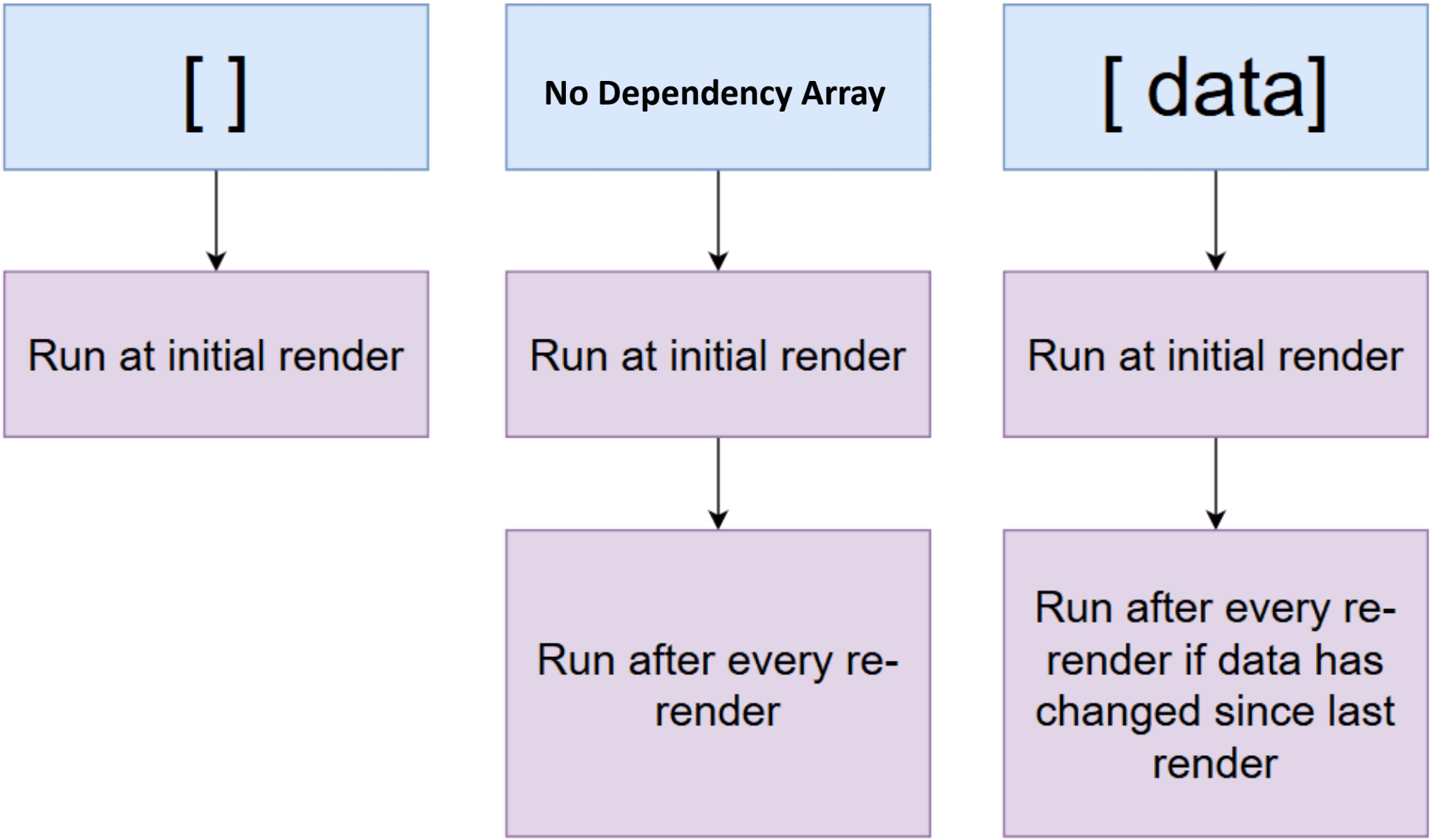
3) Before Unmount: React runs the cleanup function (if provided) just before the component is removed

Common usage scenarios of useEffect

Common usage of useEffect include:

- Fetching data when the component mounts or when specific props/state change
- Working with timers like `setInterval` or `setTimeout`
- Using APIs like Geolocation, and localStorage

useEffect - 2nd argument



Use cases for the useEffect hook

Call pattern	Code pattern	Execution pattern

No second argument	`useEffect(() => {`
	`  // perform effect`
	`});`
		Run after every render.

Empty array as second argument	`useEffect(() => {`
	`  // perform effect`
	`}, []);`
		Run once, when the component mounts.

Dependency array as second argument	`useEffect(() => {`
	`  // perform effect`
	`  // that uses dep1 and dep2`
	`}, [dep1, dep2]);`
		Run whenever a value in the dependency array changes.

Return a function	`useEffect(() => {`
	`  // perform effect`
	`  return () => {/* clean-up */};`
	`}, [dep1, dep2]);`
		React will run the cleanup function when the component unmounts and before rerunning the effect.

useEffect – Executes code during Component Life Cycle

- **Initialize state data** when the component loads

```
useEffect(() => {
    async function fetchData() {
        const url = "https://api.github.com/users";
        const response = await fetch(url);
        setUsers( await response.json() ); } // set users in state
        fetchData();
}, [ ]); // pass empty array to run this effect once when the component is first mounted to the DOM.
```

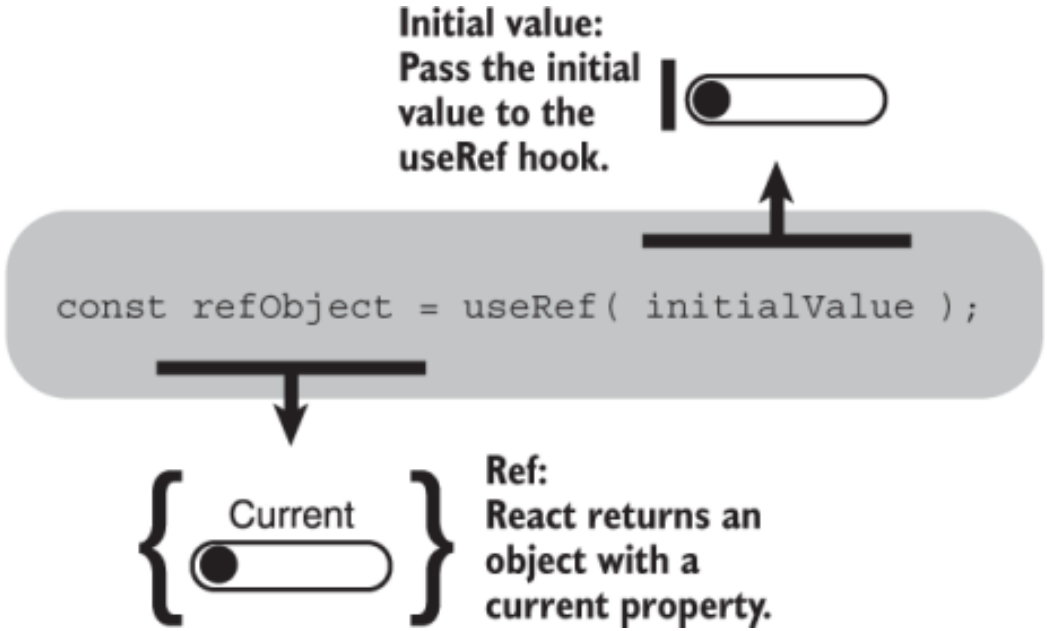
- **Executing a function every time a state variable changes**

```
useEffect(() => {
    async function fetchData() {
        const url = `https://hn.algolia.com/api/v1/search?query=${query}`;
        const response = await fetch(url);
        const data = await response.json();
        setNews(data.hits);
    }
    fetchData();
}, [query]);
```

If 2nd parameter is not set, then the useEffect function will run on every re-render

useRef

- useRef() hook to create **persisted mutable values** as well as directly **access DOM elements** (e.g., focusing an input)
  - The value of the reference is persisted (stays the same) between component re-renderings
  - Updating a reference doesn't trigger a component re-rendering.



useRef for Mutable values

- useRef(initialValue) accepts one argument as the initial value and returns a reference. A reference is an object having a special property current

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

function LogButtonClicks() {
  const countRef = useRef(0);

  const handle = () => {
    countRef.current++;
    console.log(`Clicked ${countRef.current} times`);
  };

  console.log('I rendered!');

  return <button onClick={handle}>Click me</button>;
}
```

- `reference.current` accesses the reference value, and `reference.current = newValue` updates the reference value
- The value of the reference is persisted (stays the same) between component re-renderings
- Updating a reference doesn't trigger a component re-rendering

useRef for accessing DOM elements

- useRef() hook can be used to access DOM elements

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

function InputFocus() {
  const inputRef = useRef();

  useEffect(() => {
    inputRef.current.focus();
  }, []);

  return (
    <input
      ref={inputRef}
      type="text"
    />
  );
}
```

- Define the reference to access the element

```
const inputRef = useRef();
```

- Assign the reference to **ref** attribute of the element:

```
<input  ref={inputRef} />
```

- After mounting, `inputRef.current` points to the DOM element

=> In this example, we access the input to focus on it when the component mounts. After mounting we call `inputRef.current.focus()`

Store Previous State Value

```jsx
import React, { useState, useEffect, useRef } from 'react';

export default function PreviousValueTracker() {
  const [count, setCount] = useState(0);
  const prevCountRef = useRef();

  useEffect(() => {
    prevCountRef.current = count; // update after render
  }, [count]);

  return (
    <div>
      <p>Current count: {count}</p>
      <p>Previous count: {prevCountRef.current ?? 'N/A'}</p>
      <button onClick={() => setCount(count + 1)}>Increment</button>
    </div>
  );
}
```

prevCountRef stores the previous count value **after each render**.
Unlike useState, updating useRef **does not cause a re-render**.

useRef vs. useState

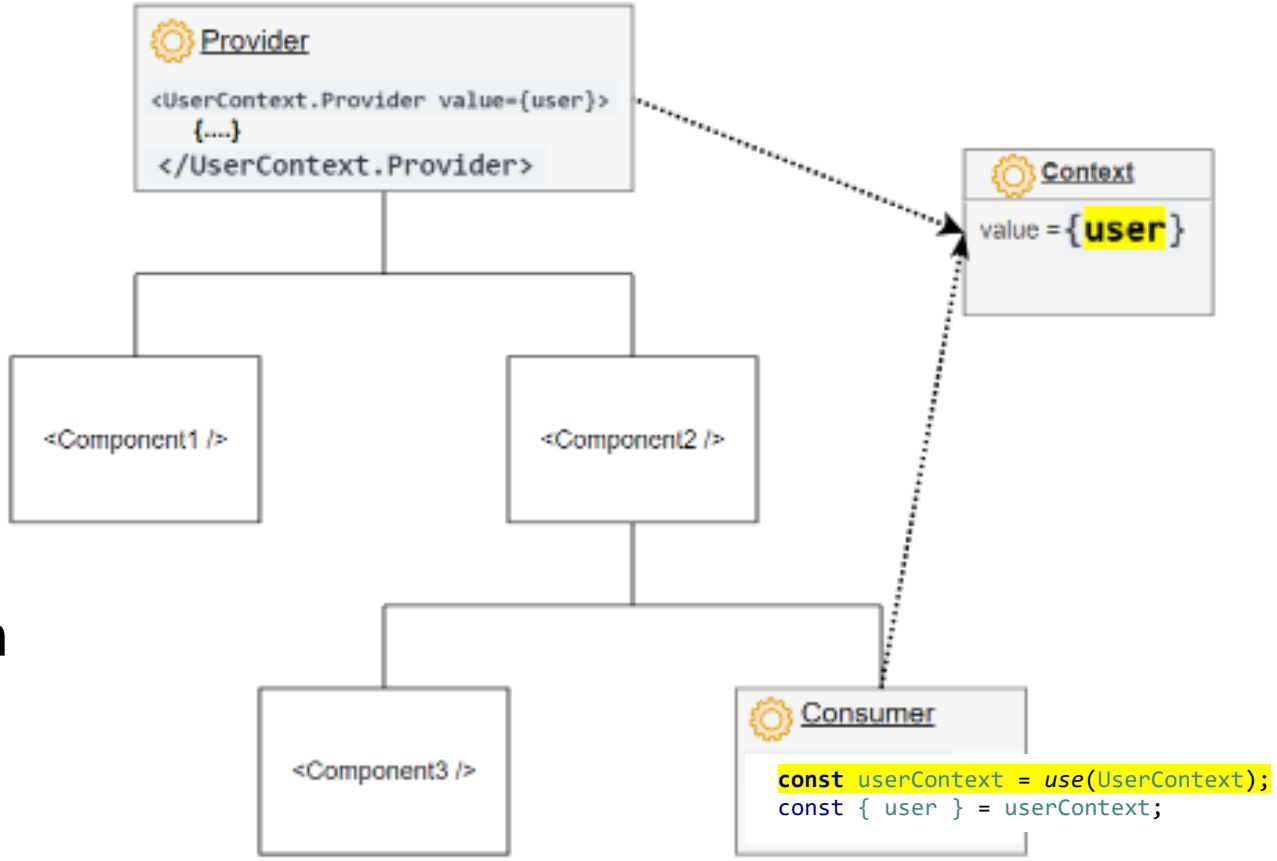
- useState, and useContext hooks triggering re-renders when a state variable changes
- useRef remembers the state value but change of value does not trigger rerender
  - The values of refs persist throughout render cycles

useContext

- Share state (e.g., current user, user settings) between deeply nested components more easily than prop drilling (i.e., without pass the state as props through each nested component)

- Using the context requires 3 steps: **creating**, **providing**, and **consuming** the context

- If the context variables change then all consumers are notified and **re-rendered**



useContext – provides shared variables and functions

1. **Create a context** instance (i.e., a container to hold shared variables and functions)

```
import {createContext } from 'react';
const UserContext = createContext();
export default UserContext;
```

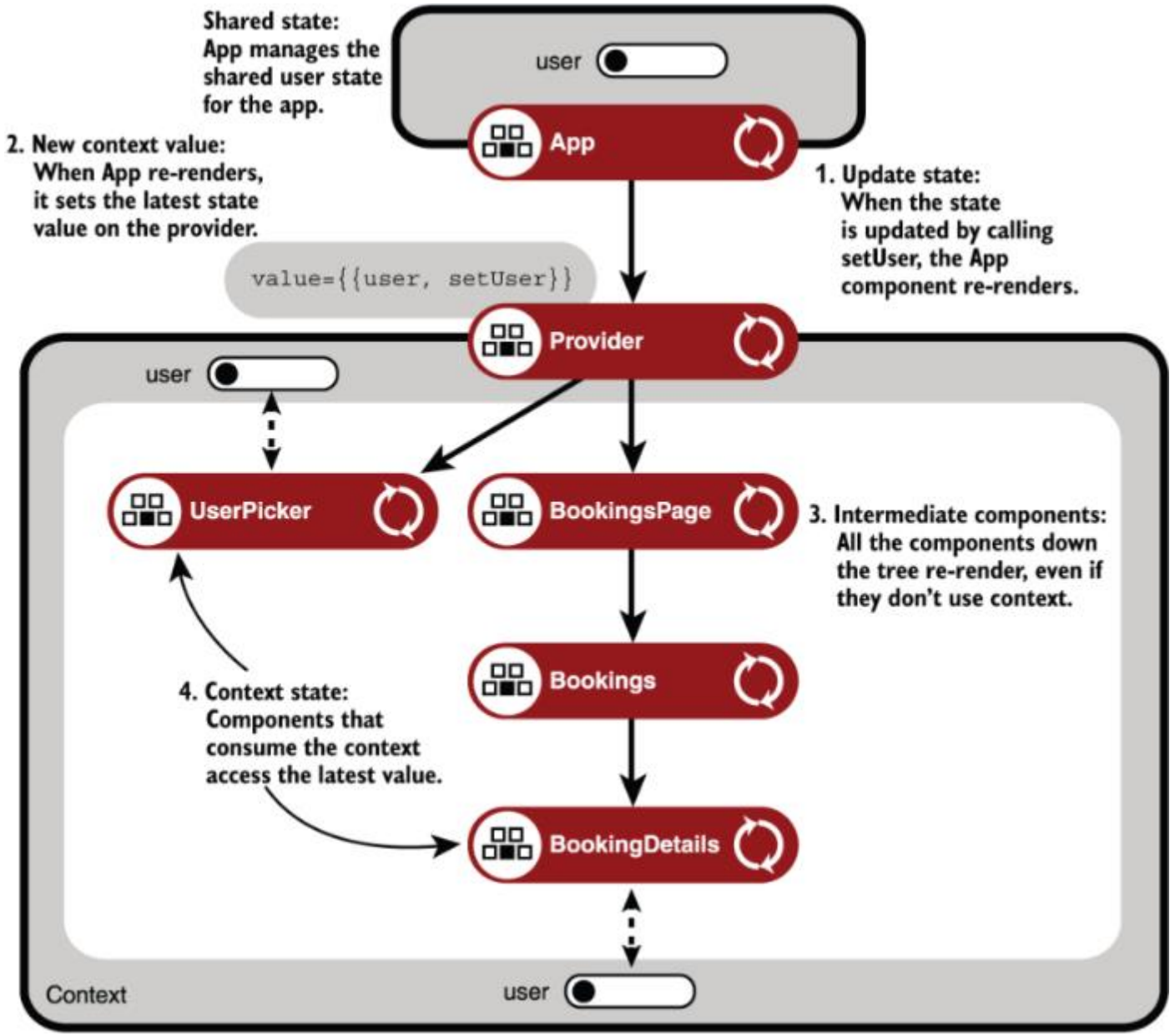
2. **Provider places shared variables / functions in the context** to make them available to child components

```
import UserContext from './components/UserContext';
function App() { return (
     <UserContext.Provider value={ user }>
            <Welcome /> …
      </UserContext.Provider>
   ); }
```

3. **Consumer access the shared variables / functions in the context**

```
import { use } from "react";  import UserContext from './UserContext';
export default function Welcome() {
    const userContext = use(UserContext);
    const { user } = userContext;
    return <div>You are login as: {user.username}</div>;
}
```

Shared State Example



useRouter

- **useRouter** hook allows you to programmatically change routes inside Client Components
    - Use the <Link> component for navigation unless you have a specific requirement for using useRouter

```
'use client'

import { useRouter } from 'next/navigation'

export default function Page() {
  const router = useRouter()

  return (
    <button type="button" onClick={() => router.push('/dashboard')}>
      Dashboard
    </button>
  )
}
```

useActionState

- **Purpose:** useActionState, simplifies managing the lifecycle of a server action (pending, success, error) and the data returned by it - typically in response to form submissions
- **Signature**: `const [state, formAction, isPending] = useActionState(actionFn, initialState);`

  Parameters:

  - **actionFn**: An async Server Action that performs logic/validation and returns a new state object (success or error information)
  - **initialState**: An object representing the initial form state (e.g., feedback messages, error status).

  Returns:

  - **state**: state: The latest state, updated based on actionFn's result
  - **formAction**: A function to trigger the actionFn. Typically assigned to a form's action attribute `<form action={formAction}>`
  - **isPending**: A boolean indicating whether the actionFn is currently executing
- **Benefits**: Automatically handles the pending UI state, simplifies updating the UI with success or error feedback after an action

Example

```
"use client";
import { useActionState } from 'react';
import { addTaskAction } from "./actions";

export default function TaskAdder() {
  const [state, formAction, isPending] = useActionState(addTaskAction, initialState );
  return (
    <div>
      <h2>Add New Task</h2>
      <form action={formAction}>
        <label htmlFor="taskInput">Task Name: </label>
        <input type="text" id="taskInput"  name="taskName" disabled={isPending}  required  />
        <button type="submit" disabled={isPending}>
          {isPending ? 'Adding...' : 'Add Task'}
        </button>
      </form>

      {/* Display feedback based on the state message */}
      {state.message !== null && (
          <p style={{ color: state.error ? 'red' : 'green', marginTop: '10px' }}>
            {state.message}
          </p>
      )}
    </div>
  );
}
```

Server Action

```
"use server";
// Define the asynchronous action function (returns new state)
async function addTaskAction(previousState, formData) {
  const taskName = formData.get('taskName');
  // Basic validation
  if (!taskName || taskName.trim().length < 3) {
    return {  message: 'Task name must be at least 3 characters long.', error: true };
  }

  try {
    // Simulate network delay/database operation
    await new Promise(resolve => setTimeout(resolve, 1000));

    // Return the new state on success
    return { message: `Successfully added task: "${taskName}"`, error: false };
  } catch (error) {
    return { message: error.message || 'Failed to add task due to a server error.',  error: true };
  }
}
```

useOptimistic

- `useOptimistic`: helps you optimistically update the UI before a server action completes
  - Improves user experience by providing feedback while awaiting confirmation from the backend
  - Once the server responds, the real state replaces the optimistic one
- **`Signature:`**

```
const [optimisticState, addOptimistic] = useOptimistic(actualState, updateFn);
```

Parameters:

- **actualState**: The current state from the server
- **updateFn**: A function used to compute a temporary state

Returns:

- **optimisticState**: The UI state including optimistic updates while waiting
- **addOptimistic**: A function you call to apply the optimistic update

Example

```
import { useState, useOptimistic } from 'react';
export default function CommentsPage() {
  const [comments, setComments] = useState([]);
  const [optimisticComments, addOptimisticComment] = useOptimistic(
    comments,
    (prevComments, newComment) => [...prevComments, newComment]
  );

  async function handleSubmit(formData) {
    const newComment = formData.get('comment');
    addOptimisticComment(newComment);
    const saved = await addCommentToServer(newComment);
    setComments(prev => [...prev, saved]);
  }
  return (
    <form action={handleSubmit}>
      <input type="text" name="comment" placeholder="Add a comment" required />
      <button type="submit">Post</button>
      <ul>
        {optimisticComments.map((c, i) => (
          <li key={i}>{c}</li>
        ))}
      </ul>
    </form>
  );
}
```

use Hook

- **Purpose:** The `use` hook lets a client component suspend rendering until a Promise (such as a Server Action) resolves
- **How it works:**
  - The component using `use(promise)` is typically wrapped in a `<Suspense>` component
  - While the Promise is pending, `<Suspense>` shows the fallback UI (e.g., ⏳ **Loading server data...**)
  - Once the Promise resolves, the fetched content is replaces to fallback UI
- **Benefits:**
  - It makes asynchronous code look synchronous inside components, simplifying logic
  - While the Promise is pending, React `<Suspense>` handles showing the fallback UI without needing manual loading flag

use Hook Example

```jsx
import { Suspense } from "react";
import UserName from "./components/UserName";
import { fetchUserName } from "./actions";

export default function Page() {
  const userPromise = fetchUserName();  // Call the Server Action
  return (
    <main>
      <Suspense fallback={<div>⏳ Loading user info...</div>}>
        <UserName userPromise = { userPromise } />
      </Suspense>
      <p style={{ marginTop: "20px" }}>Other content on the page.</p>
    </main>
  );
}
```

- This component will suspend while waiting for the server data
- At first, you see Loading user info...
- Once the Promise is resolved, the fetched data is displayed, replacing the loading fallback

The **use** hook lets the client component suspend rendering until the promise (i.e., Server Action) resolves

```jsx
"use client";
import { use } from "react";

export default function UserName({ userPromise }) {
  const user = use(userPromise);
  return <div>Hello, {user.name}!</div>;
}
```

Asynchronous Server action

```jsx
"use server";
export async function fetchUserName() {
 await new Promise((resolve) => setTimeout(resolve, 2000));
  return { name: "John Doe" };
}
```

Summary of Hooks

- **useState**: Manage local component state
- **useEffect**: Handle side effects and respond to component lifecycle events
- **useRef**: Persist values across renders or directly reference DOM elements
- **useContext**: Share state/functions globally without prop drilling
- **useRouter**: Access routing information and navigation methods
- **useActionState**: Manage form state updates and errors when using server actions
- **useOptimistic**: Implement optimistic UI updates by temporarily updating state before a server action completes

Interleaving Server and Client Components

Interleaving Server and Client Components (1 of 2)

- "use client" is the Entry Point to Client-Side Interactivity
  - It marks where the server-rendering stops and client-side rendering begins for that component and anything it imports
  - The component and everything it imports are part of the client-side JavaScript bundle
- Best practice is to **keep Client Components Small**: Push interactivity as far down the component tree as possible (towards the "leaves")
  - Make as Client Component only specific elements or sections that require client-side interactivity or browser APIs
  - Avoid placing `"use client"` high up in the tree if only a small part needs it
  - This minimizes the JavaScript sent to the browser, leading to faster page loads and better performance
- **Server Components can import and render Client Components (SC → CC)**:
  - It can pass props (strings, numbers, objects/arrays) down to the Client Component
  - This is the primary way to embed interactive components within server-rendered content

Interleaving Server and Client Components (2 of 2)

- **Client Components cannot directly import server components:**
  - Components marked with "use client" runs in the browser and cannot directly import server-components as they may contain server-only code, data fetching logic that require dependencies unavailable in the browser (like filesystem or database access)
- **Pass Server Components as children prop for composition (CC ← SC via Props):**

  - This is a workaround to overcome the previous limitation
  - The SC renders on the server, and the resulting content is slotted into the CC during the server render pass (i.e., when Next.js pre-renders the page initial HTML on the server)
  - Ideal for **interactive layout components** (like Modals, Tabs, Accordions marked with "use client") that need to wrap and display complex content rendered on the server (e.g., data-heavy sections, components accessing server-only resources)
    - This keeps the content server-rendered while the container is interactive

Server Component Renders a Client Component (SC -> CC)

- **Use Case**: You fetch data and render content on the server, but need a specific interactive element within that structure (e.g., a button, a form, a dynamic counter)
- **Why**: Keep the bulk of the page rendered on the server for performance and SEO, delegating only the interactive parts to the client
- **Example**: A product page (SC) displays product details fetched from a database and includes an interactive `"Add to Cart"` button (CC)

Example: SC Renders a CC

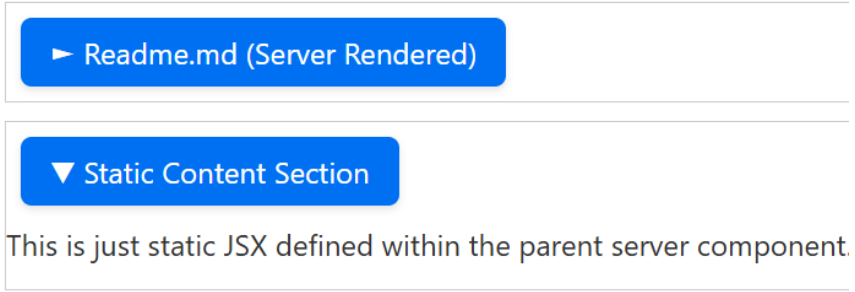
```jsx
// product/[id]/page.jsx (Server Component - Default)
import AddToCartButton from '../../components/AddToCartButton'; // Client Component
import { getProductDetails } from '../../lib/db'; // Server-side data fetching

export default async function ProductPage({ params }) {
  const product = await getProductDetails(params.id); // Fetches data on the server

  return (
    <div>
      <h1>{product.name}</h1>
      <p>{product.description}</p>
      <p>Price: ${product.price}</p>
      {/* SC renders the CC, passing necessary props */}
      <AddToCartButton productId={product.id} productName={product.name} />
    </div>
  );
}
```

Client Component accepts Server Component via children Prop (CC <- SC as children)

- **Use Case**: You have an interactive wrapper component (like a modal, tabs, accordion, tooltip, or layout element needing client-side state) that needs to display content rendered on the server
- **Why**: Allows the interactive "shell" to manage its state/behavior on the client, while the content inside benefits from server rendering (faster initial load, potentially complex server-side logic/data fetching for the content)
- **Example**: An interactive <Accordion> (CC) that displays different sections of server-rendered content (SCs)

Example: CC accepts SC via children Prop (CC <- SC as children)

```
"use client";
import { useState } from "react";
import styles from "./styles.module.css";
export default function Accordion({ title, children, startOpen = false }) {
  const [isOpen, setIsOpen] = useState(startOpen);
  return (
    <div className={styles.accordion}>
      <button
        onClick={() => setIsOpen(!isOpen)}
        className={styles.accordionButton}
      >
        {isOpen ? ▼ : ▶ } {title}
      </button>
      {isOpen && <div className={styles.accordionContent}>{children}</div>}
    </div>
  ); }
```




```
import Accordion from "../components/Accordion";
import MarkdownContent from "../components/MarkdownContent";
export default function HomePage() {
      <Accordion title="Readme.md (Server Rendered)">
        {/* This is a Server Component being passed as children */}
        <MarkdownContent contentFile="README.md" />
      </Accordion>
    );
  }
```

Resources

- Thinking in React

https://react.dev/learn/thinking-in-react

- Hooks
  - https://react.dev/reference/react/hooks
  - React Hooks in Action textbook
- Useful list of resources

https://github.com/rehooks/awesome-react-hooks

- Shadcn https://ui.shadcn.com/
- Material-UI https://mui.com/