CS 4530: Fundamentals of Software Engineering
Module 09: React Hook Patterns

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Learning Objectives for this Module

- By the end of this module, you should be able to:
  - Explain the basic use cases for useEffect
  - Explain when a useEffect is executed, and when its return value is executed
  - Construct simple custom hooks and explain why they are useful.
  - Be able to explain the three core steps of a test (assemble, act, assess) can map to UI component testing

useEffect is a mechanism for synchronizing a component with an external system

```
import { clockServer } from './clock.js';

function ClockClient() {

  useEffect(() => {
    const connection = clockServer.createConnection()
    connection.connect();

    return () => {
      connection.disconnect();
    };
  }, []);
  // ...
}
```

Action to take on first render

Action to take when component dismounts

Empty array says: do this on first render only

https://react.dev/reference/react/useEffect

An external system means any piece of code that's not inside your React component

- An event in the lifecycle of a component, like redisplay.
- A timer managed with setInterval and clearInterval
- An event subscription like a chat server
- A call to fetch data from an external web site
- An external animation library
- A piece of business logic in an app that is external to your component

A real example: connecting a component to a self-ticking clock

app/Apps/SimpleClockDisplay.tsx

```
export function ClockDisplay(props: {
    //
}) {
    const [localTime, setLocalTime] = useState(0)
    const incrementLocalTime = () => setLocalTime(localTime => localTime + 1)
    const listener1 = () => { incrementLocalTime() }
    const clock = SingletonClockFactory.instance(1000)

    useEffect(() => {
        clock.addListener(listener1)
        return () => {
            clock.removeListener(listener1)
        }
    }, [])
```

On first render, add this listener to the clock

On dismount, remove the listener.

Simple example of using an external service: a self-ticking clock

src/app/Apps/SimpleClockDisplayApp.tsx

```
import { ClockDisplay } from './SimpleClockDisplay'

function doNothing() { }

export default function App() {
  return (<VStack>
    <ClockDisplay key={1} name={'Clock A'}
                  handleAdd={doNothing} handleDelete={doNothing}/>
    <ClockDisplay key={2} name={'Clock B'}
                  handleAdd={doNothing} handleDelete={doNothing} />
    <ClockDisplay key={3} name={'Clock C'}
                  handleAdd={doNothing} handleDelete={doNothing}/>
  </VStack>)
}
```

src/app/Classes/ClockWithListeners.ts

Next, let's look at the clock

```
type Listener = () => void

class Clock {
    public time = 0
    private _listeners: Listener[] = []
    private _notifyAll() {this._listeners.forEach(eachListener => {eachListener()})}

    public addListener(listener: Listener) {---}
    public removeListener(listener: Listener) {---}
    }

    public get nListeners () {return this._listeners.length}

    private _timer : NodeJS.Timeout

    public constructor(interval: number) {
            this._timer = setInterval(() => {
                this._tick();
            }, interval);

        }
```

```
    private _tick() {
            this.time++;
            this._notifyAll();
            }

        public _stop() {
            clearInterval(this._timer);

        }

}
```

…and we'll make it a singleton in the usual way

src/app/Classes/ClockWithListeners.ts

```
export default class SingletonClockFactory {

    private static theClock: Clock | undefined = undefined

    private constructor () {SingletonClockFactory.theClock = undefined}

    public static instance (interval:number) : Clock {
        if (SingletonClockFactory.theClock === undefined) {
            SingletonClockFactory.theClock  = new Clock(interval)
        }
        return SingletonClockFactory.theClock
    }

}
```

src/app/Components/SimpleClockDisplay.tsx

Next is <ClockDisplay>

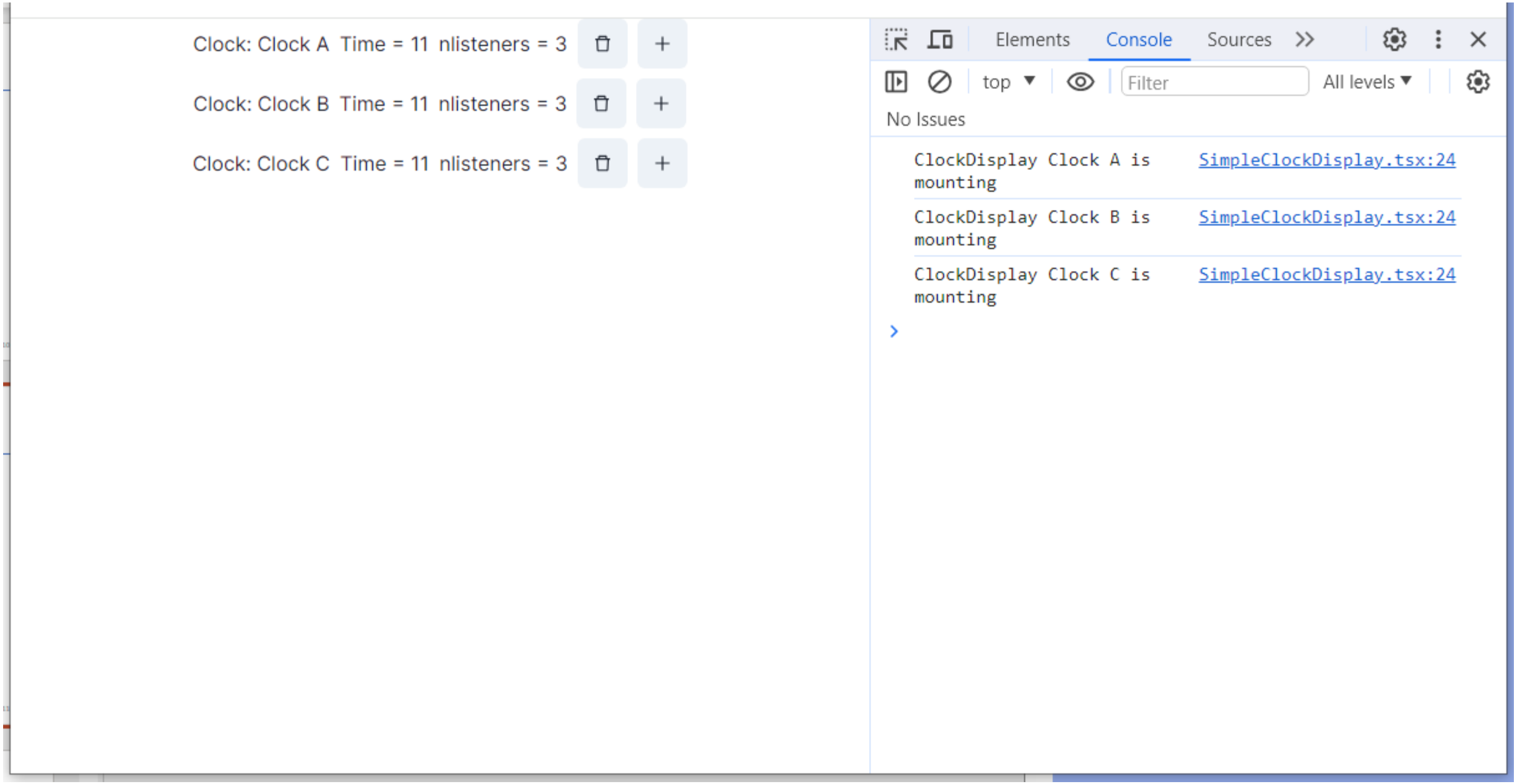
```
export function ClockDisplay(props: {
    name: string, key: number,
    handleDelete: () => void, handleAdd: () => void,
    noisyDelete?: boolean
}) {
    const [localTime, setLocalTime] = useState(0)
    const incrementLocalTime = () => setLocalTime(localTime => localTime + 1)
    const clock = SingletonClockFactory.instance(1000)  // all the displays will share
the same clock

    useEffect(() => {
        const listener1 = () => { incrementLocalTime() }
        console.log('ClockDisplay ' + props.name + ' is mounting')
        clock.addListener(listener1)
        return () => {
            console.log('ClockDisplay ' + props.name + ' is unmounting')
            clock.removeListener(listener1)
        } }, [])
```

ClockDisplay, part 2

```
return (
        <HStack>
            <Box>Clock: {props.name}</Box>
            <Box>Time = {localTime}</Box>
            <Box>nlisteners = {clock.nListeners}</Box>
            <IconButton onClick={props.handleDelete}
                        icon={<AiOutlineDelete />} />
            <IconButton onClick={props.handleAdd}
                        icon={<AiOutlinePlus />} />
        </HStack>
    )

}
```


Clock: Clock A Time = 11 nlisteners = 3
Clock: Clock B Time = 11 nlisteners = 3
Clock: Clock C Time = 11 nlisteners = 3
Elements
Console
Sources
top
Filter
All levels
No Issues
ClockDisplay Clock A is mounting
SimpleClockDisplay.tsx:24
ClockDisplay Clock B is mounting
SimpleClockDisplay.tsx:24
ClockDisplay Clock C is mounting
SimpleClockDisplay.tsx:24

useEffect's Dependencies Control Its Execution

- useEffect takes an optional array of dependencies
- The effect is only executed if the values in the dependency change (e.g. by a setter)
- Special Cases:
  - [] means run only on first render
  - No argument means run on every render

src/app/Apps/useEffect-demo.tsx

Example (Part 1)

```
export default function App() {
    const [n, setN] = useState(0)
    const [m, setM] = useState(0)

    // runs only on first render.
    useEffect(() => {
        console.log('useEffect #1 is run only on first render')}, [])

    useEffect(() => {
        console.log('useEffect #2N is run only when n changes')}, [n])

    useEffect(() => {
        console.log('useEffect #2M is run when m changes')}, [m])

    // runs on every render
    useEffect(() => {
        console.log('useEffect #3A is called on every render')})

    // runs on every render
    useEffect(() => {
        console.log('useEffect #3B is called on every render')})

// observe that effects run in order of definition
```

Example (part 2)

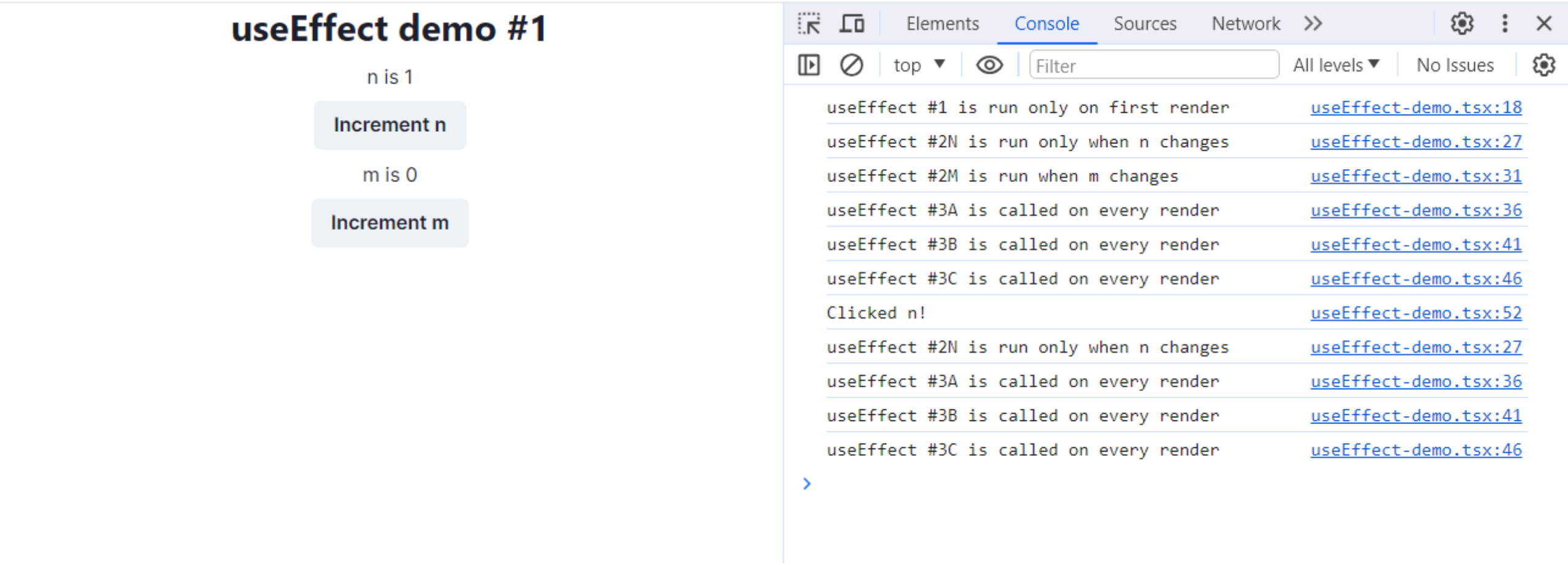
```
    function onClickN() {
        console.log('Clicked n!');
        setN(n => n + 1);
    }

    function onClickM() {
        console.log('Clicked m!');
        setM(m => m + 1);
    }

    return (
        <VStack>
            <Heading>useEffect demo #1</Heading>
            <Text> n is {n} </Text>
            <Button onClick={onClickN}>Increment n</Button>
            <Text> m is {m} </Text>
            <Button onClick={onClickM}>Increment m</Button>
        </VStack>

}
```

Demo


useEffect demo #1
n is 1
Increment n
m is 0
Increment m
Elements
Console
Sources
Network
top
Filter
All levels
No Issues
useEffect #1 is run only on first render useEffect-demo.tsx:18
useEffect #2N is run only when n changes useEffect-demo.tsx:27
useEffect #2M is run when m changes useEffect-demo.tsx:31
useEffect #3A is called on every render useEffect-demo.tsx:36
useEffect #3B is called on every render useEffect-demo.tsx:41
useEffect #3C is called on every render useEffect-demo.tsx:46
Clicked n! useEffect-demo.tsx:52
useEffect #2N is run only when n changes useEffect-demo.tsx:27
useEffect #3A is called on every render useEffect-demo.tsx:36
useEffect #3B is called on every render useEffect-demo.tsx:41
useEffect #3C is called on every render useEffect-demo.tsx:46

When is the cleanup function executed?

- In general, the cleanup function is executed sometime before the next time the hook is run.
- For the first-time-only case, this means when the component is dismounted.
- Let's look at useEffect demo again, this time with noisy cleanups.

src/app/Apps/useEffect-demoWithCleanUps.tsx

```
function cleanup(message: string) {return () => {console.log('cleanup: ' + message)}}

export default function App() {
    const [n, setN] = useState(0)
    const [m, setM] = useState(0)

    useEffect(() => {
        console.log('useEffect #1 is run only on first render')
        return cleanup('useEffect #1')
    }, [])

    useEffect(() => {
        console.log('useEffect #2N is run only when n changes')
        return cleanup('useEffect #2N')
    }, [n])

    ... // other effects
```

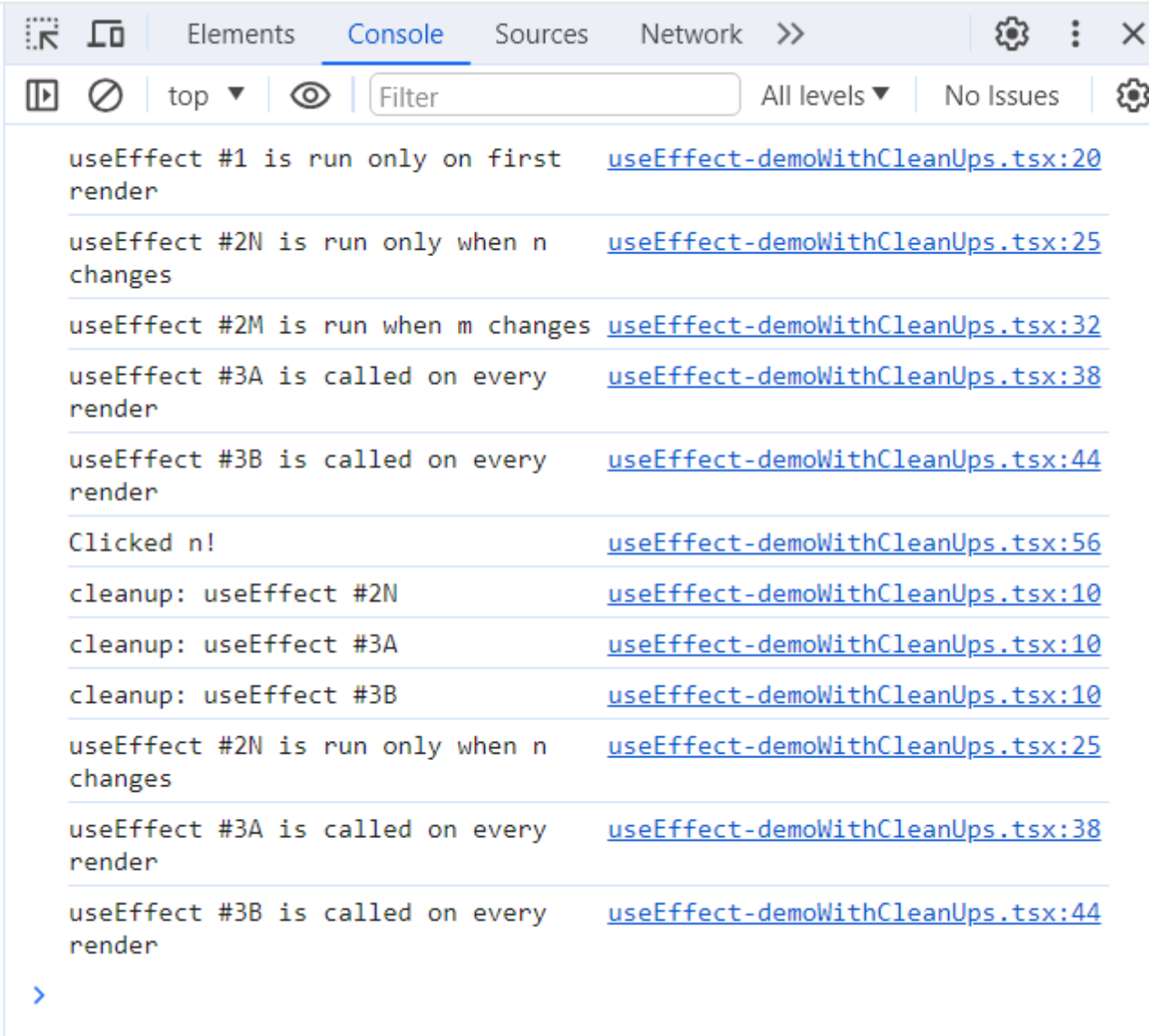
useEffect demo with CleanUps

n is 1

Increment n

m is 0

Increment m



Custom Hooks

- REACT lets us combine useState and useEffect to build custom hooks.

useFirstRender

src/app/Hooks/useFirstRender.tsx

Definition

```
import * as React from 'react';
import { useState, useEffect } from 'react'

export function useFirstRender(action:() => void) {
    useEffect(() => {
        action()
    }, [])
}
```

Use

```
 import { useFirstRender } from '../Hooks/useFirstRender’

   // illustration of useFirstRender
    useFirstRender(() => {
        console.log('useFirstRender #1 is run only on first render')
    })
```

src/app/Hooks/useClock.tsx

A more substantial example: useClock

```
import { useEffect } from 'react';
import SingletonClockFactory, { Clock } from '../Classes/ClockWithListeners';


export function useClock(listener1: () => void): Clock {
    const clock = SingletonClockFactory.instance(1000)
    useEffect(() => {
        clock.addListener(listener1)
        return () => {
            clock.removeListener(listener1)
        }
    }, []);
    return clock
}
```

app/Apps/SimpleClockDisplayWithUseClock.tsx

Using useClock

```
import { useClock } from '../Hooks/useClock';

export function ClockDisplay(props: {
    name: string, key: number,
    handleDelete: () => void, handleAdd: () => void,
    noisyDelete?: boolean

}) {
    const [localTime, setLocalTime] = useState(0)
    const incrementLocalTime = () => setLocalTime(localTime => localTime + 1)

    const clock = useClock(incrementLocalTime)


    return (
        <HStack>
            <Box>Clock: {props.name}</Box>
            <Box>Time = {localTime}</Box>
            <Box>nlisteners = {clock.nListeners}</Box>
            <IconButton --- />
            <IconButton --- />
        </HStack>
    )
```

The Rules of Hooks

1. Only call hooks at the top level
   - Not within loops, inside conditions, or nested functions
   - Rationale: The order of hooks called must always be the same each time a component renders
2. Only call hooks from React Components or Custom Hooks
   - Not from any other helper methods or classes
   - Rationale: React must know the component that the call to the hook is associated with

```
export function LikeButton(){
  const [isLiked, setIsLiked] = useState(false);
  const [count, setCount] = useState(0);
  ...
}
```

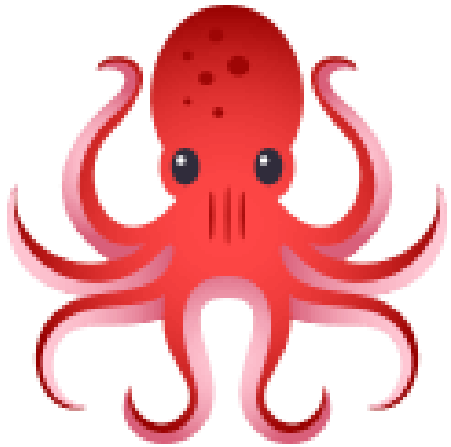
React knows which useState is which by tracking calls to them from components in the render tree

We Use Two ESLint Rules for React Hooks

- You should not violate the rules of hooks. These linter plugins help detect violations
- React-hooks/rules-of-hooks
  - Enforces that hooks are only called from React functional components or custom hooks
- React-hooks/exhaustive-deps
  - Enforces that all variables used in useEffects are included as dependencies

Testing React components

- Render components into a “virtual DOM”
  - Just like browser would, but no browser
- Interact with components by “firing events” like a user would
  - Click, enter text, etc. on DOM nodes, just like a user would in a browser
- Inspect components that are rendered
  - Tests specify how to “find” a component in that virtual DOM



“Testing Library”
https://testing-library.com
Compatible with many UI libraries and many testing frameworks

Write UI component tests just like any other test

Follow the generic testing model from Module 2:

- Assemble the situation:
  - Set up system under test (SUT) to get the state ready
  - [Optional: Prepare collaborators]
- Act - Apply the operation inputs.
- Assess - Check the outputs, verify the state change, handle the behavior

1: Render component into a testing DOM tree

2: Interact with the rendered component

3: Check the rendered result

Rendering Components in Virtual DOM

```
let deleteCalled = false;
beforeEach(() => {
  deleteCalled = false;
  render(
    <PersonalizedLikableDeletableHello name="Ripley"
      onDelete={() => { deleteCalled = true; }} /> );
});
```

- The *render* function prepares our component for testing:
  - Creates a virtual DOM
  - Instantiates our component, mounts it in DOM
  - Mocks all behavior of the core of React
  - Allows us to inspect the rendered result in the screen import

https://testing-library.com/docs/react-testing-library/api#render

Inspecting Rendered Components: By Text

```
test("It renders the greeting", ()=>{
  const greeting = screen.getByText(/Hello, Ripley!/);
  expect(greeting).toBeInTheDocument();
})
```

First approach to inspect rendered components: match by text

Acting on Rendered Components: *userEvent*

- Testing Library provides userEvent.<event> methods
  - ```
    userEvent.type(newItemTextField, "Write a better test input");
    userEvent.click(newItemButton);
    ```
    Also: change, keyDown, keyUp, etc
- These methods simulate user behavior:
  - Before clicking: MouseOver, MouseMove, MouseDown, MouseUp
  - `type` will click the (virtual) text box, then provide characters one-at-a-time
    ```

Inspecting Rendered Components: ARIA label

```
if (isLiked) {
  likeButton = (<IconButton aria-label="unlike"
      icon={<AiFillHeart />} onClick={() => setIsLiked(false)} /> );
} else {
  likeButton = (<IconButton aria-label="like"
      icon={<AiOutlineHeart />} onClick={() => setIsLiked(true)} /> );
}
```

Test

```
test("Like button defaults to not liked, clicking it likes, clicking again
unlikes", () => {
  const likeButton = screen.getByLabelText("like");
  fireEvent.click(likeButton);
  const unLikeButton = screen.getByLabelText("unlike");
  fireEvent.click(unLikeButton);
  expect(screen.getByLabelText("like")).toBeInTheDocument();
});
```

3 Tiers for Inspecting Rendered Components

- Queries that reflect how every user interacts with your app
  - byRole – Using accessibility tree
  - byLabelText – Using label on form fields
  - byPlaceHolderText – Using placeholder text on form field
  - byText – By exact text in an element
  - byDisplayValue – By current value in a form field
- Queries that reflect how *some* users interact with your app
  - byAltText – By alt text, usually not presented to sighted users
  - byTitle - By a “title” attribute, usually not presented to sighted users
- Queries that have nothing to do with how a user interacts with app
  - byTestId

More: https://testing-library.com/docs/queries/about

But wait, there's more…

- You may want different behavior when there are different numbers of matches to a query.
- Testing-library includes a query called Find, which is *async* and will return a promise to wait for all rendering to complete

https://testing-library.com/docs/react-testing-library/cheatsheet

Learning Objectives for this Lesson

- By the end of this lesson, you should be able to:
  - Explain the basic use cases for useEffect
  - Explain when a useEffect is executed, and when its return value is executed
  - Construct simple custom hooks and explain why they are useful.
  - Be able to explain the three core steps of a test (assemble, act, assess) can map to UI component testing