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

Adeel Bhutta and Mitch Wand

Khoury College of Computer Sciences

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: a display that connects to a self-ticking clock

src/Components/ClockDisplay.tsx

```
export default function ClockDisplay(props: {
    name: string, key: number,
    clock:IClock,
    handleDelete: () => void,
    handleAdd: () => void,
})
    {
    const [localTime, setLocalTime] = useState(0)
    const incrementLocalTime = () => setLocalTime(localTime => localTime + 1)
    const clock = props.clock

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

The parent provides the clock

On first render, add this listener to the clock

On dismount, remove the listener.

Display logic will come later…

src/Apps/ThreeClocks/App.tsx

Our app will have three displays of the clock

```
import * as React from 'react'; import { useState } from 'react';
import ClockDisplay from '../../Components/ClockDisplay'
import SingletonClock from '../../Classes/SingletonClockFactory'
function doNothing() { }

export default function App() {
  const [clock, _] = useState(SingletonClock.getInstance(1000));

  return (
    <VStack>
      <ClockDisplay key={1} name={"Clock A"} clock={clock}
        handleAdd={doNothing}handleDelete={doNothing}
      />
      <ClockDisplay key={2} name={"Clock B"} clock={clock}
        handleAdd={doNothing} handleDelete={doNothing}
      />
      <ClockDisplay key={3} name={"Clock C"} clock={clock}
        handleAdd={doNothing} handleDelete={doNothing}
      />
    </VStack>
  );
}
```

src/Classes/SingletonClockFactory.ts

Next, let's look at the clock

```
type Listener = () => void

class Clock implements IClock{

    private _listeners: Listener[] = []
    private _notifyAll() {this._listeners
       .forEach(eachListener => {eachListener()})}

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

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

    private _timer : NodeJS.Timeout
    private _interval : number
    public id : string

    public constructor(interval: number) {
        this.id = nanoid(4)
        this._interval = interval;
        this.start()
    }

    public start() {
        this._timer = setInterval(() => {
            this._tick();
        }, this._interval);

    }

    private _tick() {
        this._notifyAll();
        }

    public stop() {
        console.log(`Clock ${this.id} stopping`)
        clearInterval(this._timer);

    }

}
```

We’ll make the clock a singleton in the usual way

src/Classes/SingletonClockFactory.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

Let's look at <ClockDisplay> again

```
export default function ClockDisplay(props: {
  name: string; key: number;  clock: IClock;
  handleDelete: () => void;  handleAdd: () => void;
}): JSX.Element {
  const [localTime, setLocalTime] = useState(0);
  const incrementLocalTime = () => { setLocalTime((localTime) => localTime + 1); };

  const listener1 = () => { incrementLocalTime(); };
  const clock = props.clock;

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

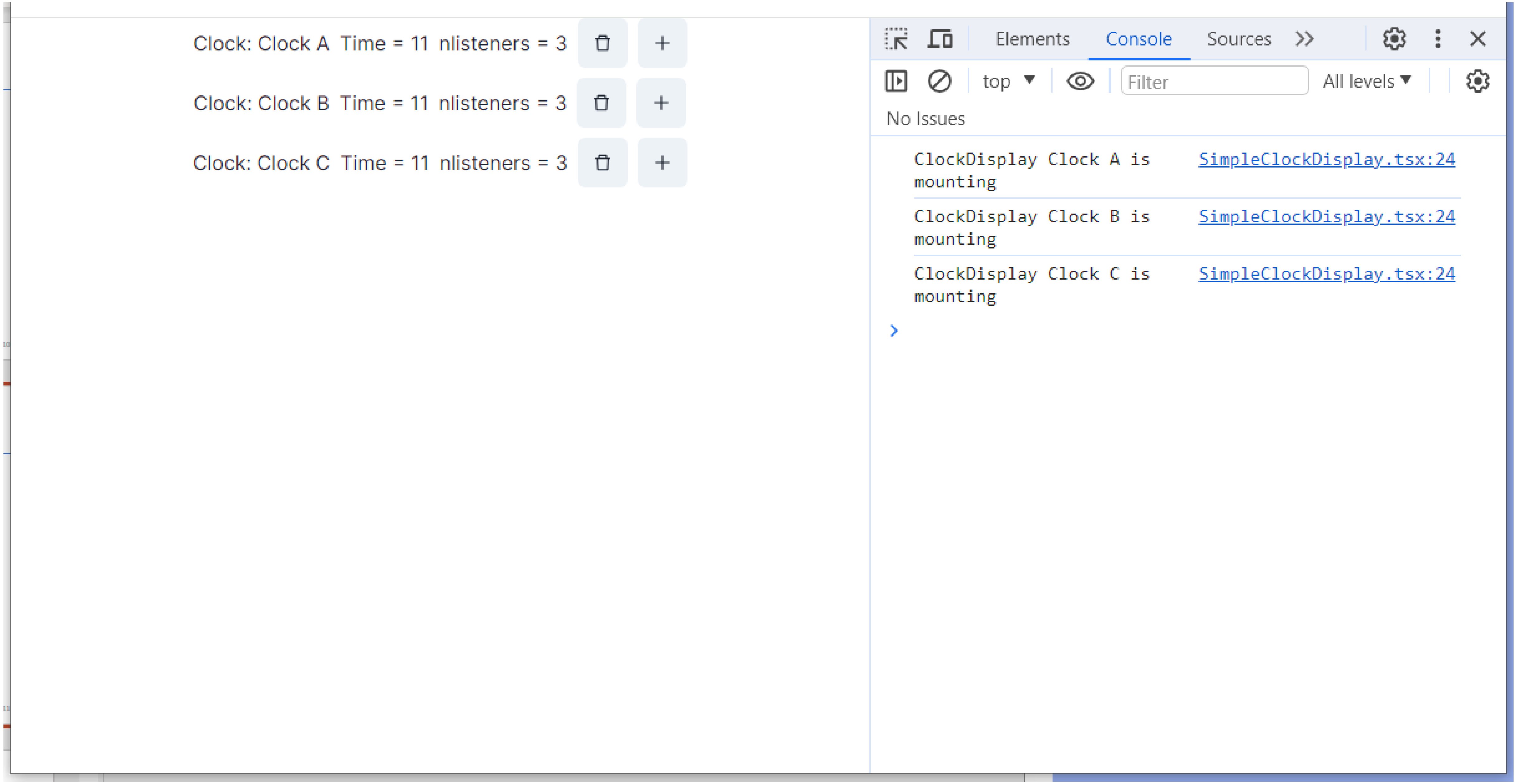
business logic

ClockDisplay, part 2: the display logic

```
function handleStop() { clock.stop(); }
function handleStart() { clock.start(); }
```

```
return (
  <HStack>
    <Box>Clock: {props.name}</Box>
    <Box>Clock ID: {clock.id} </Box>
    <Box>Time = {localTime}</Box>
    <Box>nlisteners = {clock.nListeners}</Box>
    <Button aria-label={"start"} onClick={handleStart}>Start</Button>
    <Button aria-label={"stop"} onClick={handleStop}>Stop</Button>
    <IconButton aria-label={"delete"} onClick={props.handleDelete}
                icon={<AiOutlineDelete />}
    />
    <IconButton aria-label={"add"} onClick={props.handleAdd}
                icon={<AiOutlinePlus />}
    />
  </HStack>
);
```

display logic



Clock: Clock A Time = 11 nlisteners = 3

Clock: Clock B Time = 11 nlisteners = 3

Clock: Clock C Time = 11 nlisteners = 3

```
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/Apps/useEffect-demo.tsx

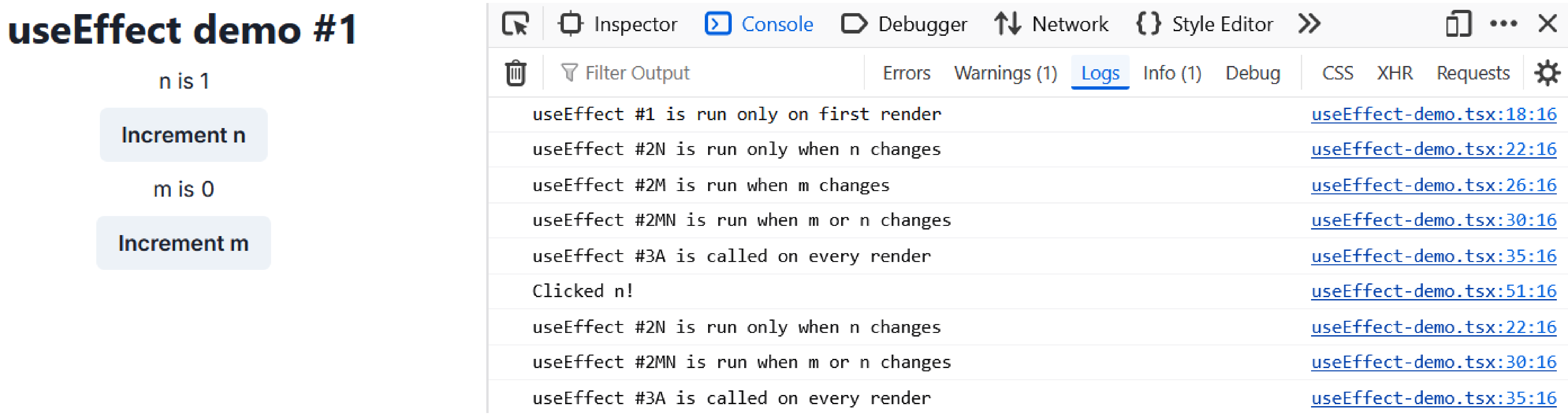
Example (Part 1)

```
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 when n or m changes
    useEffect(() => {
        console.log('useEffect #2MN is run when m or n changes’)}, [m,n])

    // 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 #1 is run only on first render           useEffect-demo.tsx:18:16
useEffect #2N is run only when n changes           useEffect-demo.tsx:22:16
useEffect #2M is run when m changes                useEffect-demo.tsx:26:16
useEffect #2MN is run when m or n changes          useEffect-demo.tsx:30:16
useEffect #3A is called on every render            useEffect-demo.tsx:35:16
Clicked n!                                         useEffect-demo.tsx:51:16
useEffect #2N is run only when n changes           useEffect-demo.tsx:22:16
useEffect #2MN is run when m or n changes          useEffect-demo.tsx:30:16
useEffect #3A is called on every render            useEffect-demo.tsx:35:16
```

When is the cleanup function executed?

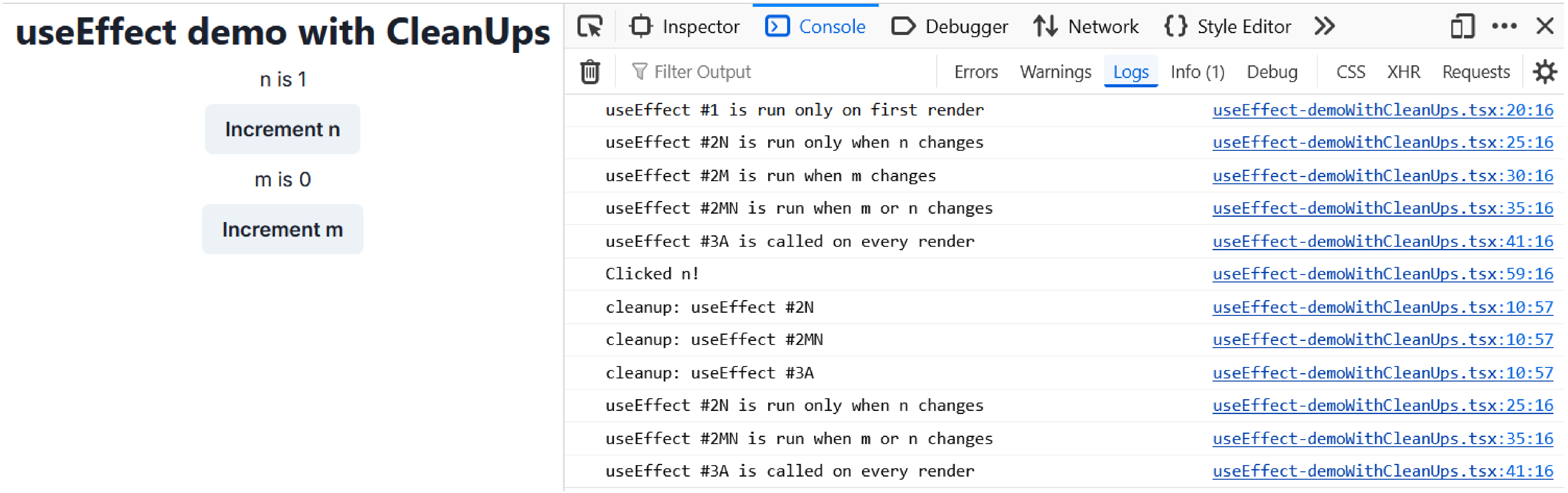
- In general, the cleanup function is executed sometime before the next time the hook is run.
- For the first-time-only case, this means when the component is dismounted.
- Let's look at useEffect demo again, this time with noisy cleanups.

Example

src/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
```

Demo



```
useEffect #1 is run only on first render          useEffect-demoWithCleanUps.tsx:20:16
useEffect #2N is run only when n changes          useEffect-demoWithCleanUps.tsx:25:16
useEffect #2M is run when m changes               useEffect-demoWithCleanUps.tsx:30:16
useEffect #2MN is run when m or n changes         useEffect-demoWithCleanUps.tsx:35:16
useEffect #3A is called on every render           useEffect-demoWithCleanUps.tsx:41:16
Clicked n!                                        useEffect-demoWithCleanUps.tsx:59:16
cleanup: useEffect #2N                            useEffect-demoWithCleanUps.tsx:10:57
cleanup: useEffect #2MN                           useEffect-demoWithCleanUps.tsx:10:57
cleanup: useEffect #3A                            useEffect-demoWithCleanUps.tsx:10:57
useEffect #2N is run only when n changes          useEffect-demoWithCleanUps.tsx:25:16
useEffect #2MN is run when m or n changes         useEffect-demoWithCleanUps.tsx:35:16
useEffect #3A is called on every render           useEffect-demoWithCleanUps.tsx:41:16
```

Custom Hooks

- REACT lets us combine useState and useEffect to build custom hooks.
- Custom Hooks let us separate business logic from display logic

Example: useClock

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

src/Components/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:IClock = useClock(incrementLocalTime)

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

}
```

src/Apps/ToDoAppOld/App.tsx

A somewhat larger example: ToDoList

```
export default function ToDoApp () {
  const [todoList,setTodolist] = useState<ToDoItem[]>([])
  const [itemKey,setItemKey] = useState<number>(0)   // first unused key

  function handleAdd (title:string, priority:string) {
    if (title === '') {return}   // ignore blank button presses
    setTodolist(todoList.concat({title: title, priority: priority, key: itemKey}))
    setItemKey(itemKey + 1)
  }

  function handleDelete(targetKey:number) {
    const newList = todoList.filter(item => item.key != targetKey)
    setTodolist(newList)
  }

  return (
  <VStack>
    <Heading>TODO List</Heading>
    <ToDoItemEntryForm onAdd={handleAdd}/>
    <ToDoListDisplay items={todoList} onDelete={handleDelete}/>
  </VStack>
  )
}
```

business logic

display logic

src/Apps/ToDoAppWithCustomHooks/App.tsx

Refactoring ToDoList

```
export default function ToDoApp () {

  const {todoList, handleAdd, handleDelete} = useToDoItemList()


  return (
  <VStack>
    <Heading>TODO List</Heading>
    <ToDoItemEntryForm onAdd={handleAdd}/>
    <ToDoListDisplay items={todoList} onDelete={handleDelete}/>
  </VStack>
  )
}
```

business logic
is encapsulated

src/Apps/ToDoAppWithCustomHooks/useToDoItemList.tsx

The hook encapsulates the business logic

```
export default function useToDoItemList () {
  const [todoList,setTodolist] = useState<ToDoItem[]>([])
  const [itemKey,setItemKey] = useState<number>(0)   // first unused key

  function handleAdd (title:string, priority:string) {
    if (title === '') {return}   // ignore blank button presses
    setTodolist(todoList.concat({title: title, priority: priority, key: itemKey}))
    setItemKey(itemKey + 1)
  }

  function handleDelete(targetKey:number) {
    const newList = todoList.filter(item => item.key != targetKey)
    setTodolist(newList)
  }

  return {todoList: todoList, handleAdd: handleAdd, handleDelete: handleDelete}
}
```

The hook is like a class managing a piece of state

```
export default function useToDoItemList () {
  const [todoList,setTodolist] = useState<ToDoItem[]>([])
  const [itemKey,setItemKey] = useState<number>(0)   // first unused key

  function handleAdd (title:string, priority:string) {
    if (title === '') {return}   // ignore blank button presses
    setTodolist(todoList.concat({title: title, priority: priority, key: itemKey}))
    setItemKey(itemKey + 1)
  }

  function handleDelete(targetKey:number) {
    const newList = todoList.filter(item => item.key !== targetKey)
    setTodolist(newList)
  }

  return {todoList: todoList, handleAdd: handleAdd, handleDelete: handleDelete}
}
```

handleAdd and handleDelete are the only methods for manipulating the state

The hook's state becomes part of its user's state.

```
export default function useToDoItemList () {
  const [todoList,setTodolist] = useState<ToDoItem[]>([])
  const [itemKey,setItemKey] = useState<number>(0)   // first unused key

  function handleAdd (title:string, priority:string) {
    if (title === '') {return}   // ignore blank button presses
    setTodolist(todoList.concat({title: title, priority: priority, key: itemKey}))
    setItemKey(itemKey + 1)
  }

  function handleDelete(targetKey:number) {
    const newList = todoList.filter(item => item.key != targetKey)
    setTodolist(newList)
  }

  return {todoList: todoList, handleAdd: handleAdd, handleDelete: handleDelete}
}
```

calling these setters redisplays the whole component

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

- The AAA pattern ("Assemble/Act/Assess") still applies
- Need a test double for the React system
  - render components into a "virtual dom" or into a captive web browser
- The FakeStackOverflow codebase uses Cypress, a popular tool for end-to-end testing.

"Testing Library" https://testing-library.com is another test system for React. It is compatible with many UI libraries and many testing frameworks

Most tests are in AAA form: Assemble/Act/Assess

```
test('addStudent should add a student to the data
    // const db = new DataBase ()
    expect(db.nameToIDs('blair')).toEqual([])

    const id1 = db.addStudent('blair’);

    expect(db.nameToIDs('blair')).toEqual([id1])
  });
```

Assemble (and check that you’ve assembled it

Act (do the action that you are trying to test)

Assess: check to see that the response is correct

A typical cypress test

testing/cypress/e2e/addAnswer.cy.ts
(not in all branches)

```
it("5.1 | Created new answer should be displayed at the top of the answers page",
() => {
    const answers = [
      "Test Answer 1",
      A1_TXT,
      A2_TXT,
    ];
    cy.visit("http://localhost:3000");
    cy.contains(Q1_DESC).click();
    cy.contains("Answer Question").click();
    cy.get("#answerUsernameInput").type("joym");
    cy.get("#answerTextInput").type(answers[0]);
    cy.contains("Post Answer").click();
    cy.get(".answerText").each(($el, index) => {
      cy.contains(answers[index]);
    });
    cy.contains("joym");
    cy.contains("0 seconds ago");
  });
```

Assemble (and check that you've assembled it correctly)

Act (do the action that you are trying to test)

Assess: check to see that the response is correct

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