Review

Building Modern Web Applications - VSP2024

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HTML and CSS

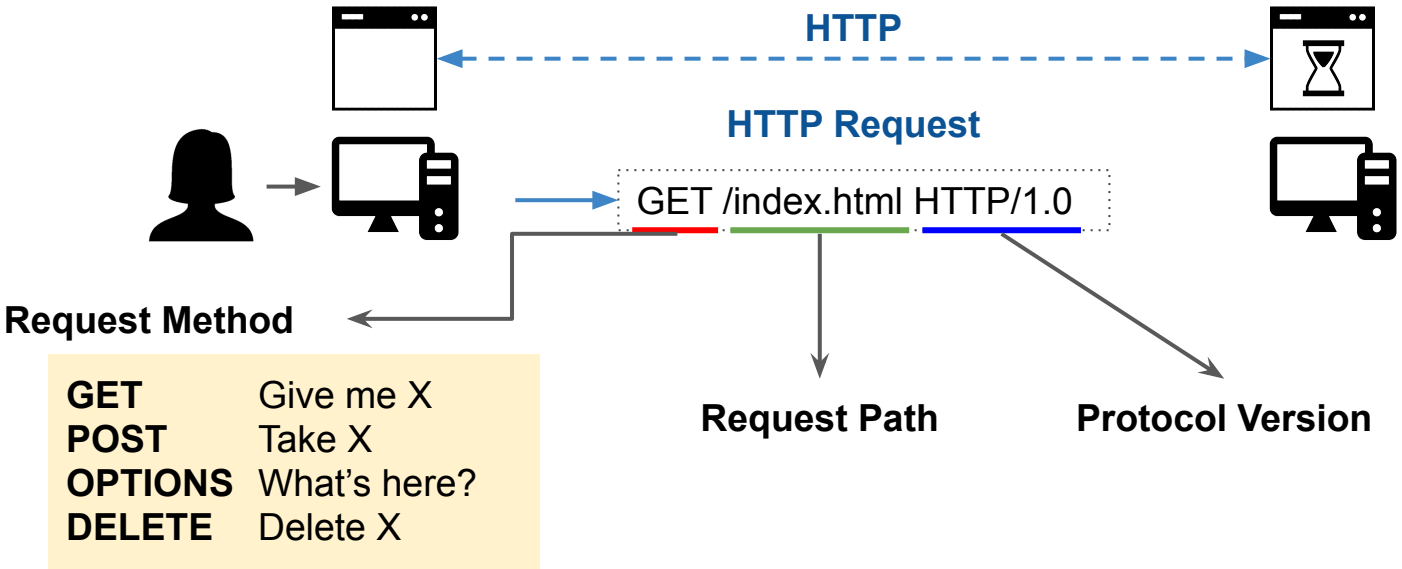
1. **HTML and CSS**
2. DOM and Events
3. JavaScript
    a. Callback and Closure
    b. ES6: Class, Arrow Functions, Promise
4. AJAX
5. Exam Logistics

Web Applications: What are they?

Desktop Application	Web Application
Connection to internet **not required**	Connection to internet **required**
Processing on **local device** only	Processing on **local device (client)** and **remote device (server)**
Software **delivered via storage medium**	Software **delivered via network**
Software **installed to the local OS**	Software **interpreted by the browser**
Can run on **local device** only	Can run **from any device**

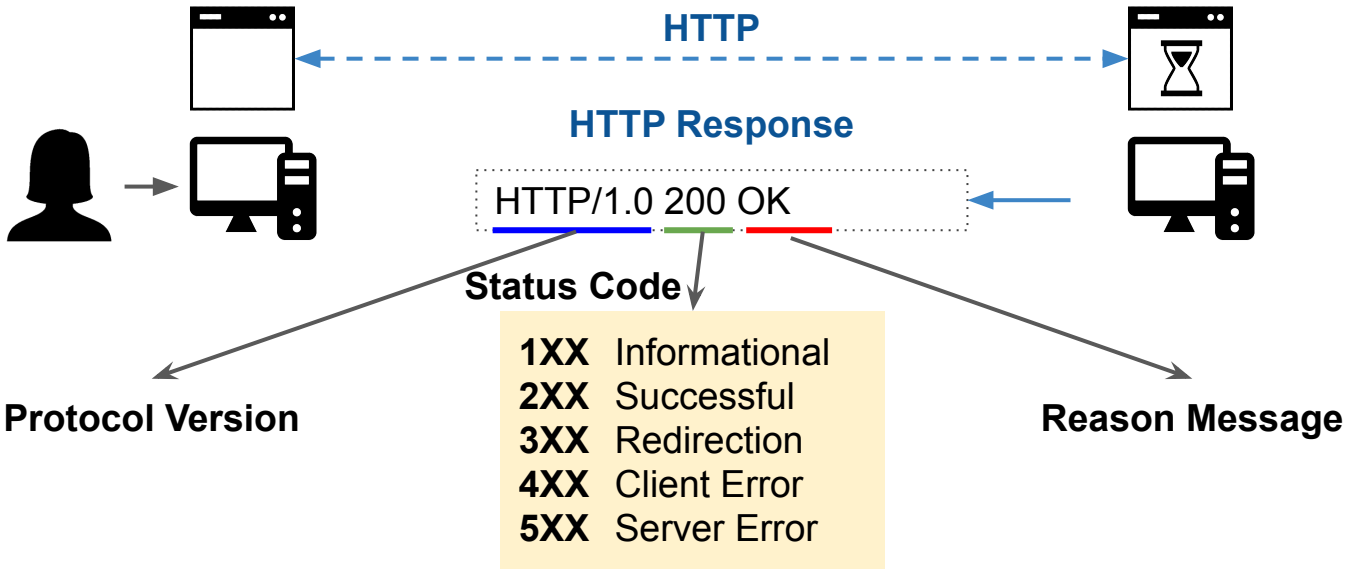
HTTP (HyperText Transfer Protocol)

- HTTP Request
  - Defines the message format a **client** should follow



HTTP (HyperText Transfer Protocol)

- HTTP Response
  - Defines the message format a **server** should follow



HTTP and HTML: The beginnings

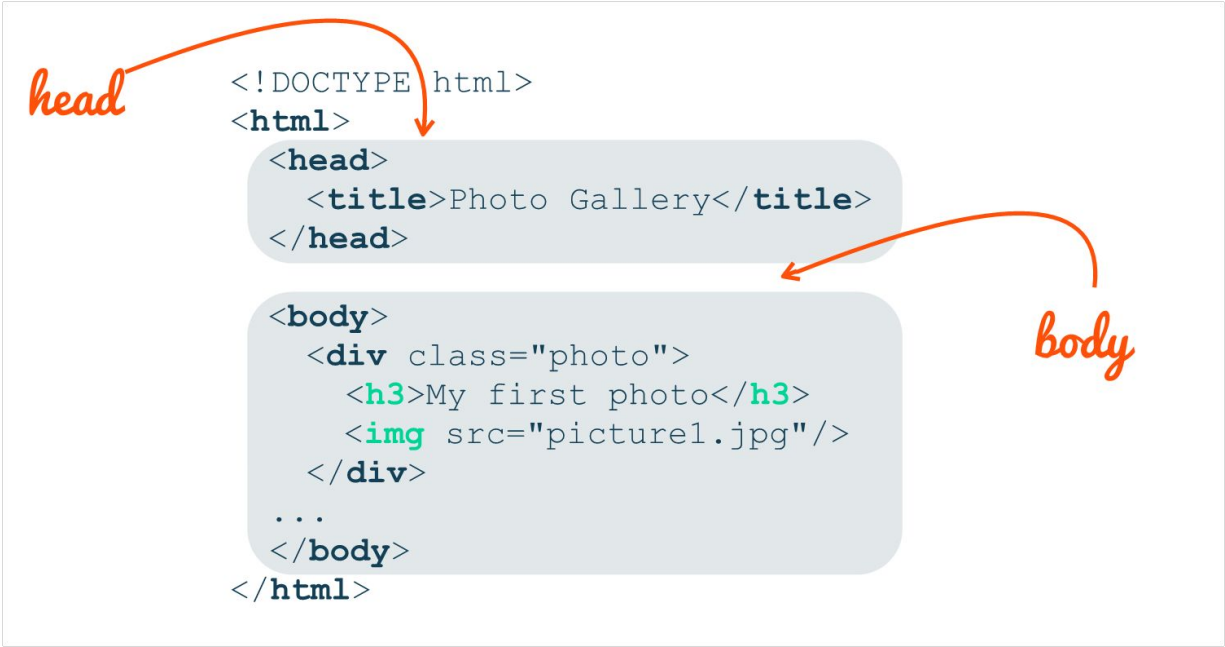
- **3 essential components** of a web application
  - **Server**: To "serve" the web-page and to send content to the client
  - **Client**: To receive content from the server and display them on the web browser window
  - **HTTP connection** for client-server interactions
- Everything else is optional

HTML (HyperText Markup Language)

- Hypertext Markup Language to describe the structure and contents of the initial page
  - **Hierarchical way to organize** documents and display them
  - **Combines semantics** (document structure) with **presentation** (document layout)
  - Allows tags to be interspersed with document content e.g., `<head>` - these are not displayed, but are directives to the layout engine
  - Also has **pointers to the JavaScript** code (e.g., `<script>`)
- Is retrieved by the browser and parsed into a tree called the Document Object Model (DOM)
  - Common way for elements to interact with the page
  - Can be read and modified by the JavaScript code
  - Modifications to the DOM are rendered by browser

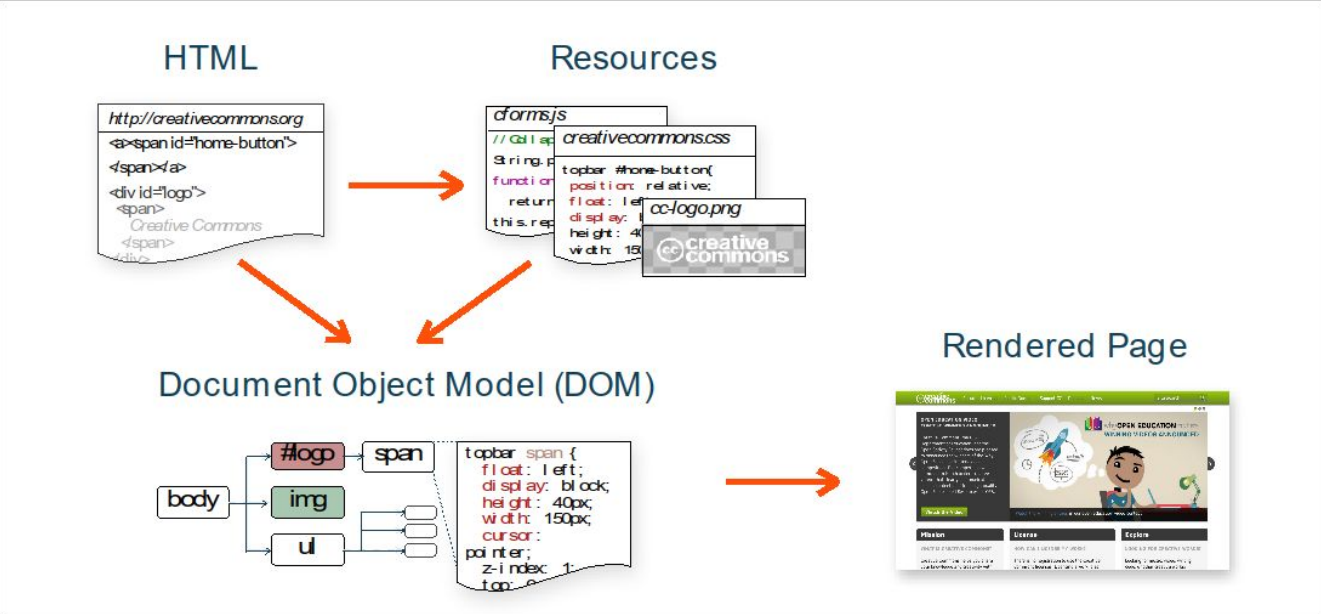
HTML (HyperText Markup Language)

Example:



HTML: Browser's View of HTML - DOM

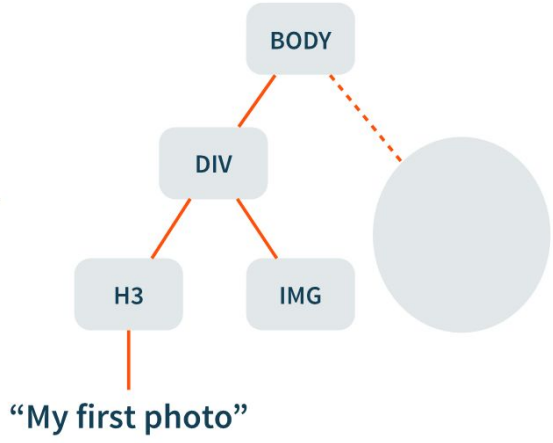
HTML is parsed by the browser into a tree structure - Document Object Model (DOM)



HTML: DOM Example

Often one-to-one correspondence between HTML and the DOM rendered by browser

```
<body>
  <div class="photo">
    <h3>My first photo</h3>
    <img src="picture1.jpg"/>
  </div>
...
</body>
```



CSS (Cascading Style Sheets)

- CSS **separate the content** of the page **from its presentation**
- Language for **specifying how** (HTML) **documents are presented** to users (separate from content)
- **Declarative** – set of rules and their actions
  - Makes it easy to modify and maintain the website
  - An element on LHS and action to apply on RHS
  - Ensure uniformity by applying the rule to all elements of the webpage in the DOM
  - Allows different rules to be specified for different display formats (e.g., printing versus display)

CSS: Inheritance

- All descendants of a DOM node inherit the CSS styles ascribed to it unless there is a "more-specific" CSS rule that applies to them
- Always apply style rules in top down order from the root of the DOM tree and overriding the rules as and when appropriate
    - Can be implemented with an in-order traversal

```
1 p {color:blue; text-decoration:underline}
2 strong {color:red}
```

```
1 <p>
2     <strong>C</strong>ascading
3     <strong>S</strong>tyle
4     <strong>S</strong>heets
5 </p>
```

Result:

CSS: Class and ID

- CSS rules can also apply to elements of a certain class or an element with a specific ID

```
.key {
  color: green;
}
```

```
#principal {
  font-weight: bolder;
}
```

```
<p class="key" id="principal">
```

CSS: Rules and Priority

- What to do when rules conflict with each other ?
  - Always apply the "most specific selector"
- "Most-specific" (‘>’ represents specificity):
  - Selectors with IDs > Classes > Tags
  - Direct rules get higher precedence over inherited rules (as before)

DOM and Events

1. HTML and CSS
2. **DOM and Events**
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Selecting HTML Elements

- With a specified `id`
- With a specified tag name
- With a specified `class`
- With generalized CSS selector

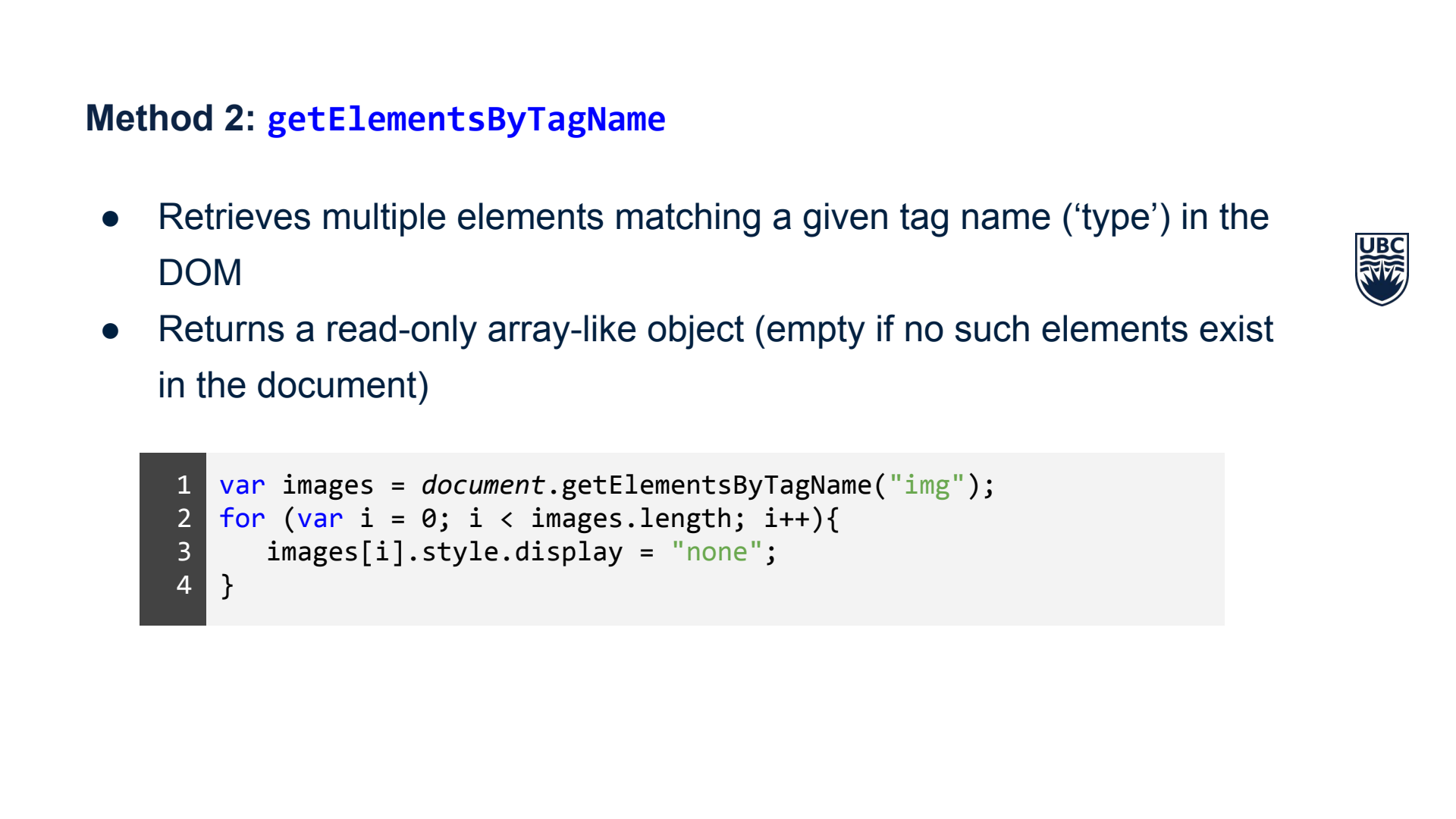
Method 1: `getElementById`

- Used to retrieve a single element from DOM
  - IDs are unique in the DOM (or at least must be)
  - Returns `null` if no such element is found

```
1 var id = document.getElementById("Section1");
2 if (id === null) throw new Error("No element found");
```

Method 2: `getElementsByTagName`

- Retrieves multiple elements matching a given tag name (‘type’) in the DOM
- Returns a read-only array-like object (empty if no such elements exist in the document)



```
1  var images = document.getElementsByTagName("img");
2  for (var i = 0; i < images.length; i++){
3     images[i].style.display = "none";
4  }
```

Method 3: `getElementsByClassName`

- Can also retrieve elements that belong to a specific CSS class
  - More than one element can belong to a CSS class


```
1 var warnings = document.getElementsByClassName("warning");
2 if (warnings.length > 0){
3    console.log("Found " + warnings.length + " elements");
4 }
```

Selecting Elements by CSS selector

- Can also select elements using generalized CSS selectors using `querySelectorAll()` method
  - Specify a selector query as argument
  - Query results are not "live" (unlike earlier)
  - Can subsume all the other methods
- `querySelector()` returns the first element matching the CSS query string, `null` otherwise

Invocation on DOM subtrees

- All of the above methods can also be invoked on DOM elements not just the document
  - Search is confined to subtree rooted at element
- Example: Assume element with `id="log"` exists

```
1 var log = document.getElementById("log");
2 var error = log.getElementsByClassName("error");
3 if (error.length === 0){ … }
4
```

Traversing the DOM

- Since the DOM is just a tree, you can walk it the way you'd do with any other tree
  - Typically using recursion
- Every browser has minor variations in implementing the DOM, so should not be sensitive to such changes
  - Traversing DOM this way can be fragile

Properties for DOM Traversal

- `parentNode`: Parent node of this one, or `null`
- `childNodes`: A read only array-like object containing all the (live) child nodes of this one
- `firstChild`, `lastChild`: The first and last child of a node, or `null` if it has no children
- `nextSibling`, `previousSibling`: The next and previous siblings of a node (in the order in which they appear in the document)

Other node properties

- `nodeType`: ‘kind of node’
  - Element node: 1
  - Text node: 3
  - Comment node: 8
  - Document node: 9
- `nodeValue`: Textual content of Text of comment node
- `nodeName`: Tag name of a node, converted to upper-case

Exercise: Find a Text Node

Solution:

```
1  function search(node, text){
2     if (node.nodeType === 3 && node.nodeValue === text){
3        return true;
4     }
5     else if (node.childNodes){
6        for (var i = 0; i < node.childNodes.length; i++){
7           var found = search(node.childNodes[i], text);
8           if (found) return found;
9        }
10    }
11    return false;
12 };
13 var result = search(window.document, "Hello world!");
```

Creating New and Copying Existing DOM Nodes

- Creating New DOM Nodes
  - Using either `document.createElement("element")` OR `document.createTextNode("text content")`

```
1 var newNode = document.createTextNode("hello");
2 var elNode = document.createElement("h1");
```

- Copying Existing DOM Nodes: use `cloneNode`
  - Single argument can be true or false
    - True: deep copy (recursively copy all descendants)
  - new node can be inserted into a different document

```
1 var existingNode = document.getElementById("my");
2 var newNode = existingNode.cloneNode(true);
```

Inserting Nodes

- `appendChild`: Adds a new node as a child of the node it is invoked on. node becomes `lastChild`
- `insertBefore`: Similar, except that it inserts the node before the one that is specified as the second argument (lastChild if it's `null`)


```
1 var s = document.getElementById("my");
2 s.appendChild(newNode);
3 s.insertBefore(newNode, s.firstChild);
```

Removing and replacing nodes

- Removing a node `n`: `removeChild`

```
1  n.parentNode.removeChild(n);
```

- Replacing a node `n` with a new node: `replaceChild`

```
1  var edit = document.createTextNode("[redacted]");
2  n.parentNode.replaceChild(edit, n);
```

DOM 2.0: addEventListener

- Used to add an Event handler to an element. Does NOT overwrite previous handlers
  - Arg1: Event type for which the handler is active
  - Arg2: Function to be invoked when event occurs
  - Arg3: Whether to invoke in the ‘capture’ phase of event propagation (more later) - false by default

```
1 var elem = document.getElementById("mybutton");
2 elem.addEventListener("click", function(event){
3    this.style.backgroundColor = "#fff";
4    return true;
5 });
```

DOM 2.0: addEventListener

- Does not overwrite previous handlers, even those set using `onclick`, `onmouseover` etc.
- Can be used to register multiple event handlers – invoked in order of registration (handlers set through DOM 1.0 model have precedence)

```
1  var elem = document.getElementById("mybutton");
2  elem.addEventListener("click", function(event){
3     alert("Hello");
4  });
5  elem.addEventListener("click", function(event){
6     alert("World");
7  });
```

DOM 2.0: removeEventListener

- Used to remove the event handler set by `addEventListener` functions, with the same arguments
  - No error even if the function was not set as event handler

```
1  var clickHandler = function(event){
2     alert("Clicked");
3  };
4  var elem = document.getElementById("mybutton");
5  elem.addEventListener("click", clickHandler);
6  elem.removeEventListener("click", clickHandler);
7
```

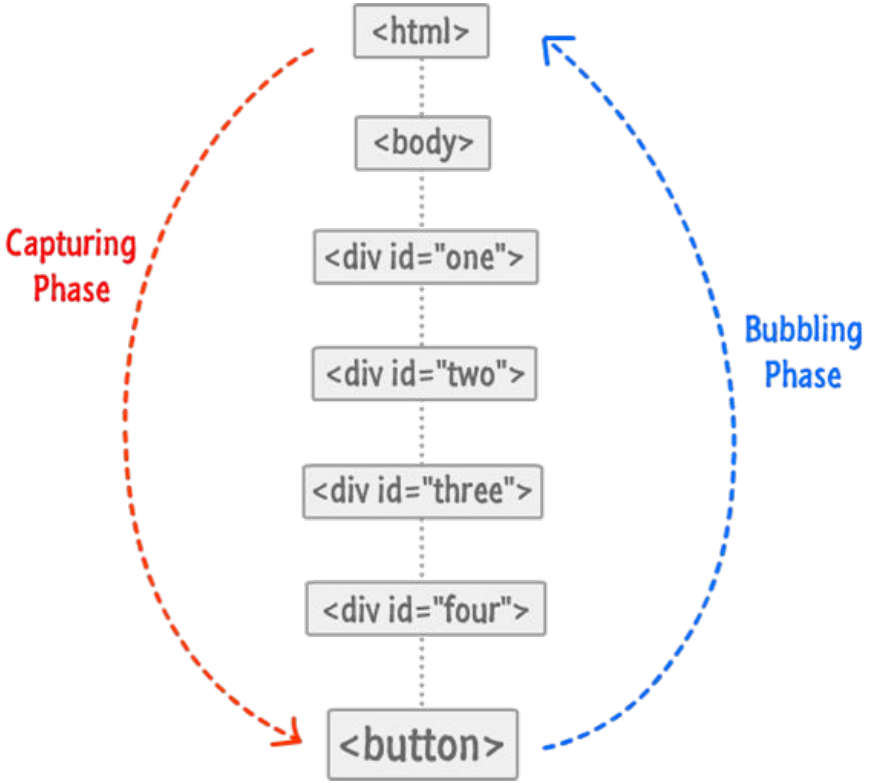
Event Handler Context

- Invoked in the context of the element in which it is set (`this` is bound to the target)
- Single argument that takes the `event` object as a parameter – different events have different properties, with info about the event itself
- Return value is discarded – not important
- Can access variables in the scope in which it is defined, as any other JS function
    - Can support closures within Event Handlers

Event Propagation

- Events triggered on an element propagate through the DOM tree in 2 consecutive phases
  - **Capture phase**: Event is triggered on the topmost element of the DOM and propagates down to the event target element
  - **Bubble phase**: Event starts from the event target element and ‘bubbles up’ the DOM tree to the top
- **Exception:** for the target element itself
  - For the target element itself, the W3C standards considers a **target phase**
  - All handlers registered for the target element are always registered for the target phase – the bubble/capture phase argument is ignored when registering handlers (see later)
  - Events may therefore trigger handlers on elements different from their targets

Capture and Bubble Phases



Event Propagation Setup

- To associate an event handler with the capture phase of event propagation, set the third parameter of `addEventListener` to `true`

```
1 var div1 = document.getElementById("one");
2 div1.addEventListener("click", handler, true);
```

- The default way of triggering event handlers is during the bubble phase (3rd argument is `false`)

Capture and Bubble Phases

```
1  var div1 = document.getElementById("one");
2  div1.addEventListener("click", handler1, true);
3  var div2 = document.getElementById("two");
4  div2.addEventListener("click", handler2, true);
```

Capture Phase

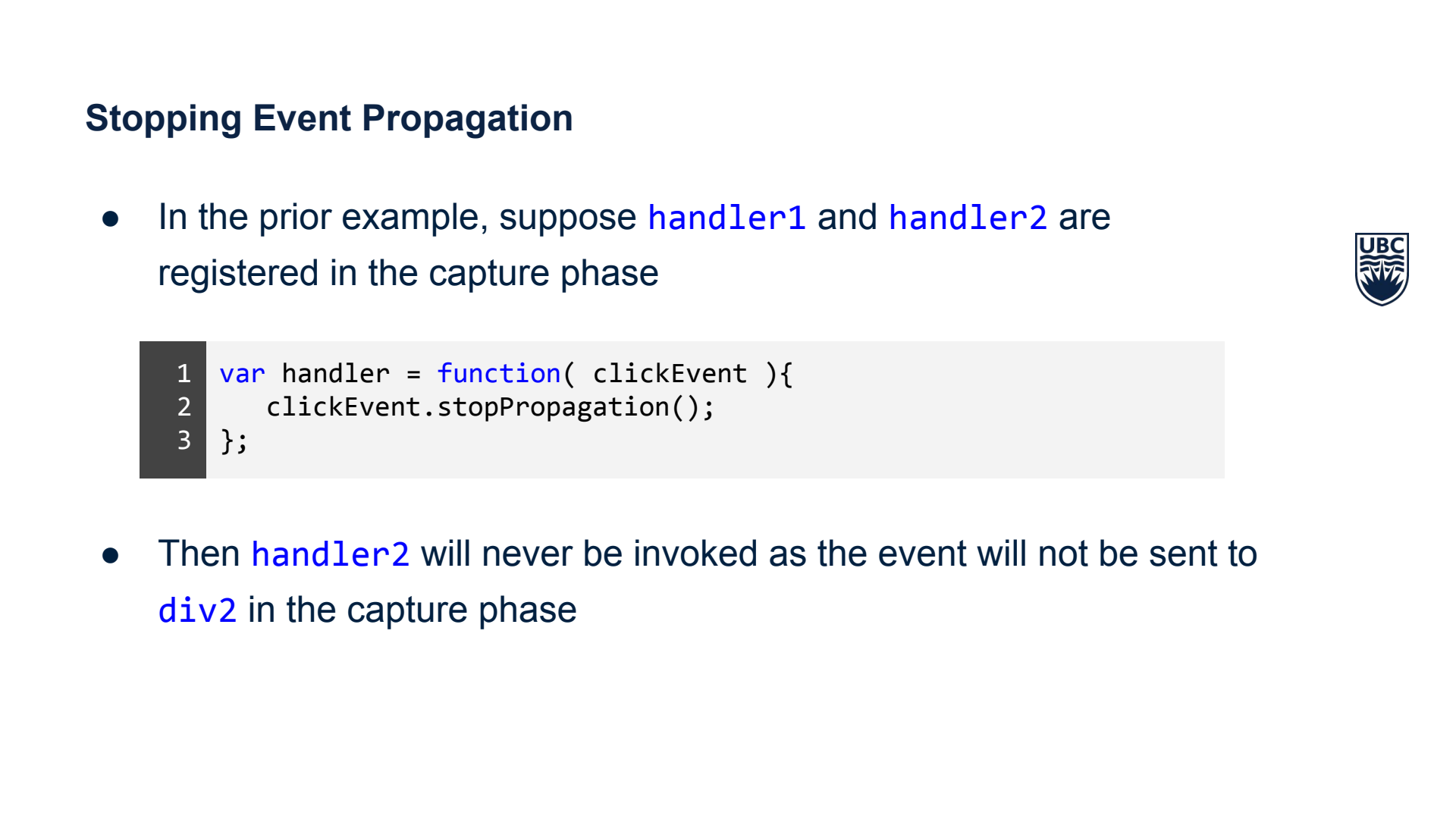
- Assume that the `<div>` element `'two'` is clicked.
- `handler1` is invoked before `handler2` as both are registered during the capture phase.

Bubble Phase

- Assume that the `<div>` element `'two'` is clicked.
- `handler2` is invoked before `handler1` as they are both registered during the bubble phase.

Stopping Event Propagation

- In the prior example, suppose `handler1` and `handler2` are registered in the capture phase



```
var handler = function( clickEvent ){
   clickEvent.stopPropagation();
};
```

- Then `handler2` will never be invoked as the event will not be sent to `div2` in the capture phase

Before accessing or manipulating the DOM...

Problem

- When your JS code executes, the page might not have finished loading
  - The DOM tree might not be fully instantiated / might change!

`window.onload`

- Event that gets fired when the DOM is fully loaded (we'll get back to events later...)
- You can give a callback function to execute upon proper loading of the DOM.
- Your DOM manipulation code should go inside that function

```
1 // Using DOM Level 1 API -- not recommended
2 window.onload = function(){ /* Access the DOM here */ }
```

JavaScript

1. HTML and CSS
2. DOM and Events
3. **JavaScript**
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Modern Browsers: JavaScript Execution Model

- Browser follows two phase execution model

Phase 1

- All code within the `<script></script>` tag is executed when they're loaded in the order of loading (unless the script tag is async or deferred)
- Some scripts may choose to defer execution or execute asynchronously. These are executed at the end of phase 1

Modern Browsers: JavaScript Execution Model

- Browser follows two phase execution model

Phase 2

- Waits for events to be triggered and executes handlers corresponding to the events in order of event execution (single-threaded model)
- Events can be of four kinds:
  - Load event: After page has finished loading (phase 1)
  - User events: Mouse clicks, mouse moves, form entry
  - Timer events: Timeouts, Interval
  - Networking: Async messages response arrives

Modern Browsers: window Object

- **Global object** that provides a gateway for almost all features of the web application
- Passed to standalone JS functions, and can be accessed by any function within the webpage
- Example Features
  - DOM: Through the `window.document` property
  - URL bar: Through `window.location` property
  - Navigator: Browser features, user agent etc.

Modern Browsers: window Object

- `alert`: Simple way to pop-up a dialog box on the current window with an OK button
  - Can display an arbitrary string as message
- `prompt`: Asks the user to enter a string and returns it
- `confirm`: Displays a message and waits for user to click OK or Cancel, and returns a boolean

```
1  do {
2     var name = prompt("What is your name?");
3     var correct = confirm("You entered: " + name);
4  } while (!correct);
5  // This is bad security practice - don't do this!
6  alert("Hello " + name);
```

Modern Browsers: window Object

- `setTimeout` is used to schedule a future event asynchronously once after a specified number of milliseconds (can be set to 0)
  - Can specify arguments to event handler
  - Can be cancelled using the `clearTimeout` method


```
1  var callback = function(){
2     alert("Hello");
3  }
4  var timer = setTimeout(callback, 1000);
5
6  clearTimeout(timer);
```

Modern Browsers: window Object

- `setTimeout` is used to schedule a future event asynchronously once after a specified number of milliseconds (can be set to 0)
  - Can specify arguments to event handler
  - Can be cancelled using the `clearTimeout` method
- `setInterval` has the same functionality as `setTimeout`, except that the event fires repeatedly until `clearInterval` is invoked

```
1  var count = 0;
2  var callback = function(){
3     alert("Hello " + (count++));
4  }
5  var timer = setInterval(callback, 1000);
6  clearInterval(timer);
```

Function: Variadic Function

- JavaScript functions **cannot be overloaded**
- To emulate function overloading, we can define a **variadic function** using the special `arguments` object

```
1  function sayHi (){
2     if (arguments.length < 3)
3        console.log("Hi " + arguments[0] + " " + arguments[1]);
4     else
5        console.log("Hi " + arguments[0] + " " + arguments[1] + " " +
6  arguments[2]);
7  };
8  sayHi("Alice", "Brown");  // prints: Alice Brown
```

TRY IT!

Function: Immediate Evaluation

- Function Expressions can be evaluated **immediately after definition**
  - Useful for capturing dynamic variables when creating a closure (coming up later)

```
1  var y = (function foo (x){
2     return x + 10;
3  })(1);
4
5  console.log(y);     // prints: 11
```

TRY IT!

Function: Nesting

- JavaScript functions can be nested arbitrarily

```
1  function alpha (x){
2     var i = x + x;
3     function bravo (y){
4        var j = y + i;
5        function charlie (z){
6           var k = z + j;
7           return k;
8        }
9        return charlie(j);
10    }
11    return bravo(i);
12 };
13
14 console.log(alpha(1));  // prints?
```

TRY IT!

Function: Scope

- A child function has access to its parent's **scope**

```
1  function alpha (x){
2     var i = x + x;
3     function bravo (y){
4        i = y + y;
5        console.log(i);    // prints: 4
6     }
7     bravo(i);
8     console.log(i);       // prints: 4
9  };
10
11 alpha(1);
12
13
14
```

TRY IT!

Function: Scope

- A parent function does not have access to its child's **scope**

```
1  function alpha (x){
2     var i = x + x;
3     function bravo (y){
4        var j = y + y;
5        console.log(i);    // prints: 2
6     }
7     bravo(i);
8     console.log(j);       // throws: ReferenceError: j is not defined
9  };
10
11 alpha(1);
12
13
14
```

TRY IT!

Function: First-Class Objects

- Functions can be passed to other functions as arguments

```
1  function filter (list, f){
2     var arr = [];
3     for (var i = 0; i < list.length; i++){
4        if (f(list[i]) === true) arr.push(list[i]);
5     }
6     return arr;
7  };
8
9  var myList = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9];
10 var filtered = filter(myList, function (item){
11    return (item < 5);
12 });
13 console.log(filtered);     // prints: 0, 1, 2, 3, 4
14
```

TRY IT!

JavaScript: Callback and Closure

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Callback Function

- Callback functions are just regular functions, used in a certain way
  - They are not some special function type
- Used for performing **asynchronous operations**
  - JavaScript applications are **full of asynchronous operations**, so callbacks are used very frequently
  - Most notable examples are **event listeners**
- Why use callbacks?
  - Some operations are **fundamentally asynchronous** (e.g., network requests)
  - We **don’t want to wait for result indefinitely**. We would rather get a **call back** when something is done.

Callback Function

```
1  function asyncFunction (arg1, arg2, callback){
2     /*
3        do some asynchronous operations
4      */
5        callback(result);    // invoke callback when result is available
6     return null             // return immediately
7  };
8
9  asyncFunction(val1, val2, function(result){
10    /* do something with result */
11 });                        // this call returns null immediately
12
13 /* do other things */
14
```

Closure Function

- Closure functions are just regular functions, used in a certain way
  - They are not some special function type
- Closures are functions that carry references outside of their own scope
  - Used to hide objects while still providing the functionality
  - Used to create stateful functions

Closure Function

```
1  function makeCounter (initial, increment){
2     var count = initial;
3     return function next(){
4        count += increment;
5        return count;
6     }
7  };
8  var counter1 = makeCounter(3, 1);
9  var counter2 = makeCounter(5, 5);
10 console.log(counter1());          // prints: 4
11 console.log(counter2());          // prints: 10
12 console.log(counter1());          // prints: 5
13 console.log(counter2());          // prints: 15
```

TRY IT!

Closure Function

```
1  function makeCounters (n){
2     var counts = [];
3     var counters = [];
4     for (var i = 0; i < n; i++){
5        counts[i] = 0;
6        counters[i] = function next(){
7           counts[i] ++;
8           return counts[i];
9        };
10    }
11    return counters;
12 };
13
14 var cs = makeCounters(10);
15 console.log( cs[0]() );      // prints?
16 console.log( cs[4]() );      // prints?
```

Closure Function

```
1  function makeCounters (n){
2     var counts = [];
3     var counters = [];
4     for (var i = 0; i < n; i++){
5        counts[i] = 0;
6        counters[i] = function next(){
7           counts[i] ++;
8           return counts[i];
9        };
10    }
11    return counters;
12 };
13
14 var cs = makeCounters(10);
15 console.log( cs[0]() );      // prints: NaN
16 console.log( cs[4]() );      // prints: NaN
```

Closure Function

```
1  function makeCounters (n){
2     var counts = [];
3     var counters = [];
4     for (var i = 0; i < n; i++){
5        counts[i] = 0;
6        counters[i] = (function (j){
7           return function next(){
8              counts[j] ++;
9              return counts[j];
10          };
11       })(i);
12    }
13    return counters;
14 };
15
16 var cs = makeCounters(10);
```

JavaScript: ECMAScript 2015 (ES6)

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4. AJAX and Node.js
5. Session, Cookie, and Web Security
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Object-oriented Programming

`this` keyword

- `this` refers to the object on which the function is called

```
1  function accelerate (fuel){
2    this.velocity += fuel * this.power;
3  }
4  var myCar = {
5    name: "Smart",
6    power: 1,
7    velocity: 0,
8    accelerate: accelerate
9  }
10 myCar.accelerate(10);
11 accelerate(12);         // What is "this"?
```

Object-oriented Programming

`this` keyword

- Function objects have a method called `bind`, which can be used to "lock" what `this` refers to

```
1  function accelerate (fuel){
2    this.velocity += fuel * this.power;
3  }
4  var myCar = {
5    name: "Smart",
6    power: 1,
7    velocity: 0,
8    accelerate: accelerate
9  }
10 myCar.accelerate(10);
11 accelerate.bind(myCar)(12);        // What is "this"?
```

Object-oriented Programming

`class` and `constructor` keyword

```
1  class Car {
2    constructor (name, power=1){
3      this.name = name;
4      this.power = power;
5      this.velocity = 0;
6    }
7    accelerate (fuel){
8      this.velocity
9        += fuel * this.power;
10   }
11 }
12
13 var myCar = new Car("Smart");
14 myCar.accelerate(10);
```

Object-oriented Programming

`extends` and `super` keyword

```
1  class RacingCar extends Car {
2    constructor (name){
3      super(name, 3.5);
4    }
5
6    turbo (fuel){
7      this.velocity += fuel * this.power * 1.5;
8    }
9
10 }
11
12 var superCar = new RacingCar("F1");
13 superCar.accelerate(10);
14 superCar.turbo(5);
```

Functional Programming

- JavaScript supports functional programming
- When used appropriately, `function`s can implement pure functions
  - Except it is not actually a pure function
  - Keywords like `this`, `arguments` make JavaScript functions impure
- ES6 introduces **arrow functions** to support real functional programming

Functional Programming

- Arrow functions are **not replacements** for ES5 functions
- Arrow functions are **anonymous functions**
- `this` and `arguments` inside arrow functions are lexically bound

Syntax Example:

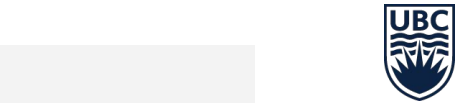
```
1  (radius, height) => {
2     return radius * radius * Math.PI * height;
3  }
4
5  (radius, height) => (radius * radius * Math.PI * height);
```

Functional Programming

- Pure functions
  - Always returns the same value given the same arguments
  - Have no side effects like mutating an external object (e.g., I/O, network resource, variables outside of its scope)
  - Examples:
    - area of circle, distance between 2 points in 3-dimensional space
- Impure functions
  - Might depend on an external context
  - Might change an external object
  - Examples:
    - `Date.now()`
    - `console.log()`

Functional Programming

- Arrow Function usage scenario



```
class Timer {
  constructor (){
    this.seconds = 0;
    this.reference = null;
  }
  start (){
    this.reference = setInterval(function(){
      this.seconds += 1;
    }, 1000);
  }
  stop (){
    clearInterval(this.reference);
  }
}
```

Functional Programming

- Arrow Function usage scenario


```
class Timer {
  constructor (){
    this.seconds = 0;
    this.reference = null;
  }
  start (){
    this.reference = setInterval(()=> {
      this.seconds += 1;
    }, 1000);
  }
  stop (){
    clearInterval(this.reference);
  }
}
```

What is a Promise

- Promise is a new built-in object **introduced in ES6**
- Provides a **cleaner interface** for handling **asynchronous operations**
- When multiple asynchronous operations need to be made, the **callback** pattern **becomes hard to follow**
  - Scope of variables in multiple nested closures
  - Error handling for each of the callback steps

Promise

- `Promise` is an object with the following methods
  - `then (onResolve, onReject)`: used to register resolve and reject callbacks
  - `catch (onReject)`: used to register reject callback
  - `finally (onComplete)`: used to register settlement callback
- `Promise` will be in one of the three states: pending, resolved, rejected
- `Promise` also has static methods
  - `resolve (value)`: returns a `Promise` that resolves immediately to `value`
  - `reject (error)`: returns a `Promise` that rejects immediately to `error`
  - `all (promises)`: returns a `Promise` that resolves when all promises resolve
  - `race (promises)`: returns a `Promise` that resolves if any of the promises resolve

Promise

- Creating a `Promise` object
  - `new Promise(func)`: The `Promise` constructor expects a single argument *`func`*, which is a function with 2 arguments: `resolve`, `reject`
  - `resolve` and `reject` are callback functions for emitting the result of the operation
    - `resolve(result)` to emit the result of a successful operation
    - `reject(error)` to emit the error from a failed operation

```
1  var action = new Promise((resolve, reject)=> {
2     setTimeout(()=> {
3        if (Math.random() > 0.5) resolve("Success!");
4        else reject(new Error("LowValueError"));
5     }, 1000);
6  });
7
```

Promise

- Using the result of a `Promise` fulfillment through the `then` method
  - `then(onResolve, onReject)`: used to register callbacks for handling the result of the `Promise`. It returns another `Promise`, making this function **chainable**
  - `onResolve` is called **if the previous `Promise` resolves**; it receives the resolved value as the only argument
  - `onReject` is called **if the previous `Promise` rejects** or **throws an error**; it receives the rejected value or the error object as the only argument

```
1  action.then(
2     (result)=> console.log(result), // result: "Success!"
3     (error)=> console.log(error)    // error: Error("LowValueError")
4  )
5  .then(()=> console.log("A"))
6  .then(()=> console.log("B"));
```

Promise

- The `catch` method is used to handle the result of a rejected `Promise`
  - `catch(onReject)`: used to register a callback for handling the result of the failed `Promise`. It returns another `Promise`, making this function **chainable**
  - `onReject` is called **if the previous `Promise` rejects** or **throws an error**; it receives the rejected value or the error object as the only argument

```
action.then(
   (result)=> console.log(result), // result: "Success!"
   (error)=> console.log(error)    // error: Error("LowValueError")
)
.catch((err)=> console.log(err));

```

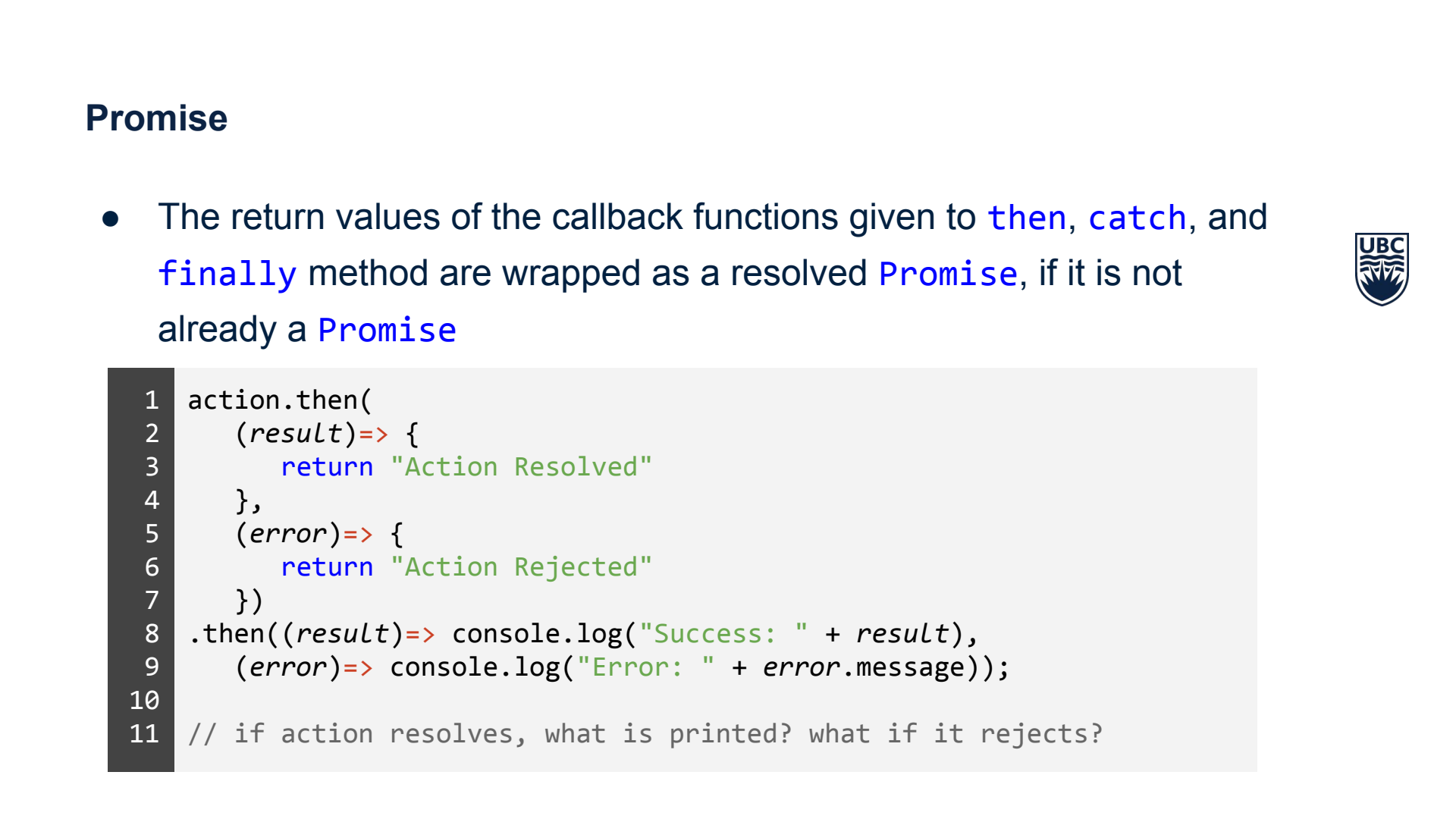
Promise

- The `finally` method is used to register a callback to be called when a `Promise` is settled, regardless of the result
  - `finally(onComplete)`: It returns another `Promise`, making this function **chainable**
  - `onComplete` is called **if the previous `Promise` is settled**


```
1  action.then(
2     (result)=> console.log(result), // result: "Success!"
3     (error)=> console.log(error)    // error: Error("LowValueError")
4  )
5  .catch((err)=> console.log(err))
6  .finally(()=> console.log("The End!"));
```

Promise

- The return values of the callback functions given to `then`, `catch`, and `finally` method are wrapped as a resolved `Promise`, if it is not already a `Promise`



```
action.then(
   (result)=> {
      return "Action Resolved"
   },
   (error)=> {
      return "Action Rejected"
   })
.then((result)=> console.log("Success: " + result),
   (error)=> console.log("Error: " + error.message));

// if action resolves, what is printed? what if it rejects?
```

AJAX and Node.js

1. HTML and CSS
2. DOM and Events
3. JavaScript
    a. Callback and Closure
    b. ES6: Class, Arrow Functions, Promise
4. **AJAX**
5. Session, Cookie, and Web Security
6. Exam Logistics

What is AJAX?: Usage

- Interactivity
  - To enable content to be brought in from the server in response to user requests
- Performance
  - Load the most critical portions of a web-page first, and then load the rest asynchronously
- Security (this is doubtful)
  - Bring in only the code/data that is needed on demand to reduce the attack surface of the web application

XMLHttpRequest: Creating a Request

- `XMLHttpRequest`: Constructor function for supporting AJAX
- `open`: opens a new connection to the server using the specified method (GET or POST) and to the specified URL or resource


```
1  var req = new XMLHttpRequest();
2  req.open("GET", "/example.txt");
3
4
5
6
7
8
9
10
```

XMLHttpRequest: Sending the Request

- `send`: sends the data to the server asynchronously and returns immediately. Takes a single parameter for the data to be sent (can be omitted for GET)


```
1  var req = new XMLHttpRequest();
2  req.open("GET", "/example.txt");
3  req.send(null);    // or simply - req.send();
4  // Returns here right after the send is complete
5
6
7
8
9
10
```

XMLHttpRequest: Registering Callbacks

- Because the `send` returns right away, the data may not be sent yet (as it's sent asynchronously). Also, we have no way of knowing when the server has responded.
- We need to setup a callback to handle the various events that can occur after a send as the `onreadystatechange` function

```
1  var req = new XMLHttpRequest();
2  req.open("GET", "/example.txt");
3  req.onreadystatechange = function() {
4     // triggered whenever ready state changes
5  }
6  req.send(null);    // or simply - req.send();
7  // returns here right after the send is complete
8
```

XMLHttpRequest 2: Methods

- Events triggered by the XHR2 Model
  - Load: Response was received (does not mean that it was error-free, so still need to check status)
  - Timeout: Request timed out
  - Abort: Request was aborted
  - Error: Some other error occurred
  -


```
1  req.onload = function() {
2     if (req.status == 200){
3        // do something with req.responseText
4     }
5  }
```

Aborting Requests

- A request can be aborted after it is sent by calling the abort method on the request
- Request may have been already sent. If so, the response is discarded
- Triggers the Abort event handler of the request


```
1  req.onabort = function() {
2     console.log("Request aborted!");
3  }
4
5
```

Timeouts

- Can also specify timeouts in the request (though this is not supported by all browsers)
- Set timeout property in ms

```
1  req.timeout = 200;    // 200 ms timeout
2  req.ontimeout = function() {
3     console.log("Request timed out");
4  }
5
```

Errors

- These occur when there is a network level error (e.g., server is unreachable).
- Trigger the error event on the request
- NOT a substitute for checking status codes

```
1  req.onerror = function() {
2     console.log("Error occurred on request");
3  }
4
5
```

Exam Logistics

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4. AJAX
5. **Session, Cookie, and Web Security**
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Session: Why is it relevant to Web Applications?

- HTTP is stateless
  - One request-response pair has no information about another request-response pair
  - Server cannot tell if 2 requests came from the same browser → server cannot maintain stateful information about the client (e.g., how many times a client viewed a page)
- **Interaction** between 2 communicating parties (client & server) involving multiple messages **require** some **state to be maintained**

Cookie: What is it?

- Cookie is a piece of data that is always passed between the server and the client in consecutive HTTP messages
- At the minimum, a cookie can store a session ID to relate multiple HTTP requests and responses
- Mainly used for:
  - Session management
  - Personalization
  - Tracking User Behaviour

Cookie: Format

- Name: indicates the type of information
- Value: the data representing the information
- Attributes: set by server only
  - Domain: specifies the scope of the cookie
  - Path: which path the cookie is allowed to be sent to
  - Expires: when the cookie should expire
  - Max-Age: the maximum age for the cookie
  - Secure: enforce cookie to be sent only via https
  - HttpOnly: do not expose the cookie to application layer (e.g., JavaScript)

Web Security: Same-Origin Policy

- Same-Origin Policy says only scripts loaded from the same origin can be executed in the page
  - Enforced by all browsers
- Intent: Two different web domains should not be able to tamper with each other's contents
- Easy to state, but many exceptions in practice
  - Visual display is shared
  - Timing and DOM events are shared
  - Cookies can be shared
  - Send/receive messages for Cross-Origin Requests

Web Security: Cross-site Scripting

- Cross-site Scripting is executing a foreign (and malicious) piece of code as if it was included in the compromised webpage
- Somehow get the browser to execute a script with the permissions of the attacked domain
  - Non-persistent (disappears after page reloads)
  - Persistent (persists across page reloads)
- Most common method: somehow inject JavaScript code into a resource of the attacked domain so that the code executes with the authority of the parent and can access it

Web Security: Cross-site Scripting

Defense

- Sanitizing user input by checking for JS
  - Hard to do as JS code can be concealed in many ways (e.g., by escaping within HTML or CSS tags)
  - Performance overhead on the server for parsing inputs
- Lighter-weight but incomplete methods
  - Tying cookies to the IP address of the user logged in (works only for XSS attacks that try to steal cookies)
  - Disabling scripts on the page or in a specific section of the page (may prevent legit. scripts from running)
  - New method: Content security policy (allow servers to specify approved origins of content for web browsers) – not yet implemented in all browsers

Web Security: Cross-site Request Forgery

- An attacker attempts to request a URL sent to a user by spoofing it to their benefit
- Relies on the use of reproducible and guessable URLs (typically as parameters of GET requests)
- Cookies are automatically sent with every request, and hence the URL can perform malicious actions on behalf of the client
    - Do not require the server to accept/allow JavaScript code (unlike XSS attacks)

Web Security: Cross-site Request Forgery

Example

- Assume that a banking website allows money transfers using the following URL format http://bank.com/transfer.do?to=me&amt=100
- A malicious user can trick another user into clicking the URL (say through an email). If they have logged into the bank's website, then the request will execute with the privileges of the logged in user.
    - Relies on social engineering to carry out attack
    - Malicious URL can be hidden (e.g., in images)

Web Security: Cross-site Request Forgery

Defense

- Make the URL hard to guess by attaching a random nonce or client-specific key to it
  - Works only if nonce/key is not leaked, and is complex
- Things that don’t work, but are often deployed
  - Using POST instead of GET requests (pointless)
  - Using multi-step transactions (makes it harder for the attacker, but they can still forge the sequence)
  - Using a secret cookie (all related cookies will be submitted with every request, even the secret ones)

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Exam Logistics

Exam Format

1. Multiple Choice Questions - 15 Questions (20 minutes)
    a. Closed Book, Closed Notes
    b. Only your pencil and eraser allowed

2. Programming Questions - 5 Questions (2 hours)
    a. Open Book - refer to notes, websites, tutorials etc.
    b. You **must** use your own laptop
    c. Must be done individually
    d. No messaging platforms - i.e., SMS, Instant Messaging, Email
    e. No ChatGPT or equivalent
    f. You must cite all your sources (by including a comment with the URL)

Exam Logistics

What to bring

1. Pencil for Optical Sheets
    a. Optical sheet scanner **will NOT recognize answers marked with a pen**

2. Laptop (Fully-charged)
    a. Need to use hackerrank website (register for an account ahead of time)
    b. Password released in class - timer will start when you start the test
    c. Exam will autosubmit after 2 hours is up from start time
    d. We'll close the exam at 12 PM
    e. We'll only evaluate what's submitted

Some Tips

Study well…. Understand the problems… memorization will NOT help

Try to solve class activities by yourself without looking at solutions

Code with solutions for all activities is available on the Git repo

We'll give partial points sparingly, so it's better to try to solve a few questions fully correctly than many questions partially correctly

We do run plagiarism checks - don't risk it. Plagiarism will earn you a 0 !

Exam Logistics

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