Callback and Closure

Building Modern Web Applications - VSP2019

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Function

1. **Function**
2. Callback Function
3. Closure Function

Function: Recap

- JavaScript functions are **not typed**
- JavaScript functions are **first-class objects**
  - They can be **assigned to variables**
  - They can be **passed as arguments** into another function call
  - Functions can **return other functions**
- Function Declarations have the format:
  - `function functionName (arg, arg, ...) { /* body */ }`
- Function Expressions can create **anonymous functions**
  - `var x = function (arg, arg, ...) { /* body */ }`

Function: Variadic Function

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

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 (firstName, lastName){
2     console.log("Hi " + firstName + " " + lastName);
3  };
4  function sayHi (firstName, middleName, lastName){
5     console.log("Hi " + firstName + " " + middleName + " " + lastName);
6  };
7
8  sayHi("Alice", "Brown");  // prints: Alice Brown undefined
```

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: Primitive vs Complex Objects

- The semantics of a function argument differs for primitive object versus complex objects
  - Primitive objects are passed by **value** - the function makes its own copy of the object passed as an argument
  - Complex objects are passed by **reference** - the function uses the same object passed as an argument

Function: Primitive vs Complex Objects

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  - Primitive objects are passed by **value** - the function makes its own copy of the object passed as an argument
  - Complex objects are passed by **reference** - the function uses the same object passed as an argument


```
1  function foo (x){
2     x = 2;
3  };
4
5  var y = 1;
6  foo(y);
7  console.log(y);     // prints: 1
```

TRY IT!

Function: Primitive vs Complex Objects

- The semantics of a function argument differs for primitive object versus complex objects
  - Primitive objects are passed by **value** - the function makes its own copy of the object passed as an argument
  - Complex objects are passed by **reference** - the function uses the same object passed as an argument

```
1  function foo (x){
2     x.z = 2;
3  };
4
5  var y = { z: 1 };
6  foo(y);
7  console.log(y.z);    // prints: 2
```

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  };
4
5  console.log(y);     // prints: [Function: foo]
```

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: 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: 8
```

TRY IT!

Function: Scope

- Each function creates its own **scope** when invoked

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

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!

Function: Class Activity

lectures/lecture-4/activity1.js

- Implement the `map` function, which takes in an Array and a function `f` as arguments, and returns a new Array whose elements are the result of applying `f` on each of the items in the original Array


```
1  function map (list, f){
2     // to implement
3  };
4
5  var myList = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9];
6  var tList = map(myList, function (item){
7     return item + 5;
8  });
9  console.log(tList);     // prints: 5, 6, 7, 8, 9, 10, 11, 12, 13, 14
```

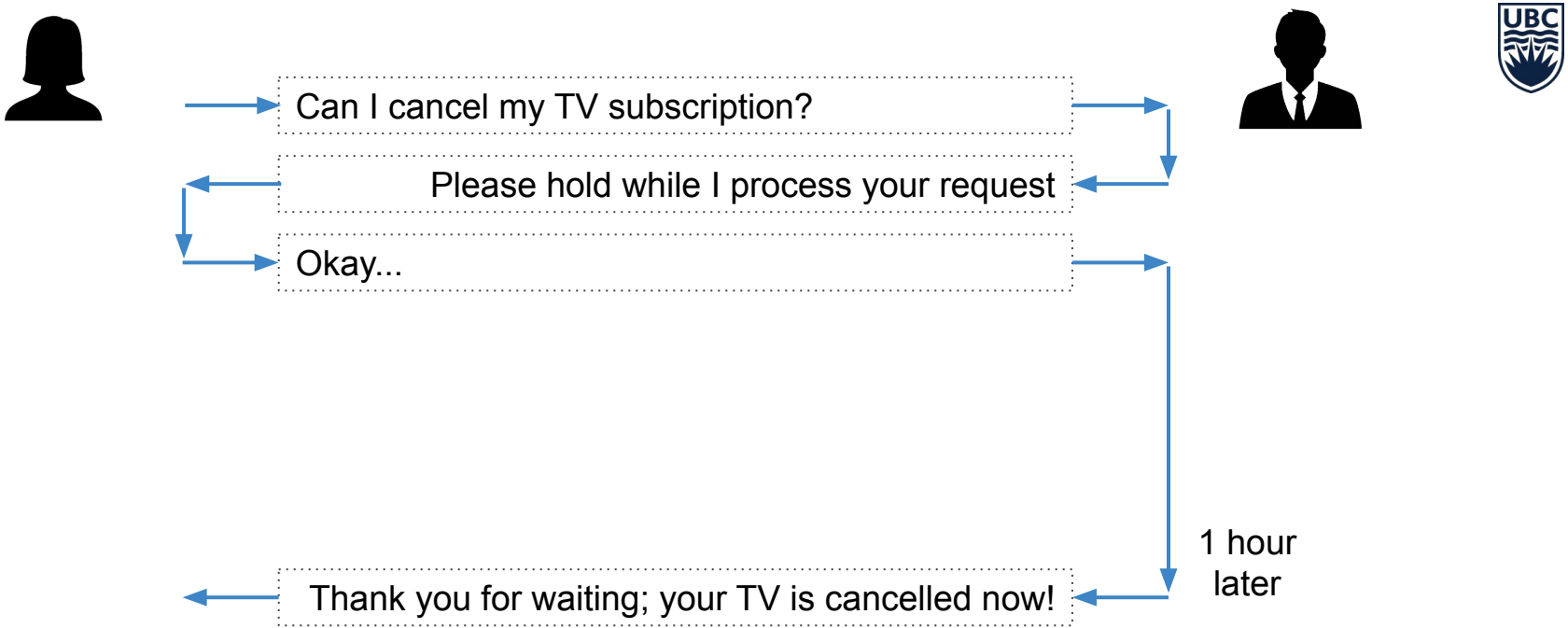
Callback Function

1. Function
2. **Callback Function**
3. Closure Function

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



Callback Function

Can I cancel my TV subscription?

Please hold while I process your request

Call me back at 123-456-7890 when you finish

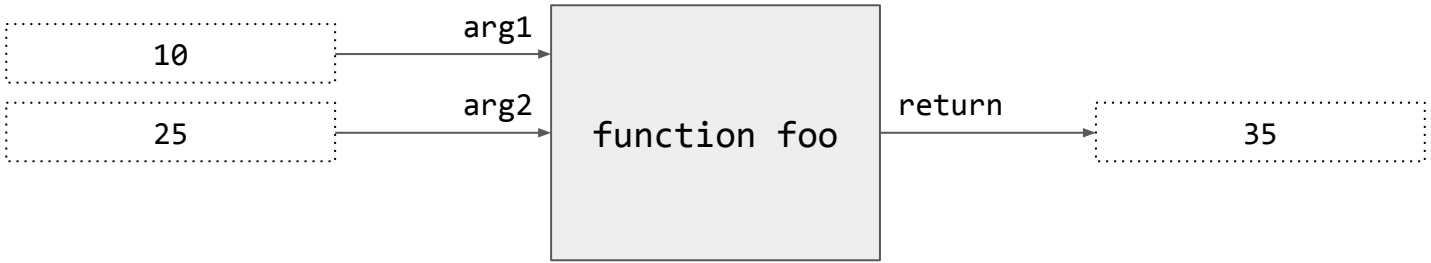
Okay

Do other things

1 hour later

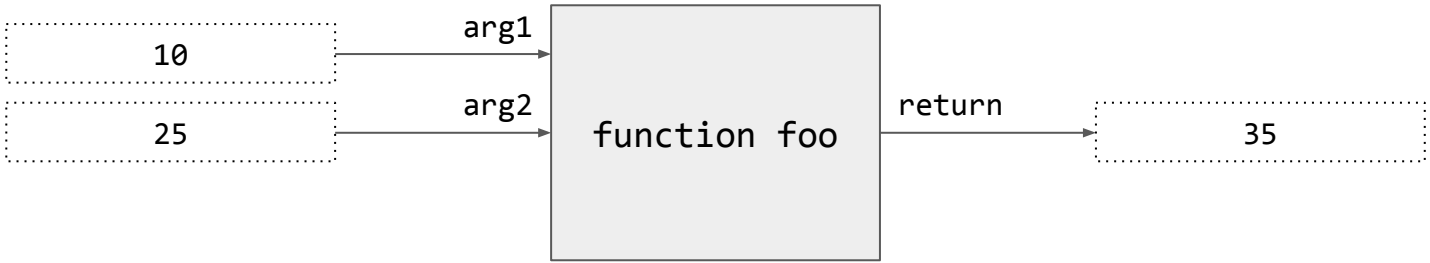
Your TV is cancelled now!

Callback Function

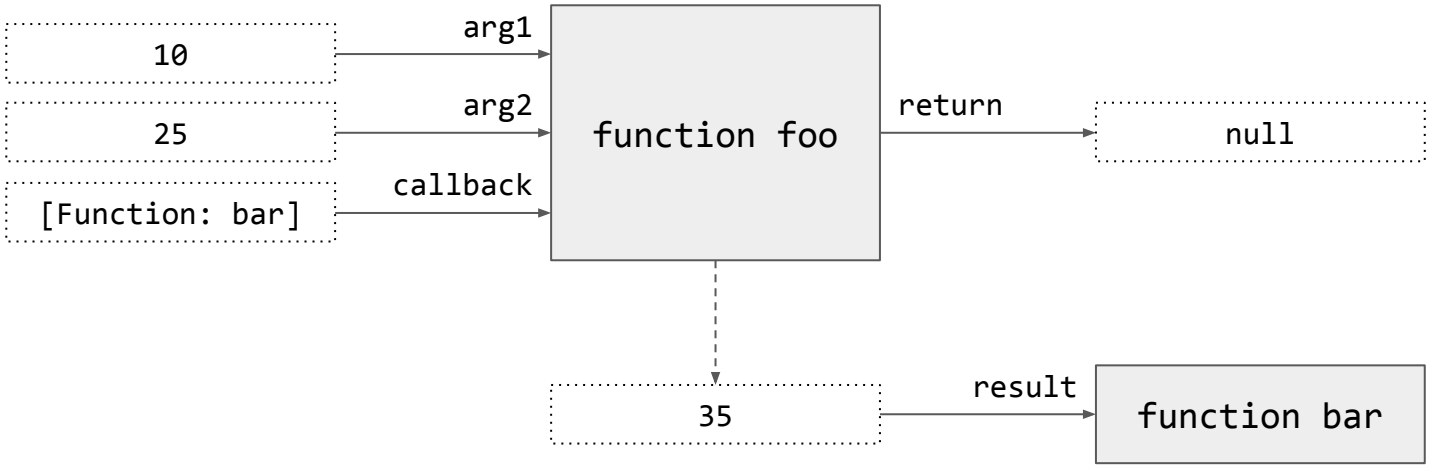



```
1  function foo (arg1, arg2){
2     // ... do something ...
3     return result;
4  };
5
6  var result = foo(10, 25);
7  console.log(result);
```

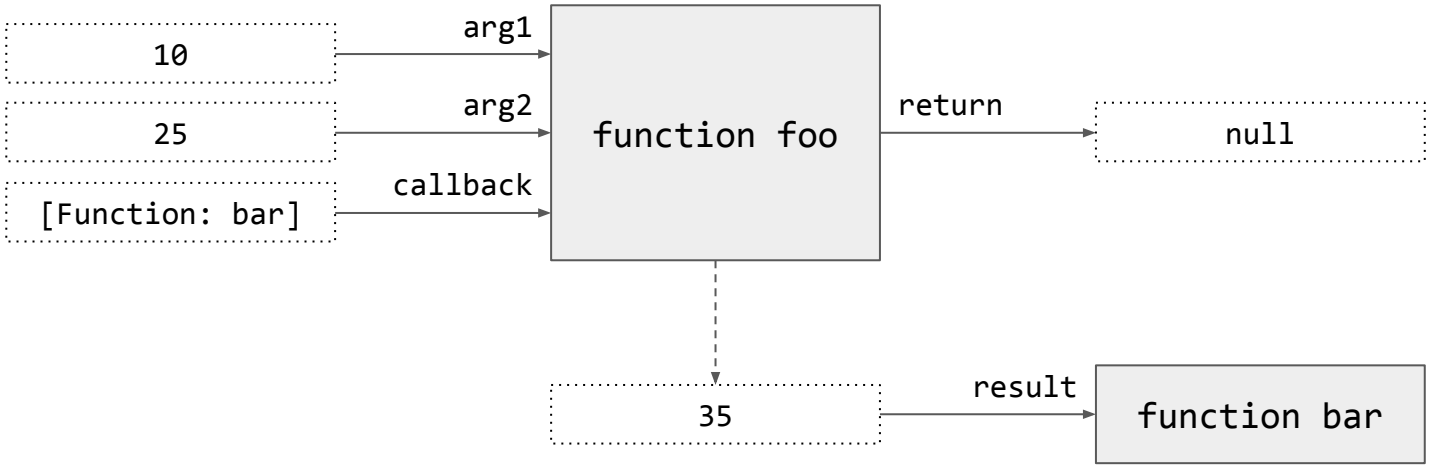
Callback Function



Callback Function



Callback Function



“Here is a function, don’t call it now,
but call it later when something happens”

Callback Function

```
1  function foo (arg1, arg2, callback){
2     // ... do something ...
3     someAsync(function(){
4        // inside the callback of some asynchronous operation
5        callback(result);
6     });
7     return null;
8  };
9
10 foo(10, 25, function bar(result){
11    console.log(result);
12 });
```

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
```

Callback Function: Class Activity

lectures/lecture-4/activity2.js

- Implement `whenBothFinish` function, which takes in 2 functions `fn1`, `fn2` and schedules them to execute after a random delay. It should invoke the 3rd argument `callback` when both have executed

```
function whenBothFinish (fn1, fn2, callback){
   /*
    to implement: use setTimeout(___, Math.floor(Math.random()*1000))
                  for scheduling fn1 and fn2
    */
};

whenBothFinish(
   function(){ console.log("fn1 finished!"); },
   function(){ console.log("fn2 finished!"); },
   function(){ console.log("Both functions finished!"); }
);
```

Closure Function

1. Function
2. Callback Function
3. **Closure Function**

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 counter = makeCounter(3, 1);
9  console.log(counter());          // prints: 4
10 console.log(counter());          // prints: 5
11 console.log(counter());          // prints: 6
12 console.log(count);              // prints: undefined
```

TRY IT!

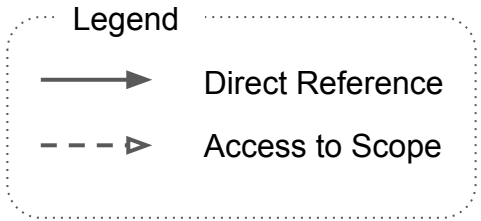
Closure Function

```
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!

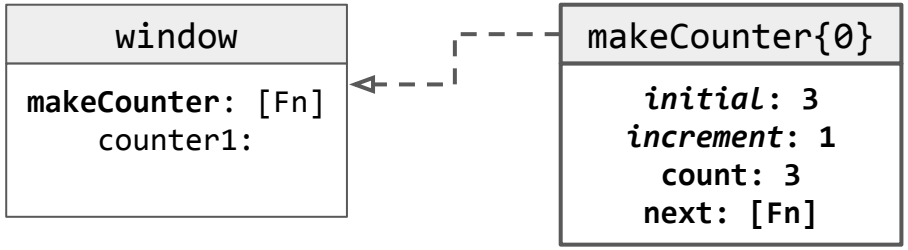
Closure Function

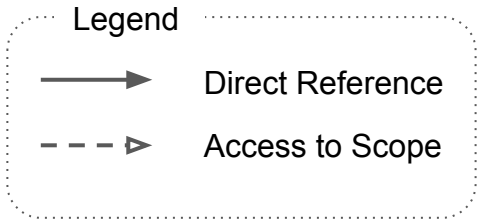
window
makeCounter: [Fn]




```
1  function makeCounter (initial,
2  increment){
3     /* makeCounter code */
4  };
5
6
```

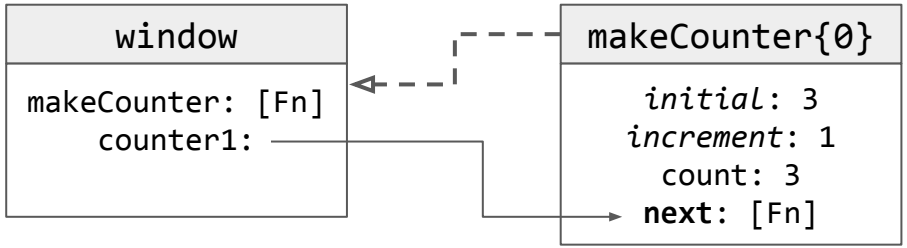
Closure Function

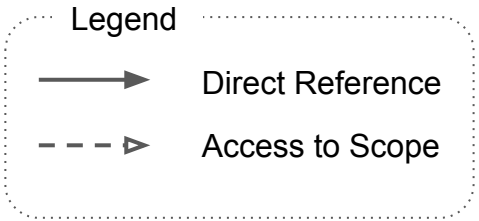





```
1  var counter1 = makeCounter(3, 1);
2
3
4
5
6
```

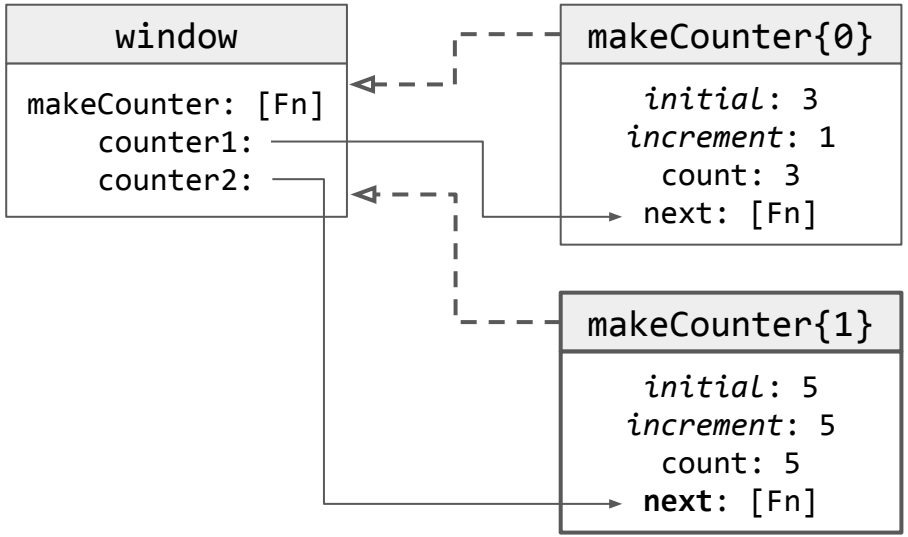
Closure Function

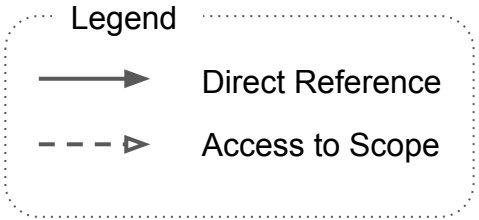





```
1  var counter1 = makeCounter(3, 1);
2
3
4
5
6
```

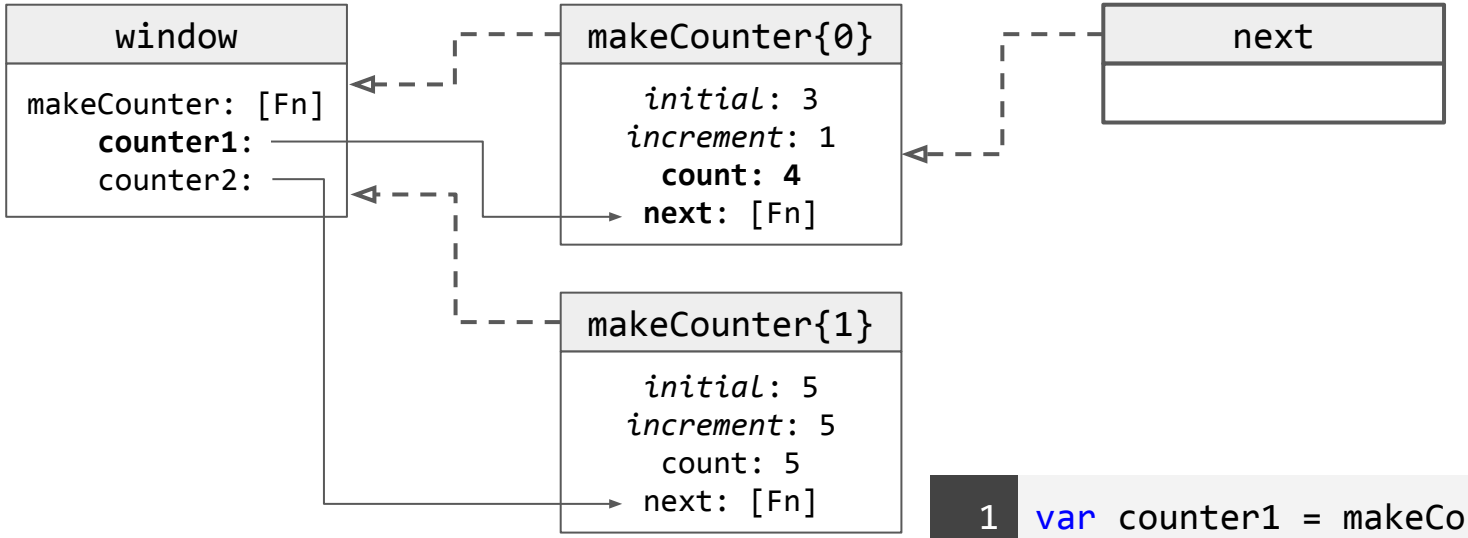
Closure Function

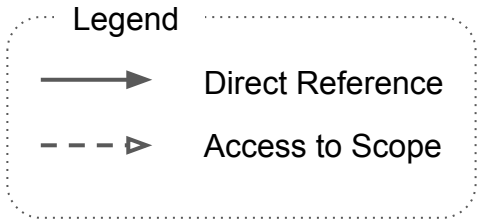





```
1  var counter1 = makeCounter(3, 1);
2  var counter2 = makeCounter(5, 5);
3
4
5
6
```

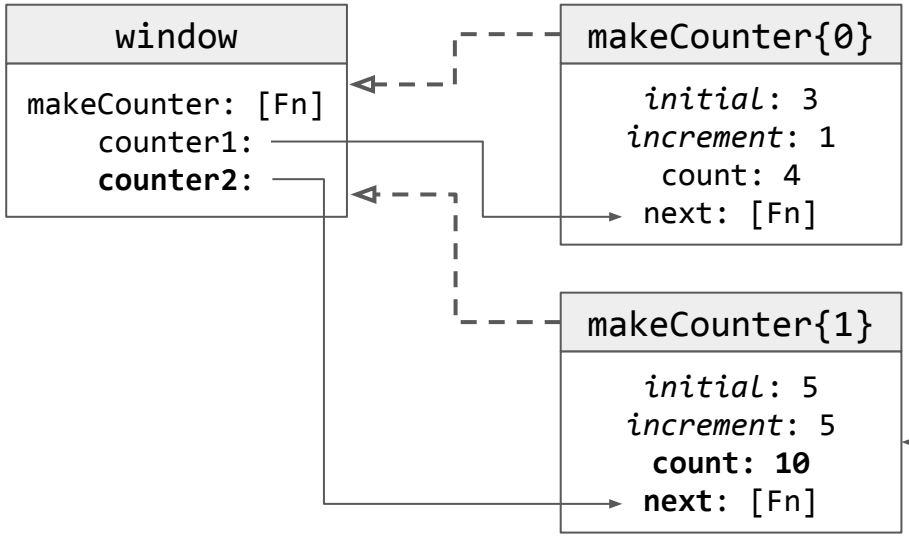
Closure Function

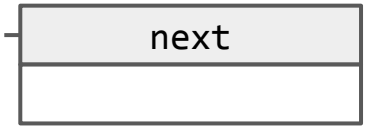


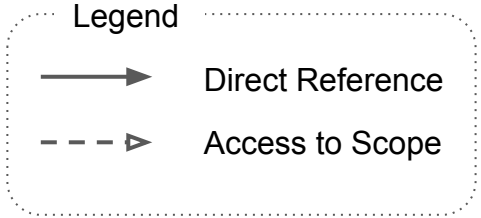



```
1  var counter1 = makeCounter(3, 1);
2  var counter2 = makeCounter(5, 5);
3  console.log(counter1());
4
5
6
```

Closure Function

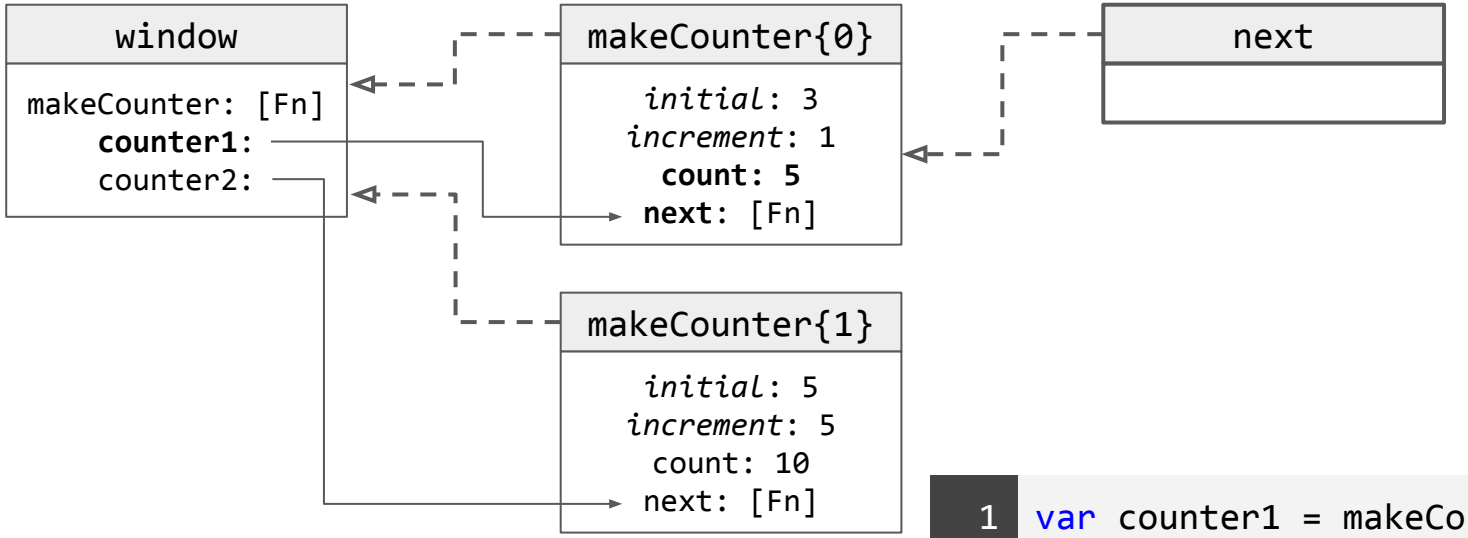


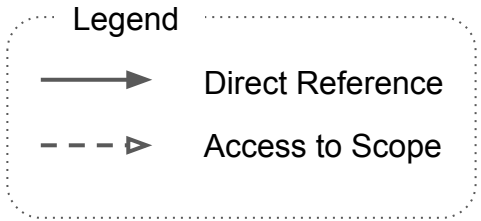





```
1  var counter1 = makeCounter(3, 1);
2  var counter2 = makeCounter(5, 5);
3  console.log(counter1());
4  console.log(counter2());
5
6
```

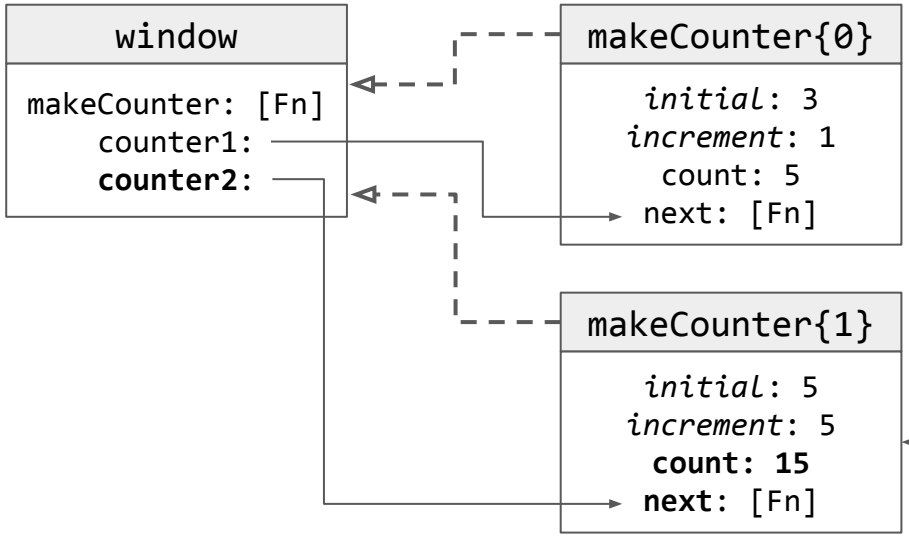
Closure Function

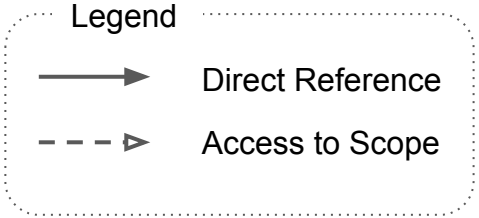





```
1  var counter1 = makeCounter(3, 1);
2  var counter2 = makeCounter(5, 5);
3  console.log(counter1());
4  console.log(counter2());
5  console.log(counter1());
6
```

Closure Function






```
1  var counter1 = makeCounter(3, 1);
2  var counter2 = makeCounter(5, 5);
3  console.log(counter1());
4  console.log(counter2());
5  console.log(counter1());
6  console.log(counter2());
```

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: Class Activity

lectures/lecture-4/activity3.js

- Implement the `makeAccount` function below
  - It should keep a variable `balance`, initially assigned the value of `initial`
  - It should return an object with 3 properties: `deposit`, `withdraw`, `getBalance`
    - `deposit`: a function that accepts an argument `amount` and adds it to `balance`
    - `withdraw`: a function that accepts an argument `amount` and subtracts it from `balance`
    - `getBalance`: a function that returns the `balance`

```
1  function makeAccount (initial){ /* your implementation */ };
2
3  var alice = makeAccount(300);
4  alice.deposit(100);
5  alice.withdraw(50);
6  console.log(alice.getBalance());        // prints: 350
```

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: 1
16 console.log( cs[4]() );      // prints: 2
```

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);
```

Closure Function: Class Activity

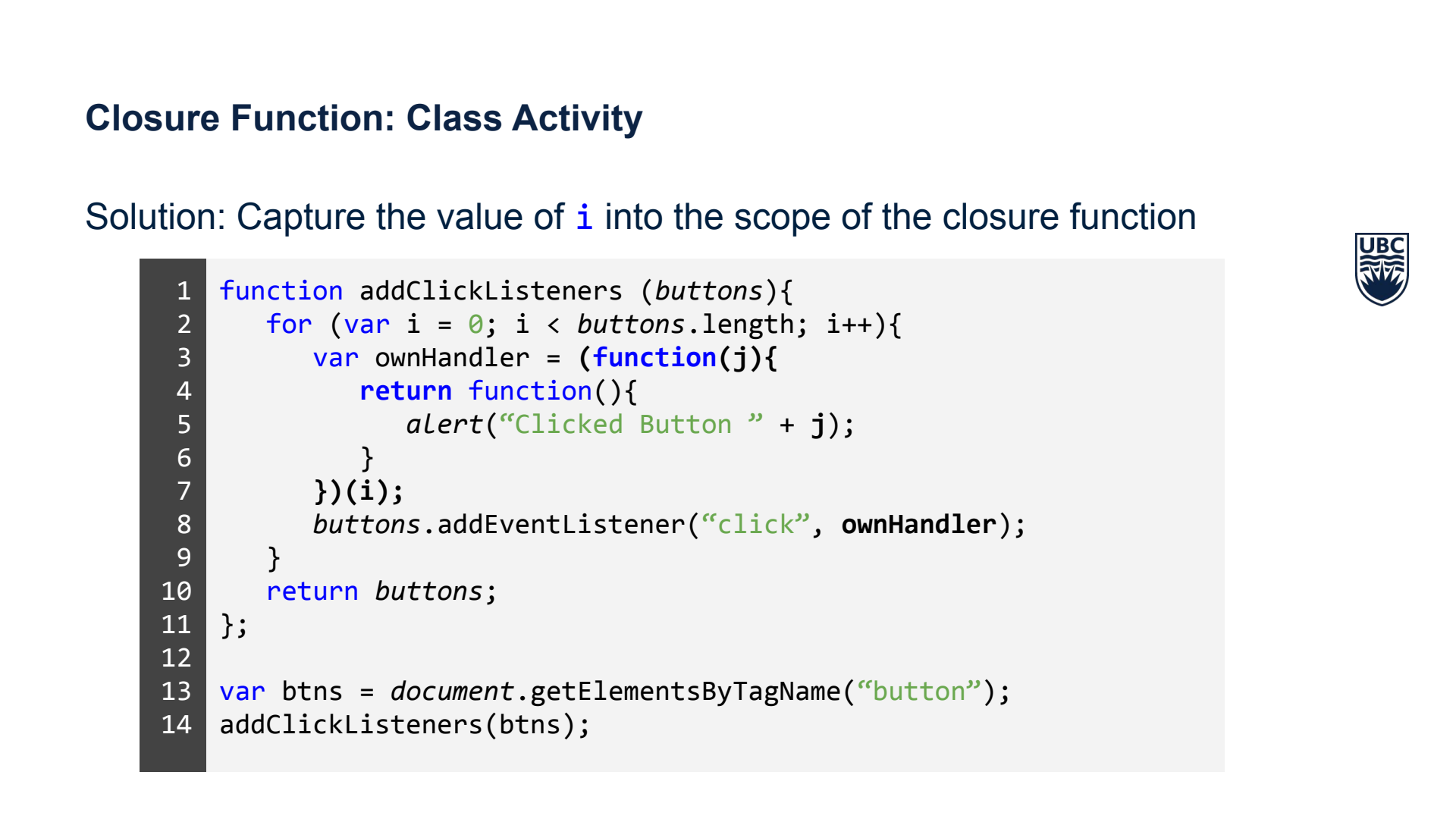
lectures/lecture-4/activity4.html
lectures/lecture-4/activity4.js

Fix the following code - all buttons are showing the same message!

```
1  function addClickListeners (buttons){
2     for (var i = 0; i < buttons.length; i++){
3        buttons.addEventListener("click", function(){
4           alert("Clicked Button " + i);
5        });
6     }
7     return buttons;
8  };
9
10 var btns = document.getElementsByTagName("button");
11 addClickListeners(btns);
12
13
14
```

Closure Function: Class Activity

Solution: Capture the value of `i` into the scope of the closure function



```
1  function addClickListeners (buttons){
2     for (var i = 0; i < buttons.length; i++){
3        var ownHandler = (function(j){
4           return function(){
5              alert("Clicked Button " + j);
6           }
7        })(i);
8        buttons.addEventListener("click", ownHandler);
9     }
10    return buttons;
11 };
12
13 var btns = document.getElementsByTagName("button");
14 addClickListeners(btns);
```