Organizing Code in Web Apps

SWE 432, Fall 2016

Design and Implementation of Software for the Web

Today

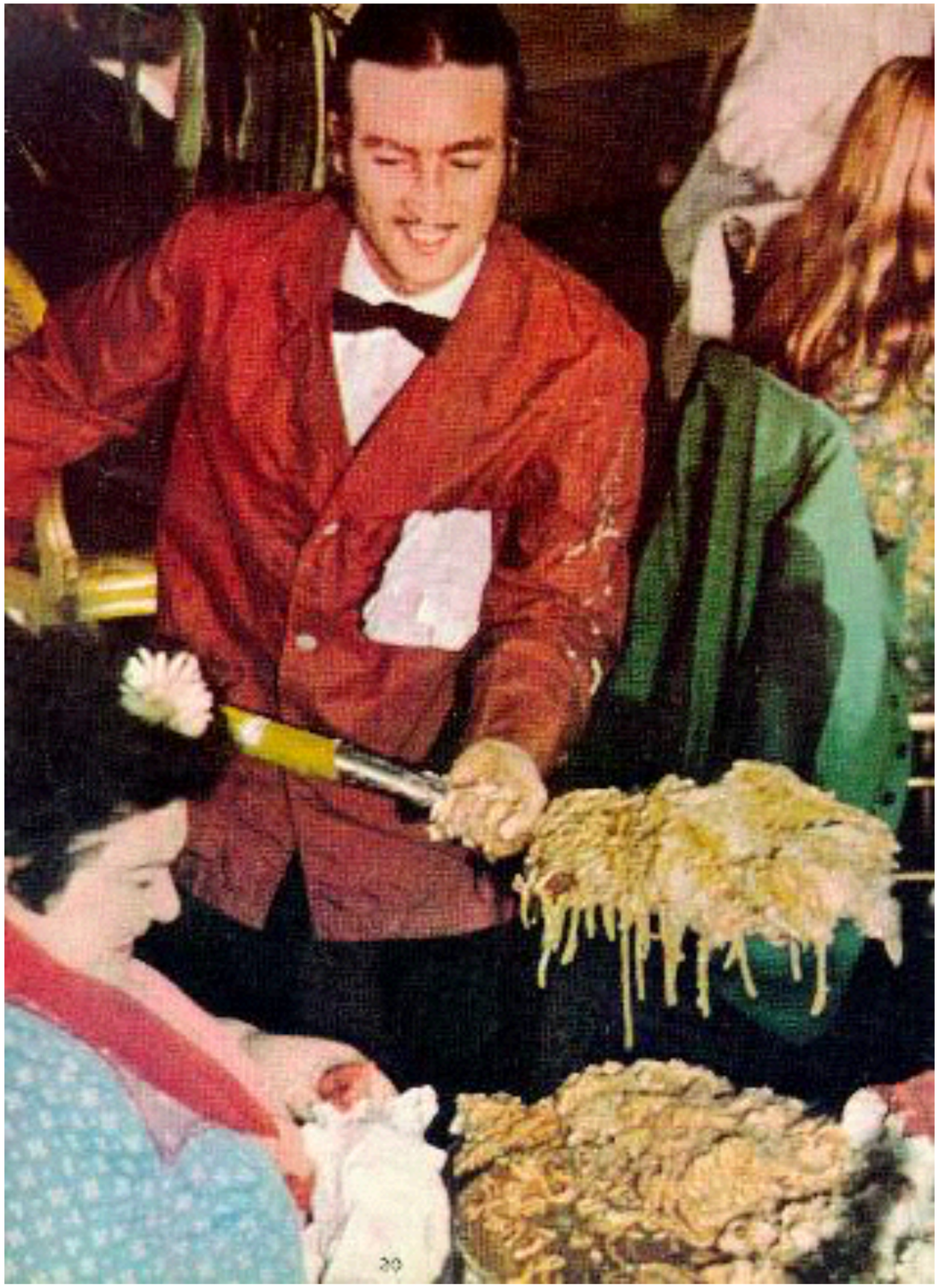
- Some basics on how and why to organize code (SWE!)
- Closures
- Classes
- Modules

For further reading:
http://stackoverflow.com/questions/111102/how-do-javascript-closures-work

History + Motivation

“Wow back in my day before ES6 we didn’t have your fancy modules”

Spaghetti Code



Brian Foote and Joe Yoder

```
window.onload = function () {
    eqCtl = document.getElementById('e
    currNumberCtl = document.getElemer
};

var eqCtl,
    currNumberCtl,
    operator,
    operatorSet = false,
    equalsPressed = false,
    lastNumber = null;

function add(x,y) {
    return x + y;
}

function subtract(x, y) {
    return x - y;
}

function multiply(x, y) {
    return x * y;
}

function divide(x, y) {
    if (y == 0) {
        alert("Can't divide by 0");
        return 0;
    }
    return x / y;
}

function setVal(val) {
    currNumberCtl.innerHTML = val;
}

function setEquation(val) {
    eqCtl.innerHTML = val;
}

function clearNumbers() {
    lastNumber = null;
    equalsPressed = operatorSet = fals
    setVal('0');
    setEquation('');
}

function setOperator(newOperator) {
    if (newOperator == '=') {
        equalsPressed = true;
        calculate();
        setEquation('');
        return;
    }

   if (!equalsPressed) calculate();
    equalsPressed = false;
    operator = newOperator;
    operatorSet = true;
    lastNumber = parseFloat(currNumberCtl.innerHTML);
    var eqText = (eqCtl.innerHTML == '
        lastNumber + ' ' + operator +
        eqCtl.innerHTML + ' ' + operat
    setEquation(eqText);
}

function numberClick(e) {
    var button = (e.target) ? e.target
    if (operatorSet == true || currNum
        setVal('');
        operatorSet = false;
    }
    setVal(currNumberCtl.innerHTML + b
    setEquation(eqCtl.innerHTML + butt
}

function calculate() {
    if (!operator || lastNumber == nul
    var currNumber = parseFloat(currNu
        newVal = 0;
  switch (operator) {
        case '+':
            newVal = add(lastNumber, c
            break;
        case '-':
            newVal = subtract(lastNumb
            break;
        case '*':
            newVal = multiply(lastNumb
            break;
        case '/':
            newVal = divide(lastNumber
            break;
    }
    setVal(newVal);
    lastNumber = newVal;
}
```

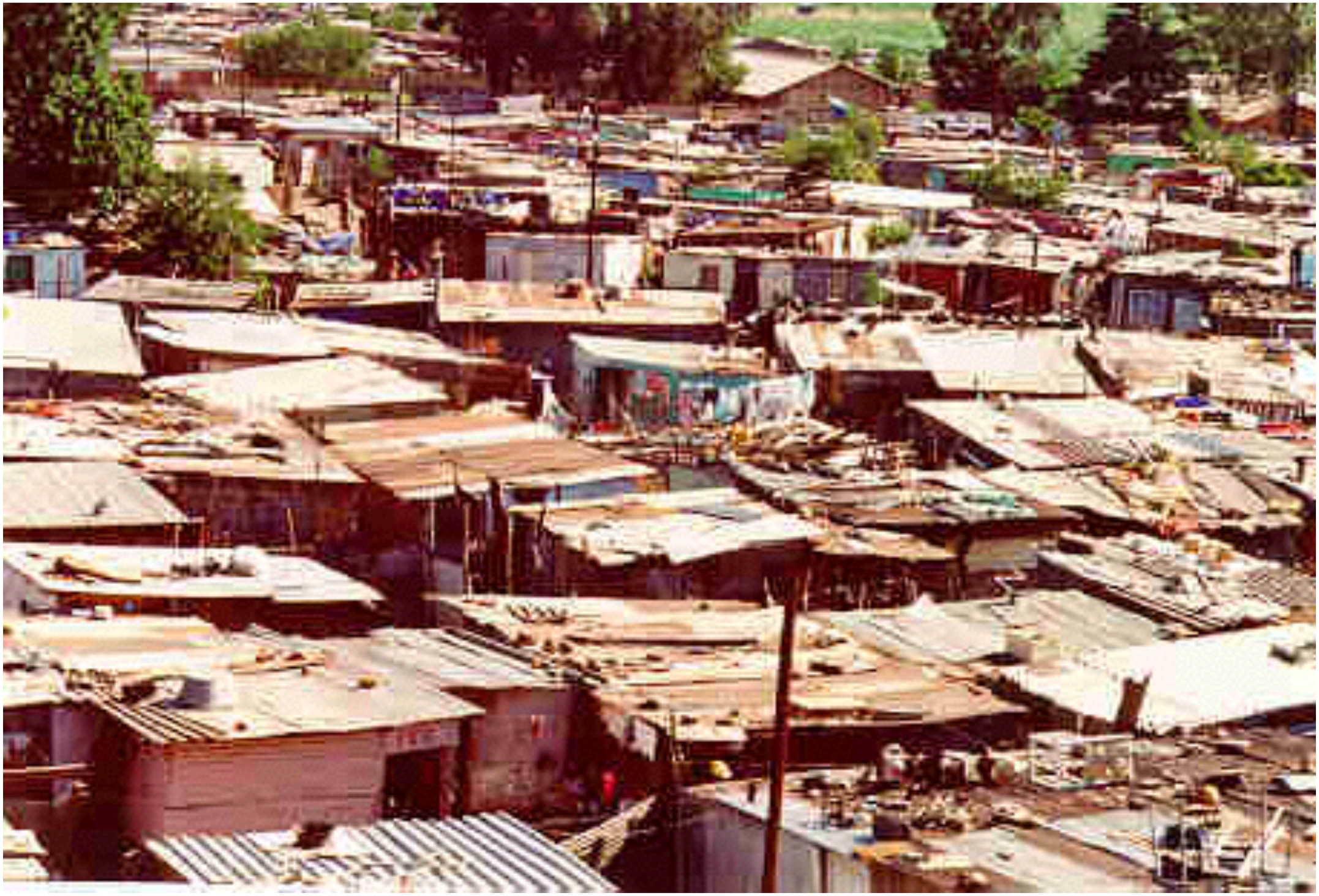
```
function setOperator(newOperator) {
    if (newOperator == '=') {
        equalsPressed = true;
        calculate();
        setEquation('');
        return;
    }

   if (!equalsPressed) calculate();
    equalsPressed = false;
    operator = newOperator;
    operatorSet = true;
    lastNumber = parseFloat(currNumberCtl.innerHTML);
    var eqText = (eqCtl.innerHTML == '' ) ?
        lastNumber + ' ' + operator + ' ' :
        eqCtl.innerHTML + ' ' + operator + ' ';
    setEquation(eqText);
}

function numberClick(e) {
    var button = (e.target) ? e.target : e.srcElement;
    if (operatorSet == true || currNumberCtl.innerHTML == '
        setVal('');
        operatorSet = false;
    }
    setVal(currNumberCtl.innerHTML + button.innerHTML);
    setEquation(eqCtl.innerHTML + button.innerHTML);
}

function calculate() {
    if (!operator || lastNumber == null) return;
    var currNumber = parseFloat(currNumberCtl.innerHTML),
        newVal = 0;
   switch (operator) {
        case '+':
            newVal = add(lastNumber, currNumber);
            break;
        case '-':
            newVal = subtract(lastNumber, currNumber);
            break;
        case '*':
            newVal = multiply(lastNumber, currNumber);
            break;
        case '/':
            newVal = divide(lastNumber, currNumber);
            break;
    }
    setVal(newVal);
```

…aka big ball of mud aka shanty town code



Brian Foote and Joe Yoder

Bad Code "Smells"

- Tons of not-very related functions in the same file
- No/bad comments
- Hard to understand
- Lots of nested functions

```
fs.readdir(source, function (err, files) {
        if (err) {
        console.log('Error finding files: ' + err)
        } else {
        files.forEach(function (filename, fileIndex) {
                        console.log(filename)
                        gm(source + filename).size(function (err, values) {
                                                if (err) {
                                                console.log('Error identifying file size: ' + err)
                                                } else {
                                                console.log(filename + ' : ' + values)
                                                aspect = (values.width / values.height)
                                                widths.forEach(function (width, widthIndex) {
                                                                height = Math.round(width / aspect)
                                                                console.log('resizing ' + filename + 'to ' + height +
                                                                this.resize(width, height).write(dest + 'w' + width +
                                                                                                if (err) console.log
                                                                                                })
                                                                }.bind(this))
                                                }
                                                })
                        })
        }
        });
```

Design Goals

- Within a component
  - Cohesive
  - Complete
  - Convenient
  - Clear
  - Consistent
- Between components
  - Low coupling

Cohesion and Coupling

- Cohesion is a property or characteristic of an individual unit
- Coupling is a property of a collection of units
- High cohesion GOOD, high coupling BAD
- Design for change:
  - Reduce interdependency (coupling): You don't want a change in one unit to ripple throughout your system
  - Group functionality (cohesion): Easier to find things, intuitive metaphor aids understanding

Design for Reuse

- Why?
  - Don’t duplicate existing functionality
  - Avoid repeated effort
- How?
  - Make it easy to extract a single component:
    - Low **coupling** between components
    - Have high **cohesion** with

Design for Change

- Why?
  - Want to be able to add new features
  - Want to be able to easily **maintain** existing software
    - Adapt to new environments
    - Support new configurations
- How?
  - Low **coupling** - prevents unintended side effects
  - High **cohesion** - easier to find things

Organizing Code

How do we structure things to achieve good organization?

	Java	Javascript
Individual Pieces of Functional Components	Classes	Classes
Entire libraries	Packages	Modules

Closures

- Closures are expressions that work with variables in a specific context
- Closures contain a function, and its needed state
  - Closure is that function and a **stack frame** that is allocated when a function starts executing and **not freed** after the function returns

Closures & Stack Frames

- What is a stack frame?
  - Variables created by function in its execution
  - Maintained by environment executing code

```
function a() {
    var x = 5, z = 3;
    b(x);
}
function b(y)  {
    console.log(y);
}
a();
```

Contents of memory:

```
a:   x: 5
     z: 3
```

Stack frame

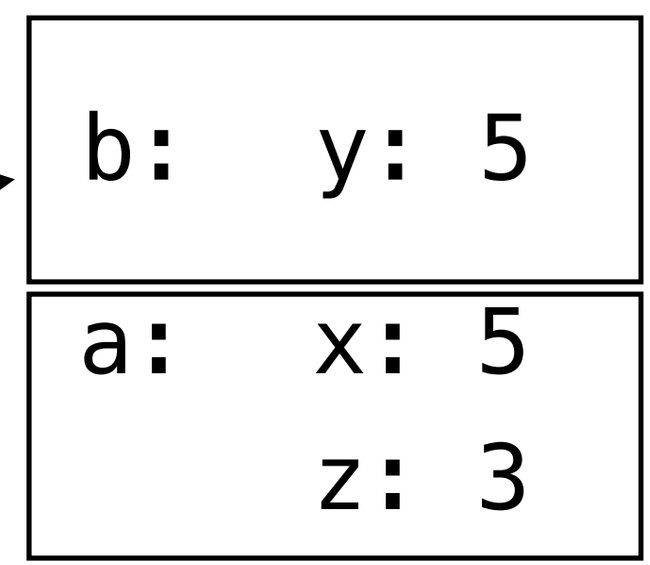
Function called: stack frame created

Closures & Stack Frames

- What is a stack frame?
  - Variables created by function in its execution
  - Maintained by environment executing code

```
function a() {
    var x = 5, z = 3;
    b(x);
}
function b(y) {
    console.log(y);
}
a();
```

Contents of memory:



Stack frame

Function called: new stack frame created

Closures & Stack Frames

- What is a stack frame?
  - Variables created by function in its execution
  - Maintained by environment executing code

```
function a() {
    var x = 5, z = 3;
    b(x);
}
function b(y)  {
    console.log(y);
}
a();
```

Contents of memory:

```
a:   x: 5
     z: 3
```

Stack frame

Function returned: stack frame popped

Closures

- Closures are expressions that work with variables in a specific context
- Closures contain a function, and its needed state
  - Closure is a stack frame that is allocated when a function starts executing and not freed after the function returns
- That state just refers to that state by name (sees updates)

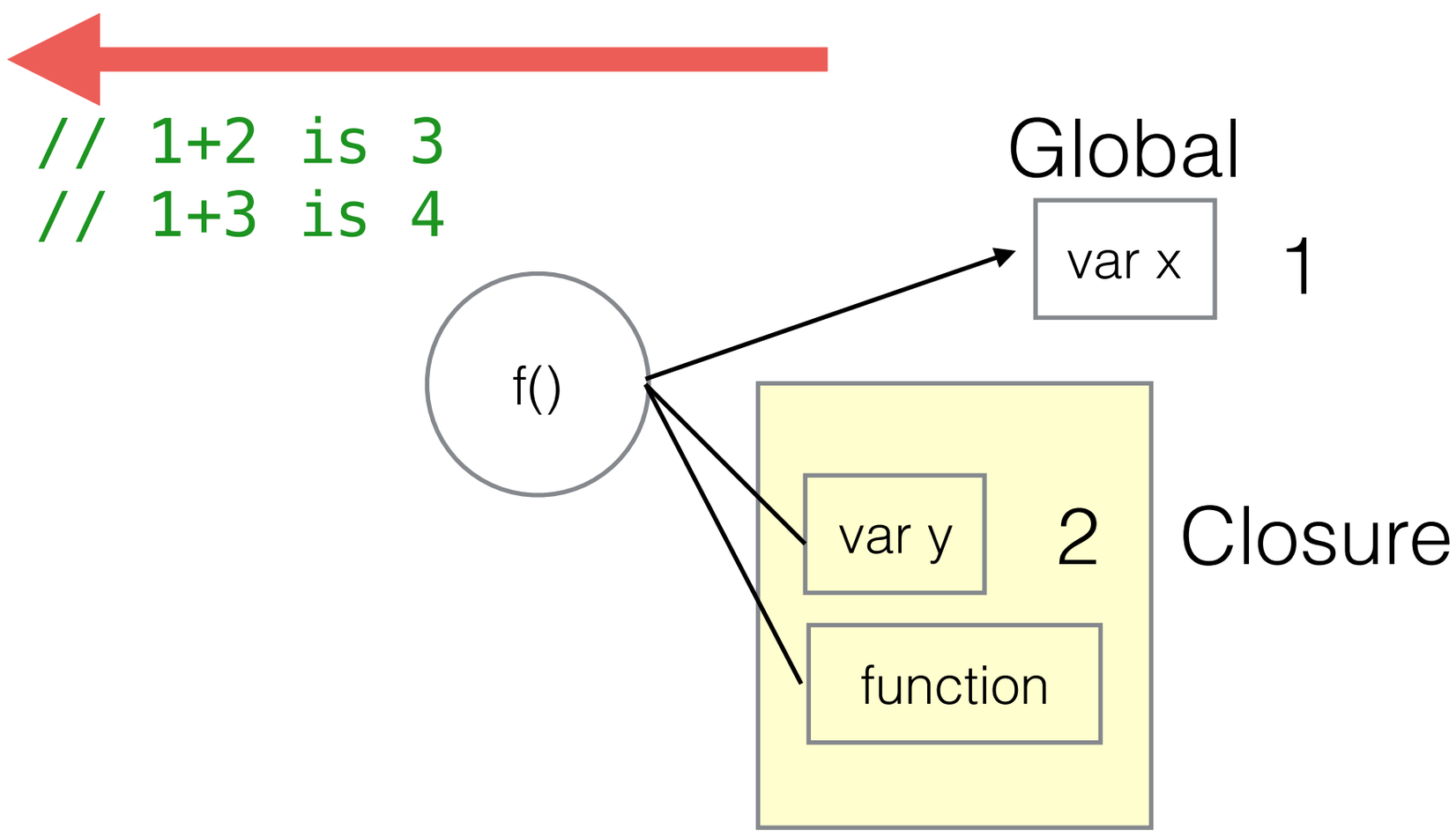
```
var x = 1;
function f() {
    var y = 2;
    return function() {
        console.log(x + y);
        y++;
    };
}
var g = f();
g();            // 1+2 is 3
g();            // 1+3 is 4
```

This function attaches itself to x and y so that it can continue to access them.

It "**closes up**" those references

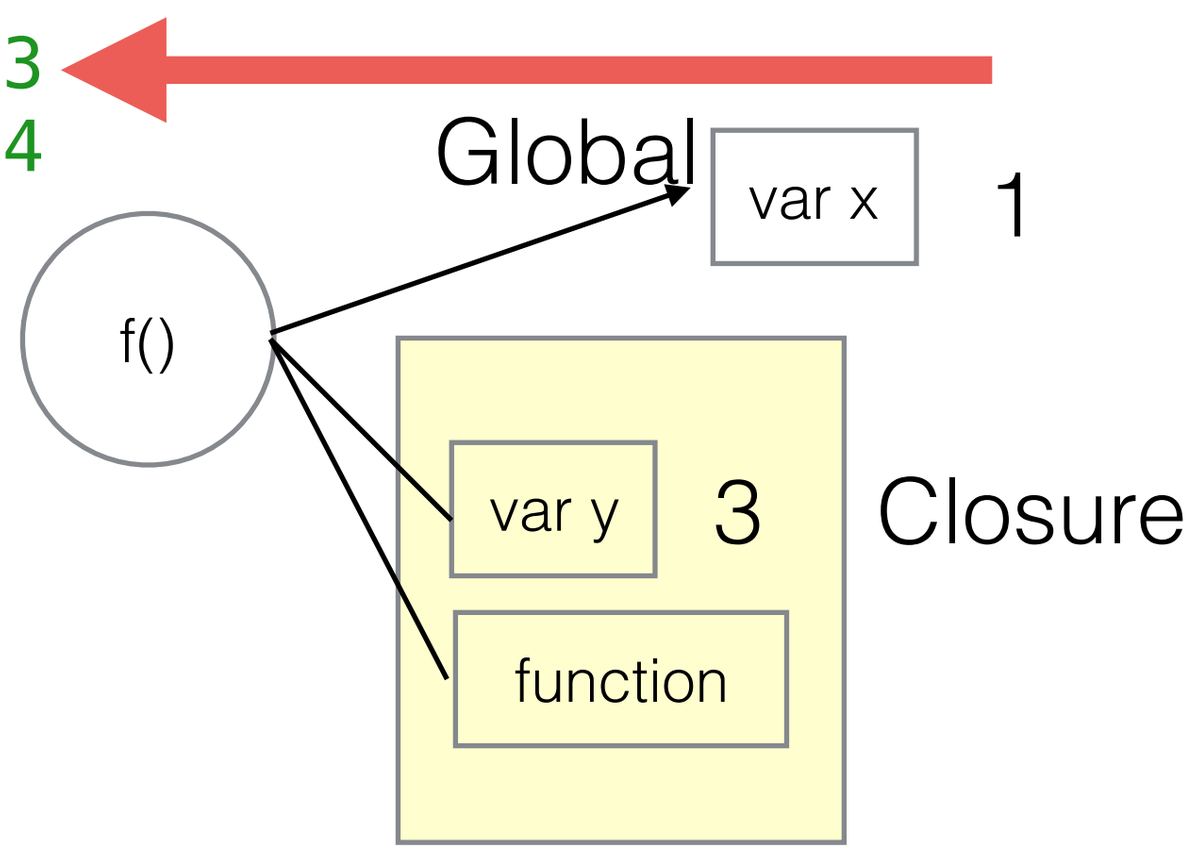
Closures

```
var x = 1;
function f() {
    var y = 2;
    return function() {
        console.log(x + y);
        y++;
    };
}
var g = f();
g();            // 1+2 is 3
g();            // 1+3 is 4
```



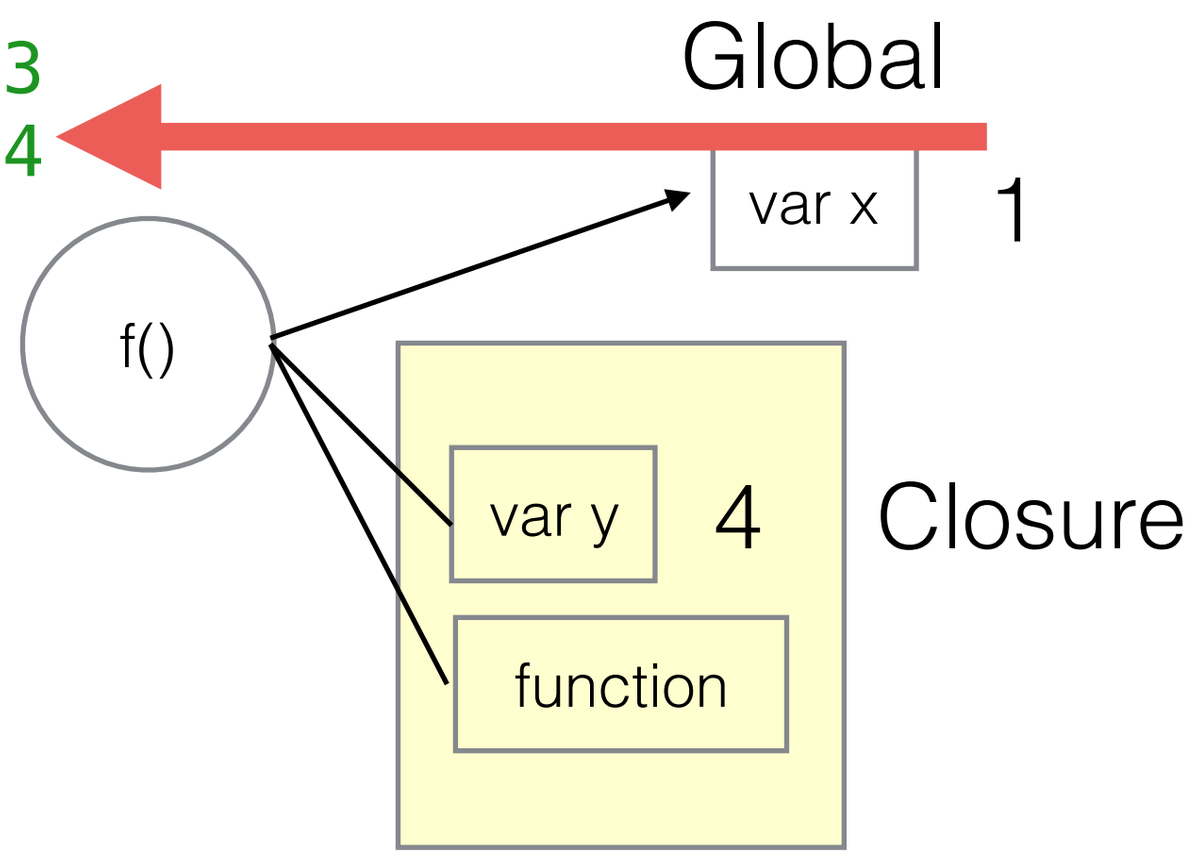
Closures

```
var x = 1;
function f() {
    var y = 2;
    return function() {
        console.log(x + y);
        y++;
    };
}
var g = f();
g();            // 1+2 is 3
g();            // 1+3 is 4
```



Closures

```
var x = 1;
function f() {
    var y = 2;
    return function() {
        console.log(x + y);
        y++;
    };
}
var g = f();
g();            // 1+2 is 3
g();            // 1+3 is 4
```



Modules

- We can do it with closures!
- Define a function
  - Variables/functions defined in that function are "private"
  - Return an object - every member of that object is public!
- Remember: Closures have access to the outer function's variables even after it returns

Modules with Closures

```
var facultyAPI = (function(){
  var faculty = [{name:"Prof Bell", section: 2}, {name:"Prof
LaToza", section:1}];

  return {
   getFaculty : function(i)
   {
    return faculty[i].name + " ("+faculty[i].section +")";
   }

 };
})();

console.log(facultyAPI.getFaculty(0));
```

This works because inner functions have visibility to all variables of outer functions!

Closures gone awry

```
var funcs = [];
for (var i = 0; i < 5; i++) {
    funcs[i] = function() { return i; };
}
```

What is the output of `funcs[0]()`?

>5

Why?

Closures retain a *pointer* to their needed state!

Closures under control

Solution: IIFE - Immediately-Invoked Function Expression

```
function makeFunction(n)
{
    return function(){ return n; };
}
for (var i = 0; i < 5; i++) {
  funcs[i] = makeFunction(i);
}
```

Why does it work?

Each time the anonymous function is called, it will create a **new variable `n`**, rather than reusing the same variable `i`

Shortcut syntax:

```
var funcs = [];
for (var i = 0; i < 5; i++) {
  funcs[i] = (function(n) {
    return function() { return n; }
  })(i);
}
```

Exercise: Closures

```
var facultyAPI = (function(){
  var faculty = [{name:"Prof Bell", section: 2}, {name:"Prof
LaToza", section:1}];

  return {
   getFaculty : function(i)
   {
    return faculty[i].name + " ("+faculty[i].section +")";
   }

 };
})();

console.log(facultyAPI.getFaculty(0));
```

https://jsfiddle.net/hkcq5vpa/

https://jsfiddle.net/hkcq5vpa/1/

Here's our simple closure. Add a new function to create a new faculty, then call `getFaculty` to view their formatted name.

Classes

A small correction:

Remember... There's no Class!*

```
var profJon = {
    firstName: "Jonathan",
    lastName: "Bell",
    teaches: "SWE 432",
    office: "ENGR 4322",
    fullName: function(){
        return this.firstName + " " + this.lastName;
    }
};
```

Our Object

```
profJon.officeHours = "Tuesdays 10:30-12:00";
```

Lazily creates a new property and sets it

```
delete profJon.office;
```

Deletes a property

LaToza/Bell GMU SWE 432 Fall 2016 19

Lecture 4, JavaScript

Classes

- ES6 introduces the `class` keyword
- Mainly just syntax - still not like Java Classes

Old

```
function Faculty(first, last, teaches, office)
{
  this.firstName = first;
  this.lastName = last;
  this.teaches = teaches;
  this.office = office;
  this.fullName = function(){
    return this.firstName + " " + this.lastName;
  }
}
var profJon = new Faculty("Jonathan", "Bell", "SWE432", "ENGR 4322");
```

New

```
class Faculty {
    constructor(first, last, teaches, office)
    {
        this.firstName = first;
        this.lastName = last;
        this.teaches = teaches;
        this.office = office;
    }
    fullname() {
        return this.firstName + " " + this.lastName;
    }
}
var profJon = new Faculty("Jonathan", "Bell", "SWE432", "ENGR 4322");
```

Classes - Extends

`extends` allows an object created by a class to be linked to a "`super`" class. Can (but don't have to) add parent constructor.

```
class Faculty {
    constructor(first, last, teaches, office)
    {
        this.firstName = first;
        this.lastName = last;
        this.teaches = teaches;
        this.office = office;
    }
    fullname() {
        return this.firstName + " " + this.lastName;
    }
 }

class CoolFaculty extends Faculty {
    fullname() {
        return "The really cool " + super.fullname();
    }
}
```

Classes - static

`static` declarations in a `class` work like in Java

```
class Faculty {
    constructor(first, last, teaches, office)
    {
        this.firstName = first;
        this.lastName = last;
        this.teaches = teaches;
        this.office = office;
    }
    fullname() {
        return this.firstName + " " + this.lastName;
    }
    static formatFacultyName(f) {
        return f.firstName + " " + f.lastName;
    }
}
```

Modules (ES6)

- With ES6, there is finally language support for modules
- Module must be defined in its own JS file
- Modules **`export`** declarations
  - Publicly exposes functions as part of module interface
- Code **`imports`** modules (and optionally only parts of them)
  - Specify module by path to the file

Modules (ES6) - Export Syntax

```
var faculty = [{name:"Prof Bell", section: 2}, {name:"Prof
LaToza", section:1}];
export function getFaculty(i) {
    // ..
}
export var someVar = [1,2,3];
```

Label each declaration with "export"

```
var faculty = [{name:"Prof Bell", section: 2}, {name:"Prof
LaToza", section:1}];
var someVar = [1,2,3];
function getFaculty(i) {
    // ..
}
export {getFaculty, someVar};
export {getFaculty as aliasForFunction, someVar};
```

Or name all of the exports at once

Can rename exports too

```
export default function getFaculty(i){...
```

Default export

Modules (ES6) - Import Syntax

- Import specific exports, binding them to the same name

```
import { getFaculty, someVar } from "myModule";
getFaculty()...
```

- Import specific exports, binding them to a new name

```
import { getFaculty as aliasForFaculty } from
"myModule";
aliasForFaculty()...
```

- Import default export, binding to specified name

```
import theThing from "myModule";
theThing()... -> calls getFaculty()
```

- Import all exports, binding to specified name

```
import * as facModule from "myModule";
facModule.getFaculty()...
```

Patterns for using/creating libraries

- Try to reuse as much as possible!
- Name your module in all lower case, with hyphens
- Include:
  - README.md
  - keywords, description, and license in package.json (from npm init)
- Strive for high cohesion, low coupling
  - Separate models from views
  - How much code to put in a single module?
- Cascades (see jQuery)

Cascade Pattern

- aka “chaining”
- Offer set of operations that mutate object and returns the “this” object
  - Build an API that has single purpose operations that can be combined easily
  - Lets us read code like a sentence
- Example (String):

```
str.replace("k","R").toUpperCase().substr(0,4);
```

- Example (jQuery):

```
$(“#wrapper")
   .fadeOut()
   .html(“Welcome")
   .fadeIn();
```

Demo: Modules

Not yet supported by any browser!

Closures Exercise

- Work from our example before of the Faculty Closure API to create a Class API (with Closures).
- Private fields:
  - Faculty API
  - List of students (students are objects with names, section numbers, and partners [which are students])
- Public functions:
  - Add a student to the class
  - Retrieve the name of the student's faculty

https://jsfiddle.net/hkcq5vpa/1/

https://jsfiddle.net/hkcq5vpa/3/

Exit-Ticket Activity

Go to socrative.com and select “Student Login”

Class: SWE432001 (Prof LaToza) or SWE432002 (Prof Bell)

ID is your @gmu.edu email

1: How well did you understand today's material
2: What did you learn in today's class?
For question 3: What happens when the user clicks on the 4th button on this page and why?

```
var nodes = document.getElementsByTagName('button');
for (var i = 0; i < nodes.length; i++) {
 nodes[i].addEventListener('click', function() {
  console.log('You clicked element #' + i);
 });
}
```