JavaScript: A Crash Course

Part II: Functions and Objects

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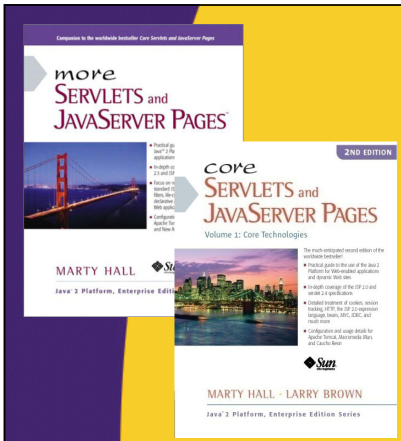
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Topics in This Section

- **Functions**
  - Basics
  - As first-class data types
  - Anonymous functions (closures)
- **Objects**
  - Object basics
  - Namespaces (static methods)
  - JSON
  - eval
- **Functions with variable numbers of arguments**

Intro

"JavaScript has more in common with functional languages like Lisp or Scheme than with C or Java."

- Douglas Crockford in article "JavaScript: The World's Most Misunderstood Programming Language".

Getting Good at JavaScript

- **JavaScript is not Java**
  - If you try to program JavaScript like Java, you will *never* be good at JavaScript.
- **Functional programming is key approach**
  - Functional programming is much more central to JavaScript programming than OOP is.
  - Java programmers find functional programming to be the single-hardest part of JavaScript to learn.
    - Because Java does not support functional programming
    - But programmers who use Ruby, Lisp, Scheme, Python, ML, Haskell, Clojure, Scala, etc. are accustomed to it
- **OOP is radically different than in Java**
  - So different in fact, that some argue that by Java's definition of OOP, JavaScript does not have "real" OOP.

Functions

"It is Lisp in C's clothing."

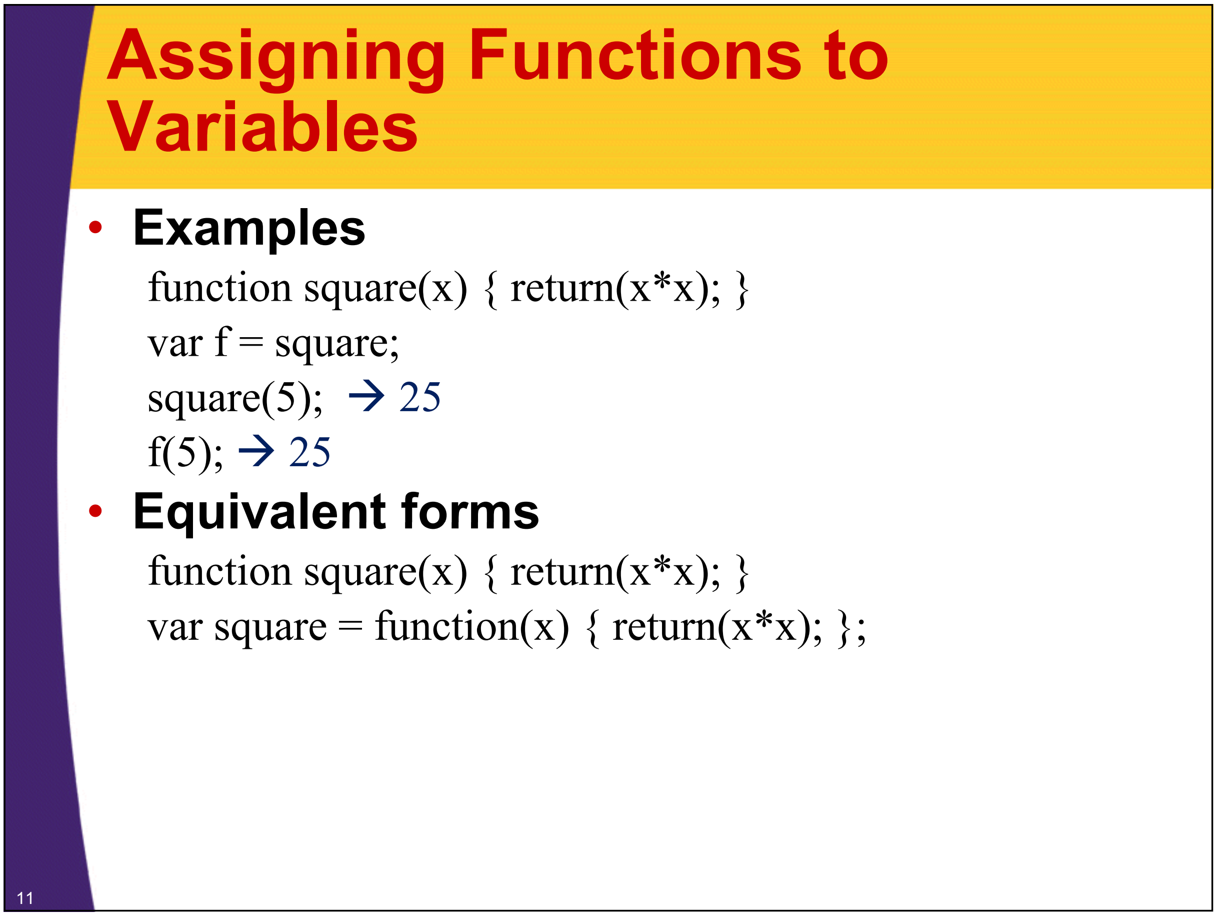
- JSON and YUI guru Douglas Crockford, describing the JavaScript language in *JavaScript: The Good Parts*.

Overview

- **Not similar to Java**
  - JavaScript functions *very* different from Java methods
- **Main differences from Java**
  - You can have global functions
    - Not just methods (functions as part of objects)
  - You don’t declare return types or argument types
  - Caller can supply any number of arguments
    - Regardless of how many arguments you defined
  - Functions are first-class datatypes
    - You can pass functions around, store them in arrays, etc.
  - You can create anonymous functions (closures)
    - Critical for Ajax
    - These are equivalent
      - function foo(...) {...}
      - var foo = function(...) {...}

Functions are First-Class Data Types

- Can assign functions to variables
  - function square(x) { return(x*x); }
  - var f = square;
  - f(5); → 25
- Can put functions in arrays
  - function double(x) { return(x*2); }
  - var functs = [square, f , double];
  - functs[0](10); → 100
- Can pass functions into other functions
  - someFunction(square);
- Can return functions from functions
  - function blah() { … return(square); }
- Can create a function without assigning it to a variable
  - (function(x) {return(x+7);})(10); → 17



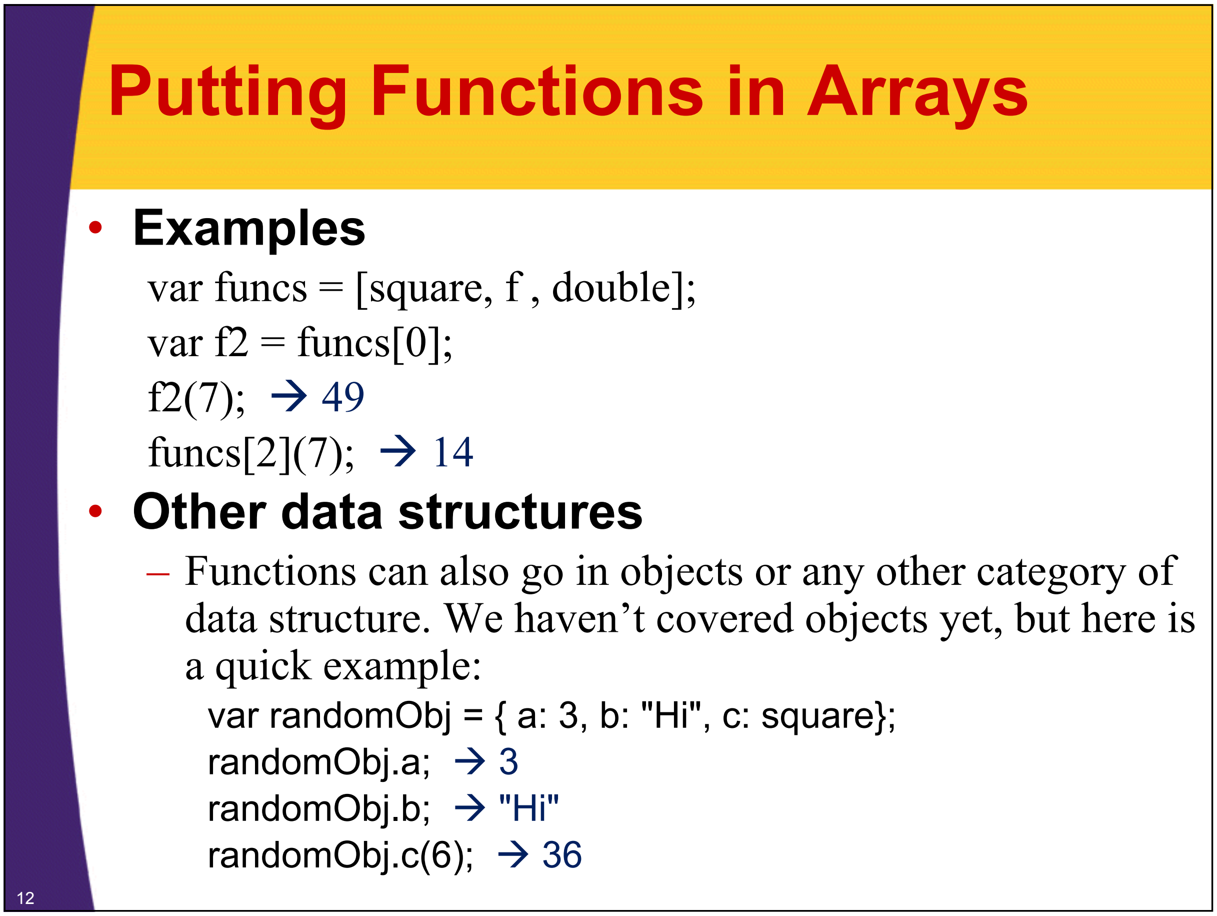
Assigning Functions to Variables

- **Examples**

```
function square(x) { return(x*x); }
var f = square;
square(5);  → 25
f(5); → 25
```

- **Equivalent forms**

```
function square(x) { return(x*x); }
var square = function(x) { return(x*x); };
```



Putting Functions in Arrays

- **Examples**

```
var funcs = [square, f , double];
var f2 = funcs[0];
f2(7);  → 49
funcs[2](7);  → 14
```

- **Other data structures**
  – Functions can also go in objects or any other category of data structure. We haven’t covered objects yet, but here is a quick example:

```
var randomObj = { a: 3, b: "Hi", c: square};
randomObj.a;  → 3
randomObj.b;  → "Hi"
randomObj.c(6);  → 36
```

Passing Functions into Other Functions

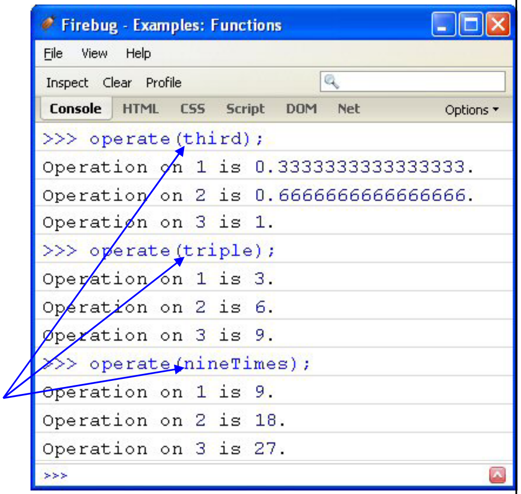
```
function third(x) {
  return(x / 3);
}

function triple(x) {
  return(x * 3);
}

function nineTimes(x) {
  return(x * 9);
}


function operate(f) {
  var nums = [1, 2, 3];
  for(var i=0; i<nums.length; i++) {
    var num = nums[i];
    console.log("Operation on %o is %o.",
                num, f(num));
  }
}
```

Function as argument.



Firebug - Examples: Functions
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```
>>> operate(third);
Operation on 1 is 0.3333333333333333.
Operation on 2 is 0.6666666666666666.
Operation on 3 is 1.
>>> operate(triple);
Operation on 1 is 3.
Operation on 2 is 6.
Operation on 3 is 9.
>>> operate(nineTimes);
Operation on 1 is 9.
Operation on 2 is 18.
Operation on 3 is 27.
>>>
```

Returning Functions from Functions

- **Examples**

```
function randomFunct() {
  if(Math.random() > 0.5) {
    return(square);
  } else {
    return(double)
  }
}
var f3 = randomFunct();
f3(5);  // Returns either 25 or 10
f3(5);  // Returns whatever it did on line above
```

- **Dynamically created functions**
  - Instead of a predefined function like square, you can return a new function with return(function(…) { …});

Can Create a Function without Assigning it to a Variable

- **Examples**

```
(function(x) {return(x+7);})(10);  → 17

function randomFunct2() {
  if(Math.random() > 0.5) {
    return(function(x) { return(x*x); });
  } else {
    return(function(x) { return(x*2); });
  }
}
```

  - Same behavior as previously shown randomFunct

- **More on anonymous functions**
  - Called “closures” if the functions refer to local variables from the outside. Can’t do Ajax without them!

Functions: Advanced Topics

Anonymous Functions with Static Data

- **Examples**

```
function makeTimes7Function() {
  return(function(n) { return(n*7); });
}
var f = makeTimes7Function();
f(7);   → 49
```

- **Equivalent form of function above**

```
function makeTimes7Function() {
   var m = 7;
   return(function(n) { return(n*m); });
}
var m = 700;  // Value of global m is irrelevant
var f = makeTimes7Function();
f(7);   → 49
```

Anonymous Function with Captured Data (Closures)

```
function makeMultiplierFunction(m) {
  return(function(n) { return(n*m); });
}



var test = 10;
var f = makeMultiplierFunction(test);
f(7);   → 70
test = 100;
f(7);   → 70   // Still returns 70
```

Point: when you call makeMultiplierFunction, it creates a function that has its own *private* copy of m. This idea of an anonymous function that captures a local variable is the *only* way to do Ajax without having the global variable problems that we showed in first section.

The apply Method: Simple Use

- **Idea**
  - Lets you apply function to array of arguments instead of individual arguments. It is a method *of* functions!
    - someFunction.apply(null, arrayOfArgs);
  - Later, we cover advanced usage with obj instead of null
- **Examples**

```
function hypotenuse(leg1, leg2) {
  return(Math.sqrt(leg1*leg1 + leg2*leg2));
}
hypotenuse(3, 4);  → 5
var legs = [3, 4];
hypotenuse.apply(null, legs);  → 5

Math.max.apply(null, [1, 3, 5, 7, 6, 4, 2]);  → 7
```

The call and apply Methods: Use with Objects

- **Idea**
  - call
    - Lets you call function on args, but sets “this” first.
      - Will make more sense once we cover objects, but the main idea is that “this” lets you access object properties. So, “call” treats a regular function like a method of the object.
  - apply
    - Same idea, but you supply arguments as array
- **Examples**

```
function fullName() {
   return(this.firstName + " " + this.lastName);
}
fullName();  → "undefined undefined"
var person = { firstName: "David", lastName: "Flanagan" };
fullName.call(person);  → "David Flanagan"
```

Object Basics

Basics

- **Constructors**
  - Functions named for class names. Then use “new”.
    - No separate class definition! No “real” OOP in JavaScript!
  - Can define properties with “this”
    - You must use “this” for properties used in constructors

```
function MyClass(n1) { this.foo = n1; }
var m = new MyClass(10);
```

- **Properties (instance variables)**
  - You don’t define them separately
    - Whenever you refer to one, JavaScript just creates it

```
m.bar = 20; // Now m.foo is 10 and m.bar is 20
```

    - Usually better to avoid introducing new properties in outside code and instead do entire definition in constructor
- **Methods**
  - Properties whose values are functions

Objects: Example (Circle Class)

```
function Circle(radius) {
  this.radius = radius;

  this.getArea =
    function() {
      return(Math.PI * this.radius * this.radius);
    };
}

var c = new Circle(10);
c.getArea(); // Returns 314.1592...
```

The prototype Property

- **In previous example**
  - Every new Circle got its own copy of radius
    - Fine, since radius has per-Circle data
  - Every new Circle got its own copy of getArea function
    - Wasteful, since function definition never changes
- **Class-level properties**
  - Classname.prototype.propertyName = value;
- **Methods**
  - Classname.prototype.methodName = function() {...};
    - Just a special case of class-level properties
  - This is legal anywhere, but it is best to do it in constructor
- **Pseudo-Inheritance**
  - The prototype property can be used for inheritance
    - Complex. See later section on Prototype library

Objects: Example (Updated Circle Class)

```
function Circle(radius) {
  this.radius = radius;

  Circle.prototype.getArea =
    function() {
      return(Math.PI * this.radius * this.radius);
    };
}

var c = new Circle(10);
c.getArea(); // Returns 314.1592...
```

Static Methods

Static Methods (Namespaces)

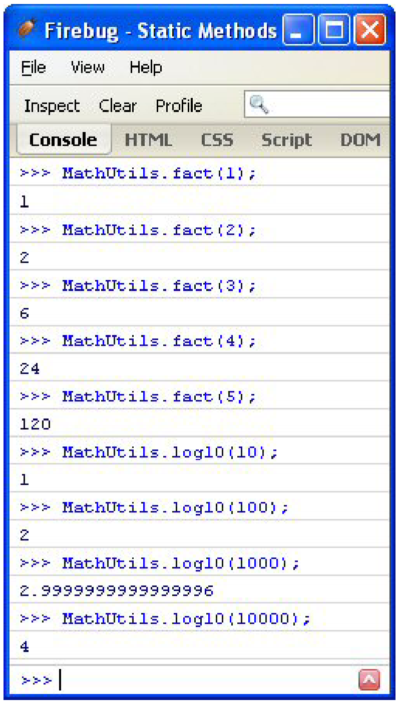
- **Idea**
  - Have related functions that do not use object properties
  - You want to group them together and call them with Utils.func1, Utils.func2, etc.
    - Grouping is a syntactic convenience. Not real methods.
    - Helps to avoid name conflicts when mixing JS libraries
  - Similar to static methods in Java
- **Syntax**
  - Assign functions to properties of an object, but do not define a constructor. E.g.,
    - var Utils = { }; // Or new Object(), or make function Utils
      Utils.foo = function(a, b) { … };
      Utils.bar = function(c) { … };
      var x = Utils.foo(val1, val2);
      var y = Utils.bar(val3);

Static Methods: Example (Code)

```
var MathUtils = {};

MathUtils.fact = function(n) {
  if (n <= 1) {
    return(1);
  } else {
    return(n * MathUtils.fact(n-1));
  }
};

MathUtils.log10 = function(x) {
  return(Math.log(x)/Math.log(10));
};
```



```
>>> MathUtils.fact(1);
1
>>> MathUtils.fact(2);
2
>>> MathUtils.fact(3);
6
>>> MathUtils.fact(4);
24
>>> MathUtils.fact(5);
120
>>> MathUtils.log10(10);
1
>>> MathUtils.log10(100);
2
>>> MathUtils.log10(1000);
2.9999999999999996
>>> MathUtils.log10(10000);
4
>>>
```

Namespaces in Real Applications

- **Best practices in large projects**
  - In many (most?) large projects, *all* global variables (including functions!) are forbidden due to the possibility of name collisions from pieces made by different authors.
  - So, these primitive namespaces play the role of Java's packages. Much weaker, but still very valuable.
- **Fancy variation: repeat the name**
    - var MyApp = { };
    - MyApp.foo = function foo(…) { … };
    - MyApp.bar = function bar(…) { … };
  - The name on the right does not become a global name. The only advantage is for debugging
    - Firebug and other environments will show the name when you print the function object.

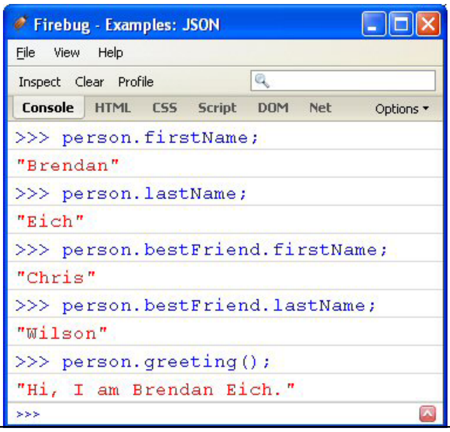
JSON: Anonymous Objects

JSON (JavaScript Object Notation)

- **Idea**
  - A simple textual representation of JavaScript objects
    - Called “object literals” or “anonymous objects”
  - Main applications
    - One-time-use objects (rather than reusable classes)
    - Objects received via strings
- **Directly in JavaScript**
  -
```
var someObject =
  { property1: value1,
    property2: value2,
    ... };
```
- **In a string (e.g., when coming in on network)**
  - Surround object representation in parens
  - Pass to the builtin “eval” function

JSON: Example

```
var person =
  { firstName:  'Brendan',
    lastName:   'Eich',
    bestFriend: { firstName: 'Chris',
                  lastName:  'Wilson' },
    greeting: function() {
                  return("Hi, I am " + this.firstName +
                         " " + this.lastName + ".");
                }
  };
```



```
>>> person.firstName;
"Brendan"
>>> person.lastName;
"Eich"
>>> person.bestFriend.firstName;
"Chris"
>>> person.bestFriend.lastName;
"Wilson"
>>> person.greeting();
"Hi, I am Brendan Eich."
>>>
```

Internet Explorer and Extra Commas

- **Firefox & Chrome tolerate trailing commas**
  - Tolerated in both arrays and anonymous objects
    - var nums = [1, 2, 3,];
    - var obj = { firstName: "Joe", lastName: "Hacker", };
- **IE will crash in both cases**
  - For portability, you should write it *without* commas after the final element:
    - var nums = [1, 2, 3];
    - var obj = { firstName: "Joe", lastName: "Hacker"};
  - This issue comes up moderately often, especially when building JSON data on the server, as we will do in upcoming lectures.

Other Object Tricks

- **The instanceof operator**
  - Determines if lhs is a member of class on rhs
    - if (blah instanceof Array) {
        doSomethingWith(blah.length);
      }
- **The typeof operator**
  - Returns direct type of operand, as a String
    - "number", "string", "boolean", "object", "function", or "undefined".
      - Arrays and null both return "object"
- **Adding methods to builtin classes**

```
String.prototype.describeLength =
    function() { return("My length is " + this.length); };
"Any Random String".describeLength();
```

- **eval**
  - Takes a String representing *any* JavaScript and runs it
    - `eval("3 * 4 + Math.PI");  // Returns 15.141592`

More on eval

- **Simple strings**
  - Just pass to eval
  - var test = "[1, 2, 3, 2, 1].sort()";
  - eval(test); → [1, 1, 2, 2, 3]
- **Strings that are delimited with { … }**
  - You have to add extra parens so that JavaScript will know that the braces are for object literals, not for delimiting statements.
    - It never hurts to do this, so add parens routinely
  - var test2 = "{ firstName: 'Jay', lastName: 'Sahn' }";
  - var person = eval("(" + test2 + ")");
  - person.firstName; → "Jay"
  - person.lastName; → "Sahn"

Functions with a Variable Number of Arguments

Variable Args: Summary

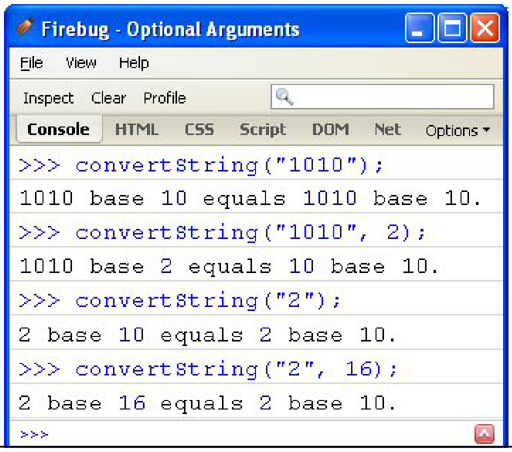
- **Fixed number of optional args**
  - Functions can *always* be called with any number of args
  - Compare typeof args to "undefined"
  - See upcoming convertString function
- **Arbitrary args**
  - Discover number of args with arguments.length
  - Get arguments via arguments[i]
  - See upcoming longestString function
- **Optional args via anonymous object**
  - Caller always supplies same number of arguments, but one of the arguments is an anonymous (JSON) object
    - This object has optional fields
    - This is the most widely used approach for user libraries
  - See upcoming sumNumbers function

Optional Args: Details

- **You can call *any* function with any number of arguments**
  - If called with fewer args, extra args are undefined
    - You can use typeof arg == "undefined" for this
      - You can also use boolean comparison if you are sure that no real value could match (e.g., 0 and undefined both return true for !arg)
    - Use comments to indicate optional args to developers
      - function foo(arg1, arg2, /* Optional */ arg3) {...}
  - If called with extra args, you can use “arguments” array
    - Regardless of defined variables, arguments.length tells you how many arguments were supplied, and arguments[i] returns the designated argument.
    - Use comments to indicate varargs
      - function bar(arg1, arg2 /* varargs */) { ... }

Optional Arguments

```
function convertString(numString, /* Optional */ base) {
  if (typeof base == "undefined") {
    base = 10;
  }
  var num = parseInt(numString, base);
  console.log("%s base %o equals %o base 10.",
              numString, base, num);
}
```


Firebug - Optional Arguments
File View Help
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```
>>> convertString("1010");
1010 base 10 equals 1010 base 10.
>>> convertString("1010", 2);
1010 base 2 equals 10 base 10.
>>> convertString("2");
2 base 10 equals 2 base 10.
>>> convertString("2", 16);
2 base 16 equals 2 base 10.
>>>
```

Varargs

```
function longestString(/* varargs */) {
  var longest = "";
  for(var i=0; i<arguments.length; i++) {
    var candidateString = arguments[i];
    if (candidateString.length > longest.length) {
      longest = candidateString;
    }
  }
  return(longest);
}
```

`longestString("a", "bb", "ccc", "dddd");` → "dddd"

Using JSON for Optional Arguments

- **Idea**
  - Caller always supplies same number of arguments, but one of the arguments is an anonymous (JSON) object
    - This object has optional fields
  - This approach is widely used in Prototype, Scriptaculous, and other JavaScript libraries
- **Example (a/b: required, c/d/e/f: optional)**
  - someFunction(1.2, 3.4, {c: 4.5, f: 6.7});
  - someFunction(1.2, 3.4, {c: 4.5, d: 6.7, e: 7.8});
  - someFunction(1.2, 3.4, {c: 9.9, d: 4.5, e: 6.7, f: 7.8});
  - someFunction(1.2, 3.4);

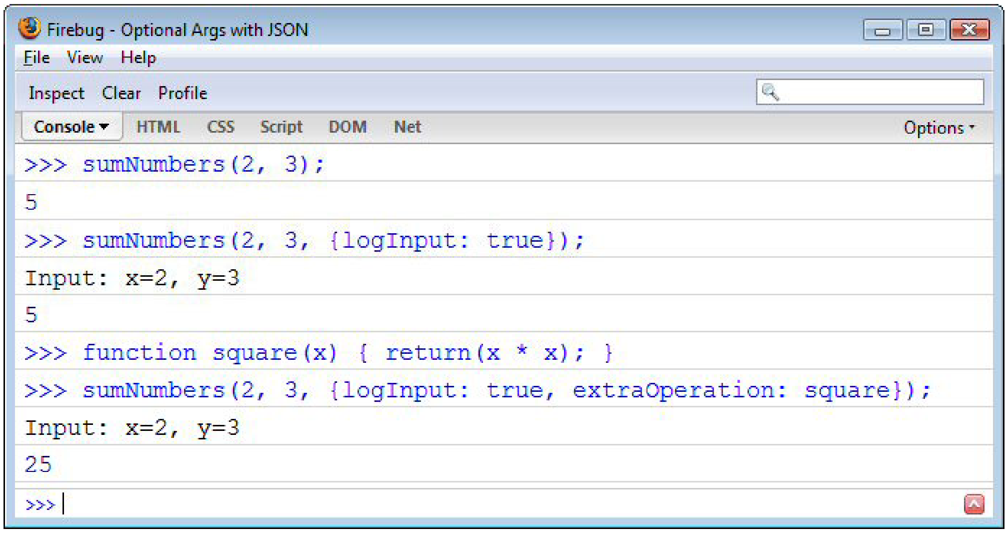
Using JSON for Optional Arguments: Example Code

```
function sumNumbers(x, y, extraParams) {
  var result = x + y;
  if (isDefined(extraParams)) {
    if (isTrue(extraParams.logInput)) {
      console.log("Input: x=%s, y=%s", x, y);
    }
    if (isDefined(extraParams.extraOperation)) {
      result = extraParams.extraOperation(result);
    }
  }
  return(result)
}

function isDefined(value) {
  return(typeof value != "undefined");
}

function isTrue(value) {
  return(isDefined(value) && (value == true))
}
```

Using JSON for Optional Arguments: Example Results



Firebug - Optional Args with JSON
File View Help
Inspect Clear Profile
Console HTML CSS Script DOM Net
Options

```
>>> sumNumbers(2, 3);
5
>>> sumNumbers(2, 3, {logInput: true});
Input: x=2, y=3
5
>>> function square(x) { return(x * x); }
>>> sumNumbers(2, 3, {logInput: true, extraOperation: square});
Input: x=2, y=3
25
>>>
```

Wrap-up

Summary

- **General**
  - Don’t try to universally use Java style when programming in JavaScript. If you do, you will see the bad features of JavaScript, but never the good features.
- **Functions**
  - Totally different from Java. Passing functions around and making anonymous functions very important.
    - Don’t think of this as rare or unusual, but as normal practice.
- **Objects**
  - Constructor defines class. Use “this”. Use prototype for methods.
    - Totally different from Java. Not like classical OOP at all.
- **Other tricks**
  - someFunction.apply(null, arrayOfArgs);
  - var someValue = eval("(" + someString + ")");
  - Various ways to do optional args. Object literals often best.

Questions?