CS 345

Introduction to JavaScript

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What's a Scripting Language?

- Language used to write programs that compute inputs to another language processor
  - One language embedded in another
    - Embedded JavaScript computes HTML input to the browser
    - Shell scripts compute commands executed by the shell
- Common characteristics of scripting languages
  - String processing – since commands often strings
  - Simple program structure, define things "on the fly"
  - Flexibility preferred over efficiency, safety
    - Is lack of safety a good thing? (Example: JavaScript used for Web applications…)

Why JavaScript?

- "Active" web pages
- Web 2.0
  - AJAX, huge number of Web-based applications
- Some interesting and unusual features
  - First-class functions - interesting
  - Objects without classes - slightly unusual
  - Powerful modification capabilities - very unusual
    - Add new method to object, redefine prototype, …
- Many security and correctness issues
- "The world's most misunderstood prog. language"

JavaScript History

- Developed by Brendan Eich at Netscape
  - Scripting language for Navigator 2
- Later standardized for browser compatibility
  - ECMAScript Edition 3 (aka JavaScript 1.5)
- Related to Java in name only
  - "JavaScript is to Java as carpet is to car"
  - Name was part of a marketing deal
- Various implementations available
  - SpiderMonkey C implementation (from Mozilla)
  - Rhino Java implementation (also from Mozilla)

Motivation for JavaScript

- Netscape, 1995
  - > 90% browser market share
    - "I hacked the JS prototype in ~1 week in May and it showed! Mistakes were frozen early. Rest of year spent embedding in browser" -- Brendan Eich, ICFP talk, 2006
- Design goals
  - Make it easy to copy/paste snippets of code
  - Tolerate "minor" errors (missing semicolons)
  - Simplified onclick, onmousedown, etc., event handling
  - Pick a few hard-working, powerful primitives
    - First-class functions, objects everywhere, prototype-based
  - Leave all else out!

Common Uses of JavaScript

- Form validation
- Page embellishments and special effects
- Navigation systems
- Basic math calculations
- Dynamic content manipulation
- Sample applications
  - Dashboard widgets in Mac OS X, Google Maps, Philips universal remotes, Writely word processor, hundreds of others…

Example 1: Add Two Numbers

```
<html>
    …
 <p>  … </p>
<script>
    var num1, num2, sum
    num1 = prompt("Enter first number")
    num2 = prompt("Enter second number")
    sum = parseInt(num1) + parseInt(num2)
    alert("Sum = " + sum)
</script>
    …
</html>
```

Example 2: Browser Events

```
<script type="text/JavaScript">
    function whichButton(event) {
     if (event.button==1) {
                alert("You clicked the left mouse button!") }
     else {
                alert("You clicked the right mouse button!")
     }}
</script>
...
<body onmousedown="whichButton(event)">
...
</body>
```

Mouse event causes page-defined function to be called

Other events: onLoad, onMouseMove, onKeyPress, onUnLoad

Example 3: Page Manipulation

- Some possibilities
  - createElement(elementName)
  - createTextNode(text)
  - appendChild(newChild)
  - removeChild(node)
- Example: add a new list item

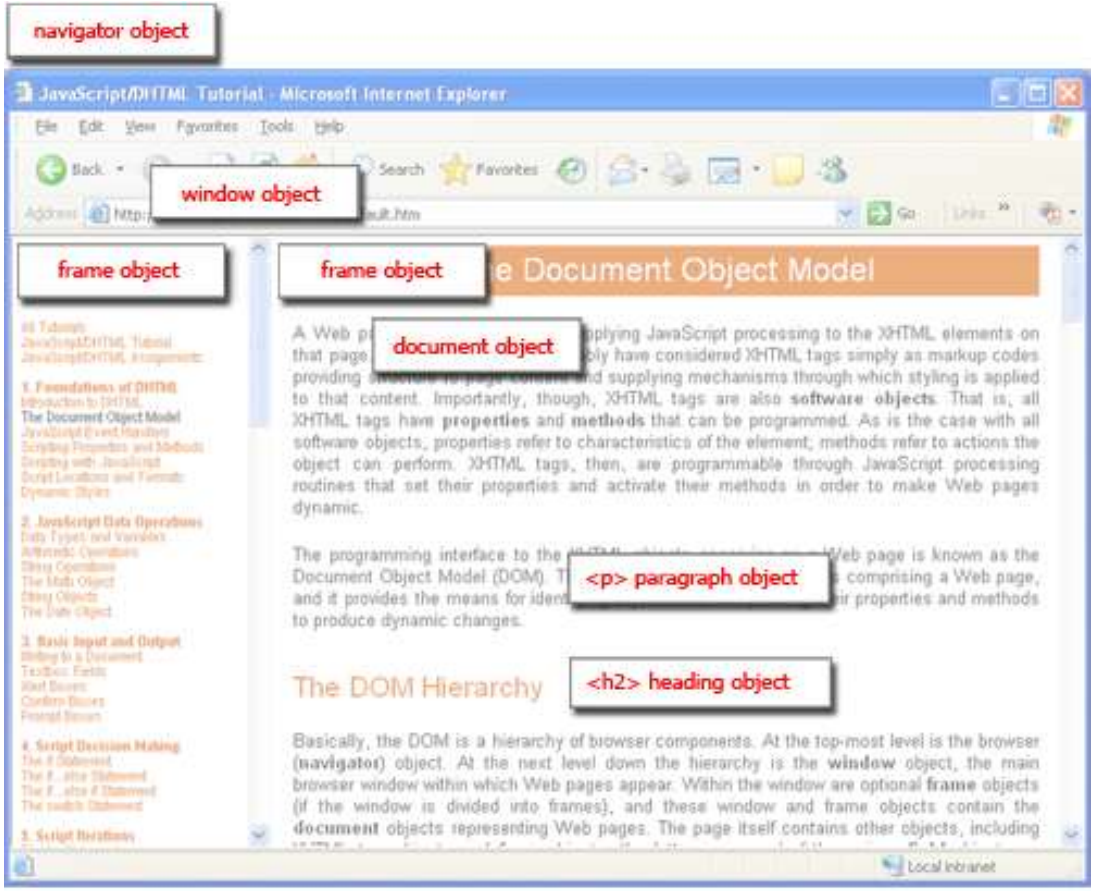
```
var list = document.getElementById('t1')
var newitem = document.createElement('li')
var newtext = document.createTextNode(text)
list.appendChild(newitem)
newitem.appendChild(newtext)
```

This uses the browser Document Object Model (DOM). We will focus on JavaScript as a language, not its use in the browser

Document Object Model (DOM)

- HTML page is structured data
- DOM provides representation of this hierarchy
- Examples
  - Properties: document.alinkColor, document.URL, document.forms[ ], document.links[ ], document.anchors[ ], …
  - Methods: document.write(document.referrer)
    - These change the content of the page!
- Also Browser Object Model (BOM)
  - Window, Document, Frames[], History, Location, Navigator (type and version of browser)

Browser and Document Structure



W3C standard differs from models supported in existing browsers

Reading Properties with JavaScript

Sample HTML

```
<ul id="t1">
<li> Item 1 </li>
</ul>
```

Sample script

```
1. document.getElementById('t1').nodeName
2. document.getElementById('t1').nodeValue
3. document.getElementById('t1').firstChild.nodeName
4. document.getElementById('t1').firstChild.firstChild.nodeName
5. document.getElementById('t1').firstChild.firstChild.nodeValue
```

- Example 1 returns "ul"
- Example 2 returns "null"
- Example 3 returns "li"
- Example 4 returns "text"
  - A text node below the "li" which holds the actual text data as its value
- Example 5 returns " Item 1 "

Language Basics

- JavaScript is case sensitive
  - onClick, ONCLICK, … are HTML, thus not case-sensitive
- Statements terminated by returns or semi-colons
  - x = x+1; same as x = x+1
- "Blocks" of statements enclosed in { …}
- Variables
  - Define using the var statement
  - Define implicitly by its first use, which must be an assignment
    - Implicit defn has global scope, even if occurs in nested scope!

JavaScript Blocks

- Use { } for grouping; not a separate scope

```
js> var x=3;
js> x
3
js> {var x=4; x}
4
js> x
4
```

- Not blocks in the sense of other languages

JavaScript Primitive Datatypes

- Boolean: true and false
- Number: 64-bit floating point
  - Similar to Java double and Double
  - No integer type
  - Special values NaN (not a number) and Infinity
- String: sequence of zero or more Unicode chars
  - No separate character type (just strings of length 1)
  - Literal strings using ' or " characters (must match)
- Special objects: null and undefined

Objects

- An object is a collection of named properties
- Think of it as an associative array or hash table
  - Set of name:value pairs
    - objBob = {name: "Bob", grade: 'A', level: 3};
  - Play a role similar to lists in Lisp / Scheme
- New members can be added at any time
    - objBob.fullname = 'Robert';
- Can have methods
- Can refer to this

Functions

- Functions are objects with method called "( )"
  - A property of an object may be a function (=method)
    - function max(x,y) { if (x>y) return x; else return y;};
    - max.description = "return the maximum of two arguments";
  - Local declarations may appear in function body
- Call can supply any number of arguments
  - functionname.length : # of arguments in definition
  - functionname.arguments.length : # arguments in call
  - Basic types are passed by value, objects by reference
- "Anonymous" functions
  - (function (x,y) {return x+y}) (2,3);

Examples of Functions

- Curried functions
  - function CurriedAdd(x) { return function(y){ return x+y} };
  - g = CurriedAdd(2);
  - g(3)
- Variable number of arguments
  - function sumAll() {

```
var total=0;
for (var i=0; i< sumAll.arguments.length; i++)
    total+=sumAll.arguments[i];
return(total); }
```

  - sumAll(3,5,3,5,3,2,6)

Anonymous Functions

- Anonymous functions very useful for callbacks
  - setTimeout(function() { alert("done"); }, 10000)
  - Evaluation of alert("done") delayed until function call
- Simulate blocks by function definition and call
  - var u = { a:1, b:2 }
  - var v = { a:3, b:4 }
  - (function (x,y) {

```
        var tempA = x.a; var tempB =x.b;  // local variables
        x.a=y.a; x.b=y.b;
        y.a=tempA; y.b=tempB
    }) (u,v)   // Works because objs are passed by ref
```

Basic Object Features

- Use a function to construct an object
  - function car(make, model, year) {
    this.make = make;
    this.model = model;
    this.year = year; }
- Objects have prototypes, can be changed
  - var c = new car("Ford","Taurus",1988);
  - car.prototype.print = function () {
    return this.year + " " + this.make + " " + this.model;}
  - c.print();

JavaScript in Web Pages

- Embedded in HTML page as <script> element
  - JavaScript written directly inside <script> element
    - <script> alert("Hello World!") </script>
  - Linked file as src attribute of the <script> element

    <script type="text/JavaScript" src="functions.js"></script>
- Event handler attribute

  <a href="http://www.yahoo.com " onmouseover="alert('hi');">
- Pseudo-URL referenced by a link

  Click me

We are looking at JavaScript as a language; ignore BOM, DOM, AJAX

Language Features in This Class

- Stack memory management
  - Parameters, local variables in activation records
- Garbage collection
- Closures
  - Function together with environment (global variables)
- Exceptions
- Object features
  - Dynamic lookup, encapsulation, subtyping, inheritance
- Concurrency

Stack Memory Management

- Local variables in activation record of function

```
function f(x) {
    var y = 3;
    function g(z) { return y+z;};
    return g(x);
}
var x= 1; var y =2;
f(x) + y;
```

Garbage Collection

- Automatic reclamation of unused memory
- Navigator 2: per-page memory management
  - Reclaim memory when browser changes page
- Navigator 3: reference counting
  - Each memory region has associated count
  - Count modified when pointers are changed
  - Reclaim memory when count reaches zero
- Navigator 4: mark-and-sweep, or equivalent
  - Garbage collector marks reachable memory
  - Sweep and reclaim unreachable memory

Closures

- Return a function from function call
  - function f(x) {
    var y = x;
    return function (z){y += z; return y;}
    }
  - var h = f(5);
  - h(3);
- Can use this idea to define objects with "private" fields (subtle)
  - See http://www.crockford.com/JavaScript/private.html

Exceptions

- Throw an expression of any type

```
throw "Error2";
throw 42;
throw {toString: function() { return "I'm an object!"; } };
```

- Catch

```
try {
} catch (e if e == "FirstException") {        // do something
} catch (e if e == "SecondException") {    // do something else
} catch (e){                                          // executed if no match above
}
```

Reference: http://developer.mozilla.org/en/docs/
Core_JavaScript_1.5_Guide :Exception_Handling_Statements

Object features

- Dynamic lookup
  - Method depends on run-time value of object
- Encapsulation
  - Object contains private data, public operations
- Subtyping
  - Object of one type can be used in place of another
- Inheritance
  - Use implementation of one kind of object to implement another kind of object

Concurrency

- JavaScript itself is single-threaded
  - How can we tell if a language provides concurrency?
- AJAX provides a form of concurrency
  - Create XMLHttpRequest object, set callback function
  - Call request method, which continues asynchronously
  - Reply from remote site executes callback function
    - Event waits in event queue…
  - Closures important for proper execution of callbacks
- Another form of concurrency
  - Use SetTimeout to do cooperative multi-tasking

JavaScript eval

- Evaluate string as code (seen this before?)
  - The eval function evaluates a string of JavaScript code, in scope of the calling code
    - var code = "var a = 1";
    - eval(code); // a is now '1‘
    - var obj = new Object();
    - obj.eval(code); // obj.a is now 1
  - Common use: efficiently deserialize a complicated data structure received over network via XMLHttpRequest
- What does it cost to have eval in the language?
  - Can you do this in C? What would it take to implement?

Unusual Features of JavaScript

- Eval, run-time type checking functions
- Support for pattern matching (reg. expressions)
- Can add methods to an object
- Can delete methods of an object
  - myobj.a = 5; myobj.b = 12; delete myobj.a;
- Iterate over methods of an object
  - for (variable in object) { statements }
- With statement ("considered harmful" – why?)
  - with (object) { statements }