

Software Development with Scripting Languages: Browser Side Scripting

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Javascript Syntax

- Standard name is ECMAScript
- C alike
- Semicolon ; is optional for multiple lines
- Interpreter is embedded on browser
- Code can be embedded in **HTML** with `<script>` tag.
- Browsers provide a **JavaScript** console

```
<head>
<!-- include a script file from URL -->
<script src="/libs/jquery/1.7.1/jquery.min.js">
</script>
</head>
<body>
<script>
var msg = 'hello'; var target='_world'
alert(msg + target) {
}
</script>
```

Values and Types

- Very minimal set of types: `string`, `number`, `object`
- Literals `'Hello'`, `"world"`, `3.454`, `7`, `{name:'value',id:5}`

- Type conversion is done as long as possible

```
a= "1"+4 ; a++ ; // a is 15
```

- Objects are created on the fly, in a way similar to `Python` dictionaries. Object method can access instance with `this`.

```
var counter = { val: 0 ,  
                get: function () {return this.val},  
                incr: function() { this.val++}}
```

```
counter.get()  
counter.incr()
```

- No type enforcement on objects.

Objects and Arrays

- Object members `student = { name: 'ali' }` can be accessed in two ways:

- `student.name`

- `student['name']`

- `Array` is a builtin object type that implements integer indexed elements.

```
a = [7,18,23] ; a[0] = a[1] + a[2]
```

- Some array methods work in place, modifies array:

```
a.sort() ; a.reverse()
```

```
a.push('hello') ; a.pop() ; a.unshift('hello') ; a.shift()
```

- Some returns new values:

```
a.indexOf(3) ; a.join(":") ; a.slice(2,4); a.length
```

```
a.filter(boolfunc) ; a.map(func); a.concat([3,4,5]) ;
```

Manipulating Objects

- Arbitrary members/methods can be added by assignments:

```
student = {} ; student.name='Ali'  
student['no'] = 444 // { name: 'Ali', no: 444 }
```

- Members can be deleted:

```
delete student.name // { no: 444 }
```

- Array elements can be deleted using `splice(start,num):`

```
a.splice(5,2) // delete a[5], a[6]
```

- Assignment is by reference. Copy can be done member by member.

- Testing for a member:

```
if ( student.hasOwnProperty('name')) or simply:  
if (student.name)
```

Operators

- Very similar to C. Most operators including increments, arithmetic assignments and conditional expression are works similar to C.
- '+' is concatenation unless both operands are numbers
- '/' is real division. `Math.floor/ceiling/round()`
- Numbers and strings are also objects. They have some conversion operators
- `Math` object contains more arithmetic functions.
- `/regexp/` creates a regular expression object.
`/^[0-9]+$/.test(mystring)` returns `true` or `false`, match result of regular expression

Conditionals and Loops

Similar to C:

- `if (cond) else if (cond2) else (cond3);`
- `switch (val) { case num1:...; break; case "str1":...;...}`
- `while (cond) { ... }`
- `do { ... } while (cond)`
- `for (i=0; i < n; i++) { ... }`
- Definite iteration on objects (`a=[1,4,6,10]; b={x:3,y:4,z:5}`)
 - `for (i in a) { ... a[i] ...} //i=0,1,2,3`
 - `for (i in b) { ... a[i] ...} //i='x','y','z'`

Exceptions

```
try {  
    ...  
} catch (excp) {  
    ...  
} finally {  
    ... // optional, executed always  
}
```

- `throw` statement can be used to raise an exception
- If not handled exceptions stop current script execution

Defining Functions

```
function f(param1, param2, param3) {  
    var x = ...  
  
    if (param3 == undefined) param3 = 'default_value'  
    ...  
    return val  
}  
  
// lambda like definition possible  
a = [1,2,3,4]  
b = a.map(function (x) { return x*x } )    // b= [1,4,9,16]  
// following two are equivalent:  
function add(x,y) { return x+y }  
var add = function (x,y) { return x+y }
```

Variable Scope and Lifetime

- Variables are global by default, regardless of their position of initialization

- `var` is used to create a variable in local scope.

```
var x; var y = 5 .
```

```
for (var i = 0; i < n ; i++) ...
```

- Using always `var` is a good practice. Otherwise using global scope causes confusions, especially in recursion.
- Variables used by an object can be hidden using scope:

```
function counter() {  
    var val = 0; // hidden inside the function  
    return { incr: function () { val++; },  
            get: function () { return val } }  
}  
a=counter()  
a.incr() ;      console.log(a.get())
```

- Similar **closures** can be defined.

```
function multiplyby(x) {  
    return function (y) {  
        return x*y;  
    }  
}  
  
twice = multiplyby(2);  
twice(4); // will return 8  
  
function sortBy(field) {  
    function compare(a,b) {  
        return (a[field] < b[field])? -1 : 1  
    }  
    return function (arr) {  
        arr.sort(compare)  
    }  
}  
  
rlist = [{name:'z',no:43},{name:'a',no:31},{name:'c',no:11}]  
namesort = sortBy('name') // a new function sorts by 'name'  
nosort = sortBy('no') // a new function sorts by 'no'  
namesort(rlist)  
nosort(rlist)
```

Assignment Semantics

- Share semantics
- Assignment copies reference, not data
- Object assignment creates two variables denoting same object
- Primitive values copied, objects shared (like Java)
- Parameters pass by value for primitives, reference for objects
- Copying requires special copy functions

- Objects can be created on the fly by `{...}`
- `this` denotes the current object inside the function members.
`{c:0, incr: function() { this.c++;}}`
- Classes can be created by class functions updating members of `this` and returning `this`.
- Updates on `this` updates a function prototype and when `return this` is executed this prototype instance is returned.
- New instances can be created as `new classfunction()`.
- Define a binary search tree class `BSTree` such that:

```
bst = new BSTree()
f=[["orange","orange"],["apple","red"],["banana","yellow"],
   ["watermelon","green"],["strawberry","pink"]]
for (i in f)    bst.insert(f[i][0], f[i][1])
color = bst.get("apple")
bst.forEach(function (n) { console.log(n.key+":"+n.value) })
```

```
function BSTree() {  
    var root = undefined;    // local scope, private  
    this.insert = function (key, value) {  
        if (root == undefined) {  
            root = { node: {key: key , value: value},  
                    left: new BSTree(), right: new BSTree() }  
        } else if ( key < root.node.key )  
            root.left.insert(key, value)  
        else if ( key > root.node.key )  
            root.right.insert(key, value)  
        else root.node.value = value;    }  
    this.get = function (key) {  
        if (root == undefined) return undefined  
        else if (key < root.node.key) return root.left.get(key)  
        else if (key > root.node.key) return root.right.get(key)  
        else return root.node.value    }  
    this.forEach = function (func) {  
        if (root == undefined)    return  
        root.left.forEach(func)  
        func(root.node)    // apply function to node content  
        root.right.forEach(func)    }  
}
```


Function Prototype

- Repeating function definitions in each instance is inefficient.
- Javascript binding searches `functionname.prototype` object for missing members for the object. So that a single copy per function/class maintained

```
function Counter() { this.value = 0 }
```

```
Counter.prototype.get = function () { return this.value }  
Counter.prototype.increment = function () { this.value++ }
```

```
c = new Counter() ; d = new Counter() ; e = new Counter()  
c.incr()  
console.log(c.get())
```

- `c,d,e` shares same prototype object of `Counter`.
- **prototype modifications after construction of an object affects the object**

BSTree class rewritten with prototype

```

function BSTree() {
    this.node = undefined;
}
BSTree.prototype.insert = function (key, value) {
    if (this.node == undefined) {
        this.node = {key: key , value: value}
        this.left = new BSTree(); this.right= new BSTree()
    } else if ( key < this.node.key )
        this.left.insert(key, value)
    else if ( key > this.node.key )
        this.right.insert(key, value)
    else this.node.value = value;
}
BSTree.prototype.get = function (key) {
    if (this.node == undefined) return undefined
    else if (key < this.node.key) return this.left.get(key)
    else if (key > this.node.key) return this.right.get(key)
    else return this.node.value
}
BSTree.prototype.forEach = function (func) {
    if (this.node == undefined)    return
    this.left.forEach(func)
    func(this.node)                // apply function to node content
    this.right.forEach(func)
}

```

Inheritance

- Prototypes can be chained for inheritance.

`Object.create(prototype)` Creates an object with prototype `prototype`. If you set prototype of `B` as an object with same prototype with `A`, bindings of `B` will be chained to `A`, results in inheritance.

```
function Shape(x, y) { this.x = x ; this.y = y }
Shape.prototype.move = function (x,y) {
  this.draw('background'); this.x = x; this.y = y;
  this.draw('foreground') }

function Circle(x, y, r) {
  Shape.apply(this,[x,y]); this.r = r    // Apply Shape constructor to this
}
Circle.prototype = Object.create(Shape.prototype)    // chain prototypes
Circle.prototype.constructor = Circle
Circle.prototype.draw = function (color) {
  console.log('drawing_circle_at', this.x, this.y, this.r, 'in', color)}

c = new Circle(10,10,5); c.move(30,20)
```

- Since EcmaScript 6 (2016) `class` definitions are implemented as syntactic sugar (maps code to old style prototype definitions)

```
class Shape {  
  constructor(x,y) { this.x = x; this.y = y}  
  move(x,y) { this.draw('background'); this.x = x; this.y = y ;  
             this.draw('foreground')  
  }  
}  
  
class Circle extends Shape {  
  constructor(x,y,r) { super(x,y); this.r = r}  
  draw(color) {  
    console.log('drawing_circle_at', this.x, this.y, this.r, 'in', color)  
  }  
}
```

BSTree class with new syntax

```
class BSTree {
  constructor() { this.node = undefined}
  insert(key, value) {
    if (this.node == undefined) {
      this.node = {key: key , value: value}
      this.left = new BSTree(); this.right= new BSTree()
    } else if ( key < this.node.key ) this.left.insert(key, value)
    else if ( key > this.node.key ) this.right.insert(key, value)
    else this.node.value = value;
  }
  get (key) {
    if (this.node == undefined) return undefined
    else if (key < this.node.key) return this.left.get(key)
    else if (key > this.node.key) return this.right.get(key)
    else return this.node.value
  }
  forEach (func) {
    if (this.node == undefined)    return
    this.left.forEach(func)
    func(this.node)                // apply function to node content
    this.right.forEach(func)
  }
}
```

Browser Objects

- `window`: an interface to browser. Loading a new page, etc.
- `document`: an interface to current document. Document Object Model members.
- `console`: Browser's Javascript console. `console.log(message)` can be used to write debugging outputs on console.
- `document` can be used to access and update current web page content dynamically.

Most important members of `document` are:

- `document.head` : Header, `<head>` element of current page.
- `document.body` : Body, `<body>` element
- `document.forms` : list of `<form>` elements in this document
- `document.title` : Page title.
- `document.cookie`: Cookies of current page.
- `document.links` : List of links of the document (as `<a>` elements).
- `document.getElementById`: searches and returns the element with given `id=...` attribute in the document.
- `document.getElementsByClassName` .`getElementsByTagName`: searches and returns all elements with given `class=...` attribute and given HTML tag respectively.
- `document.children[0]`: Top element, `<html>` of the document.

An HTML document contains nested elements. Top element is `<html>`. DOM element is a tree like representation of document structure. A DOM node named `e1` has the following members:

- `e1.children`: List of child HTML elements nested in this element. All `<...></...>` elements that are direct child of `e1`.
- `e1.childNodes`: List of child nodes including HTML elements and text.
- `e1.nodeType`: Type of the node, 1 for element, 2 for attribute, 3 for text and 8 for comment node.
- `e1.getAttribute(attr)`: returns attribute value for a given attribute. For example if an image element, `e1.getAttribute('src')` will give image URL.
- `e1.id`: Element id by `id="..."` attribute.
- `e1.className`: element class by `class="..."` attribute

- `el.innerHTML`: HTML text content enclosed by element. Can be updated.
- `el.outerHTML`: HTML text content including the element. Can be updated. i.e. assigning it to `''` deletes the element.
- `el.attributes`: Object to attributes. Attributes can be modified, inserted, removed.
- `el.setAttribute('border', '1')`: sets an attribute of the element
- `el.removeAttribute('border')`: remove an attribute of the element
- `el.insertBefore(newel, child)`: inserts an element as a child, before the child element.
`el.insertBefore(newel, el.children[0])` inserts it as the first child.
- `el.appendChild(newel)`: add element as the last child of the element.

Example: Add a `` element to document at the end of the document body:

```
var li1 = document.createElement("LI")
var li2 = document.createElement("LI")
var li3 = document.createElement("LI")
li1.appendChild(document.createTextNode("apple"))
li2.appendChild(document.createTextNode("banana"))
li3.appendChild(document.createTextNode("orange"))
var ul = document.createElement("UL")
ul.appendChild(li1)
ul.appendChild(li2)
ul.appendChild(li3)
document.body.appendChild(ul)
```

Example: Recursively traverse all elements and log the tag name and attributes:

```
function traverse(el) {  
    var str = el.tagName  
    var attr = []  
    if (el.attributes)  
        for (var i=0 ; i < el.attributes.length; i++)  
            attr.push(el.attributes[i].name + ":" +  
                      el.attributes[i].value)  
    console.log(str + "[" + attr.join(",") + "]")  
    // recurse to children  
    if (el.children)  
        for (var i=0; i < el.children.length ; i++)  
            traverse(el.children[i])  
}  
traverse(document.body)
```

DOM Actions

- HTML elements can have mouse, keyboard or other browsers events handler functions.

- Either defined as HTML attribute or set later on DOM:

```
<img .. onclick="JS_code_here">
```

```
el.addEventListener("onclick" , function () { ... })
```

- Multiple event listeners can be added and remove on DOM:

```
el.removeEventListener("onclick" , function () { ... })
```

- - `onclick`: mouse click
 - `ondblclick`: mouse double click
 - `onmouseover`: mouse pointer is over
 - `onkeypress`: keyboard key pressed (event object paramater)
 - `onbeforeload`: when object starts to be loaded
 - `onload`: when object is loaded

■ Events for form elements:

- `onchange`: when form element content changed
- `onselect`: when form element is selected
- `onfocus`: when form element gets focus
- `onblur`: when form element loses focus
- `onsubmit`: when form is submitted. Function should return `true` if default action (submit) should follow. Calling `el.submit()` will explicitly submit the form data.

■ Form data can be validated through these events. Form elements give access to input elements with their names.

`document.forms[0].surname` gives element:

`<input ... name="surname" ...>` of the first form.

■ Keyboard events get an event object containing

`keyCode`, `ctrlKey`, `shiftKey`, `AltKey` fields.

■ Mouse events get an event object containing

`button`, `clientX`, `clientY` fields.

Form data validation example:

```
<script>
function checkname(fname) {
    var n = document.getElementById('myform')
    var m = document.getElementById(fname + 'msg')
    if ( /^[a-z A-Z]+$/.test(n[fname].value)) {
        m.textContent = "[OK]"; return true
    } else {
        m.textContent = "[INVALID]"; return false
    } }

function checkage(fname) {
    var n = document.getElementById('myform')
    var m = document.getElementById(fname + 'msg')
    if ( n[fname].value > 0 && n[fname].value < 200) {
        m.textContent = "[OK]"; return true
    } else {
        m.textContent = "[INVALID, 1-200]"; return false
    } }

function checkform() {
    return (checkname('Name') && checkname('Surname') &&
        checkAge('Age')) }

</script>
```

Continued:

```
...  
<form id="myform" action="..." method="post">  
Name: <input type="text" name="Name"  
      onblur="checkname('Name')"/>  
      <span id="Namemsg"></span>  
<br/>  
Surname: <input type="text" name="Surname"  
         onblur="checkname('Surname')"/>  
         <span id="Surnamemsg"></span>  
<br/>  
Age: <input type="text" name="Age"  
     onblur="checkage('Age')"/>  
     <span id="Agemsg"></span>  
<br/>  
<input type="submit" name="submit" value="Send"  
      onclick="return_checkform()"/>  
</form>  
...
```

AJAX

- Asynchronous Javascript And XML
- Browser script can make HTTP requests to web server to load/update data dynamically.
- XMLHttpRequest object does the job.
- Synchronous operation: block until request completed and result is taken. **blocks interpreter!**.
- Asynchronous operation: gets a callback function and function is called by browser when request status changes.
- open(method,path, async) method sets up the connection
- send() will initiate the request
- On success response contains the server response.
- If server sends XML document responseXML contains DOM of it.


```
function getFlights(depcity) {
    var req = new XMLHttpRequest()
    // assume getflights/city gives direct flights
    req.open('POST', '/getflights/' + depcity, false) // synchronous
    req.send('id=all&nres=100') // blocks until response ready
    if (req.status == 200) { // success
        return req.responseXML // XML DOM of result
    } else
        return undefined
}
```

Server can return an XML DOM value of direct flights from city:

```
<xml>
<flights><flight no="LH1231" dep="ESB" dest="MUN">Munih</flight>
          <flight no="TK5434" dep="ESB" dest="ERC">Lefkosa</flight>
          <flight no="TK22" dep="ESB" dest="BRL">Berlin</flight>
</flights>
</xml>
```

This DOM can be processed similar to HTML DOM.

Asynchronous operation handled by `onreadystatechange` event, called on different stages. `readyState == 4` when connection is ended.

```
function getFlights(depcity, updatefunc) {
    var req = new XMLHttpRequest()
    req.open('POST', '/getflights/'+depcity, true) // asynchronous
    req.onreadystatechange = function () {
        if (req.readyState == 4 && req.status == 200) { // success
            updatefunc(req.responsXML)
        } else
            alert('request failed: ' + req.status)
        req.send('id=all&nres=10') // if POST, send form data here
    } // no value returned. function will be called when ready
function updflight(xmlDOM) { // update <SELECT> with flights
    var flights = xmlDOM.getElementsByTagName('flight')
    var selbox = document.getElementById('flightselect')
    selbox.innerHTML = ""
    for (var i in flights) {
        var fno = flights[i].getAttribute('no')
        var fdest = flights[i].getAttribute('dest')
        var opt = document.createElement("OPTION")
        opt.setAttribute('fno', fno)
        opt.textContent = flights[i].textContent
    }
}
getFlights('ankara', updflight)
```

JSON

- JavaScript Object Notation
- Shorter and easier than XML for exchanging data. Similar to JavaScript.

```

user = '{"name":"Onur",
      "courses": [{"code":5710498, "name":"ceng498"},
                  {"code":5710536, "name":"ceng536"}],
      "room":"B-209"}'

// eval('userobj = ' + user)  works but insecure!!!! Avoid it....
userobj = JSON(user)         // Javascript object
userstring = JSON(userobj)   // back to first string

```

- All languages have libraries for JSON generation and parsing.

```

import json
user = '{"name":"Onur",
      "courses": [{"code":5710498, "name":"ceng498"},
                  {"code":5710536, "name":"ceng536"}],
      "room":"B-209"}'

userobj = json.loads(user)  # python dictionary
userstring = json.dumps(userobj)  # back to string

```

- JSON is denoted by `application/json` in `Content-type` header.

`Content-type: application/json`

```
{ "result": "success",  
  "flights": [  
    { "no": "LH1231", "dep": "ESB", "dest": "MUN", "city": "Munih" },  
    { "no": "TK5434", "dep": "ESB", "dest": "ERC", "city": "Lefkosa" },  
    { "no": "TK2222", "dep": "ESB", "dest": "BRL", "city": "Berlin" }  
  ]  
}
```

- Server side can easily convert their objects into JSON strings.
- `XMLHttpRequest` object `response` member can be parsed directly into Javascript object.
`result = JSON.parse(x.response)`
- Much more easier than traversing XML DOM.

JQuery

- A Javascript library for easier Javascript development
 - Shorter and easy to use element selectors `$(".id")`
 - Browser version abstraction. Same code support multiple browsers
 - Animations with stylesheet
 - Easy document manipulation and AJAX
 - Ready to use interactive widgets through **JQuery-UI**
 - Many contributed applications and widgets sets.
- You need to download a version from <http://jquery.com> and include in web page for example inside of `<head></head>`:
`<script src="/jquery/jquery.min.js"></script>`
- or Google hosted one:
`<script src="//ajax.googleapis.com/ajax/libs/jquery/1.9.1/jquery.min.js">`

Selectors

- `$` is a shorthand for `jQuery`.
- Selector `$()` is entry point of jQuery.
- Selector select a set of DOM elements. Returns a result object.

```
$("tagname"), $("#id"), $(".class"), $("parent_>_immchild")
```

```
$("parent_descend") $("[attr]"), $("[attr=value]")
```

```
$("[attr!=notvalue]") $("[attr^=prefix]"), $("[attr$=suffix]")
```

```
$("p,span,div") (or conn.),
```

- There are more in selector syntax and selectors can be combined:

```
$("table.plist_img[src$=.jpg]") selects all img tags with src attribute ends with jpg and that are contained in tables with class plist.
```

Manipulation

- Matched elements inner content can be changed. Operation is applied on all elements:
 - `.html(content)` replaces inner HTML.
 - `.text(content)` replaces inner text, HTML escaped.
 - `.append(content)` add content as the last item inside
 - `.before(content)` add content as the first item inside
 - `.wrapInner(content)` enclose inner elements with content
- Matched elements surroundings can be changed:
 - `.wrap(content)` elements enclosed in content
 - `.after(content)` content inserted after elements
 - `.before(content)` content inserted before elements
- Elements can be removed or hidden
 - `.remove()` remove elements
 - `.hide()`, `show()`, `toggle()` hide, show, toggle visibility
- Attributes:
 - `.addClass(cls)`, `removeClass(cls)`
 - `.attr(attr, val)`, `.removeAttr(attr)` set/remove elements attribute

Traversal

- `.find(sel)` apply filter on current elements
- `.each(func)` apply function to all elements

```
$("#*").each(function (i,e){console.log(i+el.tagName)})
```

will print all element tags in document.
- `.next()` give sibling following each element
- `.prev()` give sibling preceding each element
- `.children()` give children of each element
- `.parent()` give parent of each element

Events

- General form of setting an event handler:

`.on("event", data, func (ev) {...})`

`data` is passed as `ev.data` to handler.

`.on("event", func (ev) {...})` is no data version

`event` can be `"click"`, `"blur"`, `"focus"`, `"submit"`, `"select"`, ...

- All events are also provided as functions:

`.click(func)`, `.blur(func)`, `.submit(func)`, ...

- Cancelling event handlers: `.off()`, all handlers.

`.off("click")`, all click handlers.

`.off("click", myfunc)` only `myfunc` handler.

- `.one()` binds a one time only event handler.

- `$.post()` and `$.get()` can be used to make AJAX requests directly.
- `$.post(url, data, succfunc, datatype)` is the full usage:
 - `data` is either a query string or an object. If object `jQuery` converts it into a query string using `$.param()`
 - `succfunc` is a function to be called on success. It gets server response as parameter.
 - `datatype` is the type of server response, xml,json,...
 - `$.post(...).fail(func(){...})` defines failure functions
- Form data can be converted on POST query string:
`$('form').serialize()`
- For detailed functionality, use `$.ajax()`.

Flights example with jQuery:

```
function getFlights(depcity, updatefunc) {  
    $.get('/getflights/'+depcity, updfight)  
    .fail(function() { alert('error')})  
    // assume JSON response, jQuery automatically parse  
    // and send object to success function  
}  
  
function updfight(resp) {    // assume json respons  
    $('#flightselect').html('')    // clear  
    for (var i in resp.flights) {  
        $('#flightselect').append('<option></option>')  
        // :last() select last child. methods can be cascaded  
        $('#flightselect>:last()').attr('fno',resp.flights[i].fno)  
        .text(resp.flights[i].city)  
    }  
}  
getFlights('ankara',updfight)
```

- Implement **View** on browser side
- **Control** on browser side call server side **Control** via **AJAX**
- Server side model updates are loaded in view on browser side.
- All server responses converted into XML or more practically JSON
- Javascript get responses and update web page.
- More dynamism achieved in HTML5 through **web sockets**.