Client-Side Programming with JavaScript

What is JavaScript?

- A cross-platform object-oriented scripting language
- Especially used for web clients (and servers, and more)
- Originally developed by Netscape (LiveScript, 1995) to add interactivity to HTML pages
- Interpreted language (browsers include JS interpreters)
  - ⇒ Source Portability
  - ⇒ Performance not as good as with compiled languages (but this is not very relevant on clients)
- Quite different from Java
  - the commonality with Java stands mainly in the C-like syntax and in some features inspired by Java

Java and JavaScript

Java

- Compiled to bytecode
- Object-oriented, based on classes and instances
- Inheritance based on class hierarchy
- Classes are defined at compile-time. No type change at runtime
- Variable type must be declared
- Restrictions apply (e.g. for writing to disk) in applets

JavaScript

- Interpreted in source form
- Object-oriented, based on classes and instances
- Inheritance based on the prototype mechanism
- Methods and attributes can be dynamically added at runtime
- Variables need not be declared
- Restrictions apply (e.g. for writing to disk) in any script

JavaScript, Jscript, ECMAScript

- Some dialects of JavaScript exist
  - most notably, Jscript (Microsoft) and ActionScript (Adobe)
- The core of JavaScript, common to the other dialects, has been standardized by ECMA (European Computer Manufacturers Association) as ECMA-262
- The standard language has been renamed ECMAScript
- The standard has been issued also as ISO/IEC-16262
- JavaScript (Netscape) JScript (IE) and ActionScript all conform to the standard
  - each of them adds nonstandard extensions and a host context (objects for interacting with the environment)

References

- These slides refer mainly to JavaScript 1.8.X (complying with ECMA-262 5.1). The main novelties introduced with subsequent ECMAScript versions (6-9) will be presented.
- Documentation:
  - Core JavaScript Guide

    https://developer.mozilla.org/en/JavaScript/Guide
  - JavaScript Reference Guide

    https://developer.mozilla.org/en/JavaScript/Reference
  - ECMAScript Standard

    http://www.ecma-international.org/publications/standards/Ecma-262.htm

What can we do with JavaScript (in a browser)?

- Without scripting, HTML is static (cannot make decisions, iterate tasks, react to single keystrokes or mouse clicks,…)
- Web scripting languages like JavaScript combine scripting with HTML in order to make pages more interactive
- In particular, with JavaScript you can make pages that
  - react to events (e.g. a user clicks on an HTML element, loading a page terminates, a user hits a key on the keyboard,…)
  - read and modify any HTML element of the displayed document
  - detect the browser being used
  - create and view cookies
  - open new windows, tabs and pop-ups

Typical Uses of Client-Side Scripts

- **Validation** of form data during form filling
  - saves processing time on the server and makes reaction to errors faster
- **User interactions** not possible with simple forms (e.g. alert boxes for message visualization and data entry)
- **Page animation** cursor movement, image drawing, etc.
- **Adaptation** of HTML pages to the browser
- And much more (e.g. contextual menus, messages on the browser status line, opening windows and pop-ups,…)

Including JavaScript into HTML

- JavaScript code can be included using the HTML **`script`** element in two different forms:

```
<script type="text/javascript">
  document.write("Hello world!")
  …
</script>
```

JavaScript code

```
<script type="text/javascript"
        src="http://my.site/menu.js">
</script>
```

JavaScript filename

- When a browser encounters a script element:
  - interprets the code included in or referenced by the script element (**`document.write`** statements write in the script position)

Script Attributes

- **`TYPE`** : the MIME type (specifies the language the script belongs to) – REQUIRED
- **`SRC:`** a reference to the source file of the script
- **`DEFER:`** specifies that execution will be deferred after page has finished loading
- **`ASYNC:`** specifies the script will be executed asynchronously (while rest of page loads)

Can improve rendering speed with no-output scripts because the browser has not to wait for script termination

Alternative Contents

- A **noscript** element can be added after a script element in order to detect cases when JavaScript code cannot be executed.
- Example:

```
<script type="text/javascript">
    document.write("Hello world!")
    …
</script>
<noscript>
  Sorry: Your browser does not support or has
  disabled javascript
</noscript>
```

Old/Nonstandard Browsers

- There is a trick based on JavaScript comments that can be used with old or nonstandard browsers that cannot interpret the script and noscript tags:

Script Positioning

- Script elements in the HTML HEAD
  - Processed when a page loads but before starting page rendering
  - Useful for writing META tags or for including code that must be readily available in the whole page (e.g. functions)
- Script elements in the HTML BODY
  - Processed when the element is encountered by the browser in the page processing flow
  - Useful for writing parts of the HTML body

Code Execution Time

- When the page loads
  - Script elements in the HEAD
- When the page is displayed
  - Script elements in the BODY
- When invoked by other code fragments or when some environment event occurs
  - functions in any (already processed) script element

Error Reporting

- Normally JavaScript is executed in a browser
- Each browser has its own way for error reporting
- Examples

Browser	JavaScript Error Reporting
Firefox	Error console displayed by Shift-Ctrl-J (Shift-Command-J)
Chrome	Error console displayed by Shift-Ctrl-J (Shift-Command-J)
IE	Automatic after customization (in Options->Advanced, uncheck Disable Script Debugging and check Display Notification about Every Script Error)

js-error.html

Basic Communication with the Environment (I/O)

- Different I/O targets supported:
  - Browser Window
  - HTML Document that is being displayed
  - Client Keyboard
  - Client Mouse
  - Files
- Pre-defined objects represent environment elements (e.g. **`window`**, **`document`**)
- Code can be associated with events (e.g. mouse clicks)

The Main Forms of I/O

- **`document.write`** writes to the current HTML page
  - The characters written are interpreted by the HTML interpreter (formatting tags can be used)
- **`window.alert`** creates an alert window with the specified text (no HTML) and one confirm button
- **`window.confirm`** similar to alert but the window has 2 buttons (one for confirming, one for cancelling) and a boolean is returned
- **`window.prompt`** similar to confirm with an additional input text field and returns the entered string

Alert Example

```
<html>
<head><title>Hello world (with alert)</title></head>
<body>
<script type="text/javascript"><!--
    alert("Hello world!")
//--></script>
<noscript>
    Sorry: Your browser does not support or has
  disabled javascript
</noscript>
</body>
</html>
```

window is implied

js-alert.html

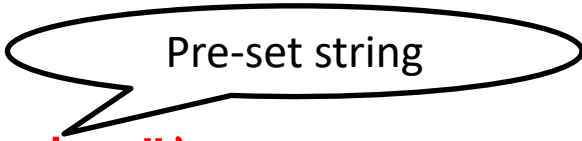
Confirm Example

```
<html>
<head><title>Confirm Example</title></head>
<body>
<script type="text/javascript"><!--
  if(confirm("press OK to proceed"))
    document.write("<H1>You confirmed</H1>");
  else
    document.write("<H1>You cancelled</H1>");
//--> </script>
<noscript>
  Sorry: Your browser does not support or has
  disabled javascript
</noscript>
</body>
</html>
```

js-confirm.html

Prompt Example

```
<html>
<head><title>Confirm Example</title></head>
<body>
<script type="text/javascript"><!--
  val = prompt("Enter location\n", "Torino");
  if(val)
    document.write("<H1>"+"You    confirmed:    "+val+
                   "</H1>");
  else
    document.write("<H1>You cancelled</H1>");
//--> </script>
…
</body>
</html>
```



[js-prompt.html]

Execution Blocking

- **`prompt, confirm`**
  - Execution is blocked waiting for user input
- **`alert`**
  - Behavior differs according to OS:
    - UNIX-like systems: Execution is not blocked
    - Windows systems: Execution is blocked

=> If you want to block execution, use prompt or confirm

Main Language Elements

- Basic Syntax Rules
- Constants and Variables
- Operators and Expressions
- Control Flow Constructs
- Functions
- Arrays
- Objects

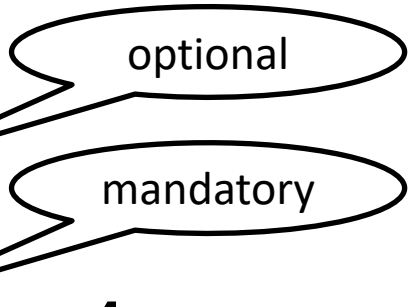
Comments

- Single-line comments introduced by `//` or by `<!--`
- Multi-line comments delimited by `/*` and `*/`
  - Start of comment `/*`
  - End of comment `*/`

Statement Termination

- Each statement should be terminated by a *semicolon* (`;`)
- The semicolon may be substituted by a *carriage-return*
- Examples:

```
a = 3
b = 4;
a = 3; b = 4;
```



- Using the semicolon is a good habit!

Identifiers

- In JavaScript identifiers are used to name variables, functions, labels, …
- Identifiers are words such that
  - The initial is a letter, underscore (_) or dollar (**$**)
  - The next characters are letters, digits, underscores or dollars
  - The word is not a reserved word
- Javascript is *case sensitive*
  - Var1 ≠ var1

Reserved words (1)

abstract	delete	function
boolean	do	goto
break	double	if
byte	else	implements
case	enum	import
catch	export	in
char	extends	instanceof
class	false	int
const	final	interface
continue	finally	long
debugger	float	native
default	for	new

Reserved words (2)

null
package
private
protected
public
return
short
static
super
switch
synchronized
this
throw
throws
transient
true
try
typeof
var
void
volatile
while
with

Literals

- Literals are used to represent constant values. Examples:

```
12

1.2

"ciao"   // a string

'ciao'   // another way of writing
         // a string

true, false

null
```

Types

- Javascript built-in types:
  - Number
  - Boolean
  - String
  - Symbol
  - **`Null`**
  - **`Undefined`**
  - Object

Primitive types

Includes functions

Numbers

- A number is a double precision floating point numeral written in decimal, octal or hexadecimal, with integer or real notation
  - range for integers: $[-2^{53}, 2^{53}]$
  - least non-zero floating point: $\pm 5 \times 10^{-324}$
  - greatest floating point: $\pm 1.7976931348623157 \times 10^{308}$
- decimal numerals start with no extra leading 0 digit

  examples: `77` `0.987645` `-3.278e-30`
- octal numerals start with 0

  examples: `077` `02376`
- hexadecimal numerals start with `0x` or `0X`

  examples: `0x77` `0X123456789abcDEF`

Special Number Constants

- **`Infinity`** or **`Number.POSITIVE_INFINITY`**
  - Represents +∞
- **`Number.NEGATIVE_INFINITY`**
  - Represents -∞
- **`NaN`** or **`Number.NaN`**
  - Represents a result that is “not-a-number”
- **`Number.MAX_VALUE`**
  - the greatest non-infinite number that can be represented
- **`Number.MIN_VALUE`**
  - the least positive non-zero number that can be represented

`Number` **is a built-in object**

Booleans and Strings

- Booleans
  - There are just two boolean literals: **`true`** and **`false`**
  - They are automatically converted into 1 and 0 when necessary

- Strings
  - Sequences of characters written between `"` or `'`
  - examples: **`"23"`** **`'JavaScript'`**

Special Characters

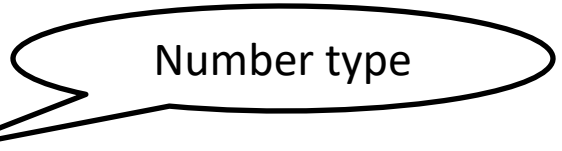
- In addition to normal character symbols and UNICODE characters (**`\uXXX`**, where **`XXX`** is an hexadecimal numeral) JavaScript strings may include:
  - `\'` (simple quote)
  - `\"` (double quote)
  - **`\b`** (backspace)
  - **`\f`** (form feed)
  - **`\n`** (line feed)
  - **`\r`** (carriage return)
  - **`\t`** (tab)
  - `\\` (backslash)
  - **`\v`** (vertical tab)
  - `\0` (NUL)

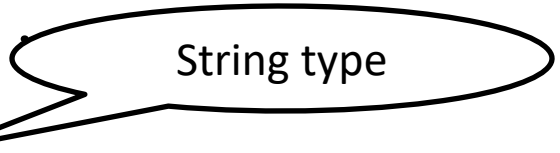
Variables

- JavaScript is loosely typed
- Variables in JavaScript can be used with much freedom
  - a variable can be identified by any identifier
  - a variable has no fixed type
    - a type is assigned at each assignment
    - type may change according to the context where the variable is referenced
  - a variable needs no declaration
  - a variable can be assigned by the assignment operator =

Example: Variable Assignments

```
<SCRIPT TYPE="text/javascript">
<!--
height=2+3.4;
document.write(height);
document.write("<BR>");
height="5.4 meters";
document.write(height);
// --> </SCRIPT>
```





[js-var-assign.html]

Variable Declaration

- Even if declaration is not necessary ***declaration is possible (and declaring variables is a good practice)***
- Variable declarations are introduced by the **`var`** keyword:

```
var a,i,str;
```

- Multiple declarations are legal
- A variable declared inside a function is local
- A variable used without declaration is always global

Variable Initialization

- A declared variable has value **`undefined`** until a value is assigned to it
- Any attempt to read a variable with undefined value raises a runtime error (just like reading a variable with no declaration and no previous assignment)

Variable Scoping

- Until EcmaScript 5 there were just two possible scopes for variables
  - Local
    - variables declared inside a function
  - Global
    - variables declared outside a function
    - variables used without an explicit declaration
- EcmaScript 6 introduced *block scope* (using let):

```
{
  let x=1;
  var y=2;
}
```

Defined only within block

Also visible outside block (global)

Arrays

- Arrays in JavaScript have C-like syntax with integer offsets starting at 0
- Example:

  `document.write(a[1])` writes the second element of array a

- An array can be simply created by assigning a variable a list of values delimited by square brackets
- Example:

```
a = [‘x’,’xyz’,’awl’] // a now contains an array
```

Multidimensional Arrays

- The array syntax can be extended to multiple dimensions by simply having array elements that are arrays
- Examples:

```
a = [
      ['x','y','z'],
      ['a','b','c'],
      ['d','e','f']
    ]

fst = ['x','y','z']
snd = ['a','b','c']
trd = ['d','e','f']
arr = [fst, snd, trd]       // equivalent to a
```

Objects

- Object = collection of *properties*
  - similar to a C struct

  but
  - properties may contain *values*, nested *objects* or *functions*
  - properties are dynamic (may be created and destroyed at runtime)
- A property inside an object is referenced by the dot notation:
  - **`imagine.height`**
  - **`imagine.length`**

Methods and built-in Objects

- A property that is a function is called a method
- Note that JavaScript is object-oriented but objects may exist even without classes

- JavaScript has a collection of built-in objects that can be referenced globally (and are like libraries):
  - Math, Date, RegExp, JSON
  - Object, Function, Array
  - String, Boolean, Number
  - The global object
  - Error objects: Error, EvalError, RangeError, SyntaxError, …

Global Object

- When the JavaScript interpreter starts the execution of a script, a *global object* is created
- Any global variable declared or used within the script is considered as a property of the global object.
- Any built-in function is a method of the global object
- The global object can be referenced by **`this`**
  - Note that inside a function **`this`** has a different meaning!

Call object

- The local variables of a function are properties of a special object called call object
- A call object is created when a function execution starts
- A call object exists only for the duration of the corresponding function execution

Constants

- A constant is like a variable but it is read-only
- A constant is such if it is declared using the **`const`** keyword:
  - **`const buf_len=81;`**
  - **`const month="february";`**
- Some constants are properties of the predefined object **`Math`**
  - Example: **`Math.PI`** denotes π

Expressions and Operators

- Expressions can be built combining literals, constants, variables, operators and function calls (C-like syntax)
- Simple expressions (no operator)

```
"result"
3.2
```

- Unary operators

```
-2.3
```

- Binary operators

```
3.14159*2.564
```

- Ternary operators

```
val>5? 4:0;
```

Arithmetic Operators

Operator	Example	Meaning
`+`	`x + y`	addition
`-`	`x - y`	subtraction
`*`	`x * y`	multiplication
`/`	`x / y`	division, returns a double
`++`	`++x`	pre-increment
	`x++`	post-increment
`--`	`--x`	pre-decrement
	`x--`	post-decrement
`-`	`-x`	opposite
`%`	`x % y`	modulus (division reminder)

Relational Operators

- Return a boolean value

`>`	`x > y`	greater than
`>=`	`x >= y`	greater than or equal to
`<`	`x < y`	less than
`<=`	`x <= y`	less than or equal to
`==`	`x == y`	is equal to
`!=`	`x != y`	is not equal to
`===`	`x === y`	is equal to (and of same type)
`!==`	`x !== y`	is not equal to (and of same type)
`in`	`a in x`	is a property of object
instanceof	`y` instanceof `x`	is an instance created by constructor

Equality Operators

- **`x==y`**
  - True if x and y are the same, after data type conversions
- **`x===y`**
  - True if x and y are the same both in value, and type

- Example

```
var x=3.2, y="3.2";
```

`x==y` is true

`x===y` is false

Inequality Operators

- **`x!=y`**
  - True if x and y are different, even after data type conversions
- **`x!==y`**
  - True if x and y are of different value or type
- Example

```
var x=3.2, y="3.2";
x!=y        is false
x!==y       is true
```

Example of `instanceof`

```
var birthday=new date(2000, 9, 12);

if  (birthday instanceof date)……
```

true

Logical and Bitwise Operators

`&&`	`x && y`	AND
`||`	`x || y`	OR
`!`	`!x`	NOT

- Bitwise operators

`&`	`x & y`	bitwise AND
`|`	`x | y`	bitwise OR
`^`	`x ^ y`	bitwise EXOR
`~`	`~x`	bitwise NOT
`<<`	`x<<3`	left shift (`x<<3`)
`>>`	`x>>3`	right **arithmetic** shift
`>>>`	`x>>>3`	right **logical** shift

The Assignment Operator

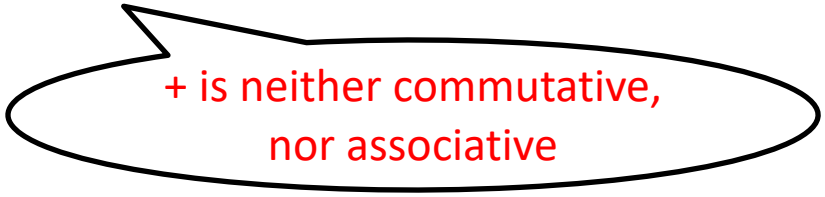
- Assignment is an operator, like in C
- Example:
  - `val=3*10.45;`
  - `x=y=0;`

Other Assignment Operators

- `x += y` is equivalent to `x = x + y`
- `x -= y` is equivalent to `x = x - y`
- `x *= y` is equivalent to `x = x * y`
- `x /= y` is equivalent to `x = x / y`
- `x %= y` is equivalent to `x = x % y`
- `x <<= y` is equivalent to `x = x << y`
- `x >>= y` is equivalent to `x = x >> y`
- `x >>>= y` is equivalent to `x = x >>> y`
- `x &= y` is equivalent to `x = x & y`
- `x ^= y` is equivalent to `x = x ^ y`
- `x |= y` is equivalent to `x = x | y`

String Operators

- Relational operators can be applied on strings
- Concatenation: **+** **+=**
- Examples
  - **"x:"+3** is equivalent to **"x:3"**
  - **1+2+" times"** is equivalent to **"3 times"**
  - **"x: "+1+2** is equivalent to **"x: 12"**
  - **name = "Charles"**
  - **name += " Dickens"**



The `typeof` Operator

- Returns the name of the operand type as a string
- Examples:
  - **`typeof 17.54`** is equivalent to **`"number"`**
  - **`typeof (“Hello”)`** is equivalent to **`"string"`**
  - **`typeof true`** is equivalent to **`"boolean"`**
  - **`typeof null`** is equivalent to **`"object"`**
  - **`typeof parseInt`** is equivalent to **`"function"`**
- If applied to a variable returns its current type (if the variable is not declared or has not yet been assigned returns **`undefined`**)
- Example
  - ```
    if(typeof(x)=="string")
      document.write(“x is a string variable: “+x);
    ```
    ```

The `void` Operator

- Prefix operator applied to an expression in order to evaluate the expression without using the result
- Always returns **`undefined`** (but any side effect of expression evaluation will be observable)
- Example:

```
<a href="javascript:void(myfun())">
Click here to call myfun</a>
```

Lets the user invoke myfun without effects on the displayed page.

The Conditional Operator

- Like in C:

(<*condition*>) ? <*expr1*> : <*expr2*>

- Semantics
  - If *condition* is true the result is *expr1*
  - else the result is *expr2*

The comma Operator

- Like in C:
  - The left operand is evaluated first
  - Then the right operand is evaluated
  - The result of the expression is the result of the evaluation of the right operand
- Example:
  - `i=28,k="hello",n=3.24;`
  - The result is 3.24 (and the assignments are executed as a side effect)

Other Miscellaneous Operators

- **`new`**
  - Makes a new instance of an object
- **`delete`**
  - deletes a property of an object

Operator Precedence Classes

class	operators	
1	`() [] .`	parenthesis, call member
2	`++ --`	increment/decr
3	`+ - ~ !`	unary
4	`* / %`	multiplicative
5	`+ -`	additive
6	`<< >> >>>`	shift
7	`&`	bitwise and
8	`|`	bitwise or
9	`^`	bitwise exor
10	`< > >= >=`	relational

class	operators	
11	`== != === !==`	equality
12	`&&`	logical and
13	`|`	logical or
14	`? :`	ternary cond.
15	`= += -= *= /= %= <<= >>= >>>= &= ^= |=`	assignment
16	`,`	sequential eval.

Operator Associativity

- Right-to-left

`new`	object creation
`++ --`	increment and decrement
`+ - ! ~`	unary operators
`? :`	conditional
`= *= /= %= += …`	assignment

- Left-to-right
  - all the other operators

Explicit Casting

- In JavaScript there is no cast operator but there are conversion functions
- A string can be converted to a number by the functions:
  - **`parseInt(str)`** for integers
  - **`parseFloat(str)`** for reals

  If the string is not a number, the result is **`NaN`**
- A string can be converted to a boolean by the function:
  - **`Boolean(str)`**
- Any data can be converted to a string by the function
  - **`String()`**

Statements

- The simplest statement is a single assignment

```
i=3.2478;
```

- Sequences of statements can be grouped into blocks (delimited by curly braces as in C):

```
{
    x=3;
    y="hello";
    z=x+y;
}
```

`if` Statement

- Syntax (C-like):

Optional part

`if(`<*predicate*>**`)`** <*statement1*> **`else`** <*statement2*>

- Examples
  - `if(x<=3) k=0;`
  - `if(x<=3) k=0 else k=-1;`
  -
```
if(x<=3)
      k=0
else if (y==0)
        k=-1
      else k=1;
```

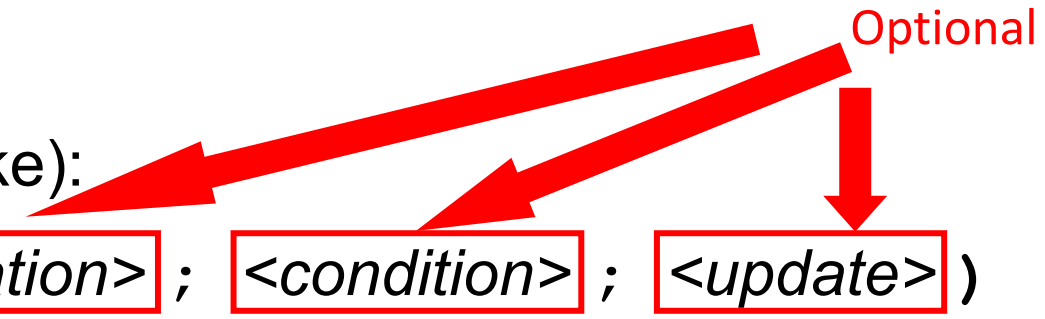
`switch` Statement

- Syntax (C-like):

```
switch(<expression>){
        case <label1>: <statement_1>;
        case <label2>: <statement_2>;
        …
        default: <statement_n>;
}
```

- A label can be any expression (even with non-integer and non-numeric value) Examples:
  - `Math.PI`
  - `V[3]`

`for` Loop



- Syntax (C-like):

```
for (<initialization> ; <condition> ; <update> )
    <statement>
```

- Example:

```
for (s=0,x=5,y=1 ; x>0 ; x--,y+=2)
        s+=x*y;
```

`for……in` Loop

- Syntax:

`for (`<*variable*>**` in `**<*object*>**`)**

<*statement*>

- Example (print properties of object my_object):

```
for (prop in my_object) {
     name= "Property Name: " + prop;
     val = "Value: " + my_object[prop];
     document.write(name+"-"+val+"<br>");
}
```

`while` Loop

- Syntax (C-like):

  `while(`<*condition*>**`)`**

  <*statement*>

- Example:

```
var x=5;
var y=1;
while (x>1)
    {y*=x; x--};
```

do…while Loop

- Syntax (C-like):

  do <*statement*>

  while(<*condition*>**)**

- Example:

```
var x=5;
var y=1;
do {
   y*=x; x--
 } while (x>1);
```

`break` Statement

- Like in C, interrupts the innermost loop or switch
- Example:

```
switch (x){
   case "item1": y="10, 20, 30";
                 break;
   case "item2": y="2, 4, 6";
                 break;
   default: y="no availability of "+x;
}
```

Labels and `continue`

- **`continue`** causes the control flow to proceed to the next iteration
- A label can be used to identify a particular program point (same C syntax)
- Labels cannot be referenced by goto (there is no goto in JavaScript) but can be referenced by continue and break

Labels and `continue` Example

```
checkiandj :
   while (i<4) {
      document.write(i + "<BR>");
      i+=1;
      checkj :
         while (j>4) {
            document.write(j + "<BR>");
            j-=1;
            if ((j%2)==0)
               continue checkiandj;
            document.write(j + " is odd.<BR>");
         }
      document.write("i = " + i + "<br>");
      document.write("j = " + j + "<br>");
   }
```

`with` Statement

- Lets the programmer refer implicitly to a given prefix
- Syntax:

```
with(<object>)
  <statement>
```

- Example

```
x=Math.sin(i*Math.PI/4);
y=Math.cos(j*Math.PI/4);
```

is equivalent to

```
with(Math){
    x=sin(i*PI/4);
    y=cos(j*PI/4);
};
```

Functions

- Can be defined by the user in various ways
  - By a function definition
  - By a literal function definition
  - By the **`Function`** constructor
- A function can be called only if it is built-in or it has already been defined within the script (with a scope including the call site)

`function` Definition

- Syntax (C-like):

Optional

`function` *<identifier>* **`(`** *<parameter list>* **`)`**

`{` *<function body>* **`}`**

- Example:

```
function nfact(n)
{ var i=1;
  while(n>1) {i*=n; n--};
  return i;
}
```

Recursion

- Javascript admits recursive functions

- Example:

```
function nfact_rec(n)
{ if (n>1)
      return n*nfact_rec(n-1)
      else return 1
}
```

Argument Passing

- Function arguments are always passed by value

but

- If an object is passed as argument, the object property values can be modified
- Actual argument lists may have variable length
  - Arguments passed in excess can be accessed by the built-in array **`arguments[i]`**
  - The actual number of arguments passed in a call can be accessed by the built-in property **`arguments.length`**

Example: Accessing a Variable-Length Argument List

- Example:

```
function myConcat(separator) {
      var result="";
      for(var i=1; i<arguments.length; i++) {
         result+=arguments[i]+separator;
      }
      return result;
}
```

- Call example:

```
myConcat(", ",1,2.32,"3",4)
```

- Output:

```
1, 2.32, 3, 4,
```

Nested Functions

- A function can be defined inside another function
- Example:

```
function addSquares (a,b) {
     function square(x) {
        return x*x;
     }
     return square(a) + square(b);
}
a=addSquares(2,3) // a is 13
b=addSquares(3,4) // b is 25
c=addSquares(4,5) // c is 41
```

Scope of square

Scoping Rules

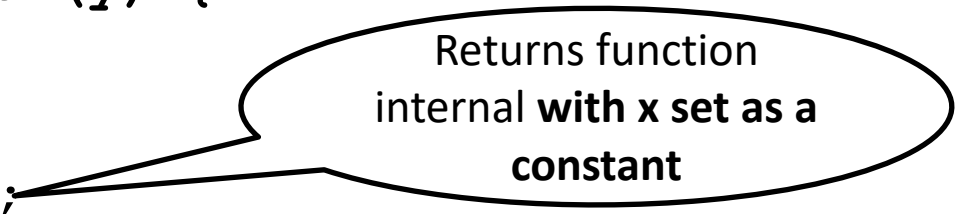
- JavaScript uses lexical scoping rules
- A function definition opens a new scope with accessibility to
  - whatever is accessible in the outer scope
  - variables, arguments and functions defined in the function block (these are visible only in the new scope and its sub-scopes, except variables used without the var keyword, which are global)
- Example:

```
var x = 10;
function testScope(y) { return y + x; }
alert(testScope(7)); // displays 17
function testEnv() {
  var x = -1;
  return testScope(7); // displays 17
}
```

Functions as Objects

- Functions are objects: they can be passed as arguments, returned as return values and assigned to variables
- Example (special case):

```
function external(x) {
      function internal(y) {
         return x-y;
      }
      return internal;
}
result = external(3)(5) // result is -2
```

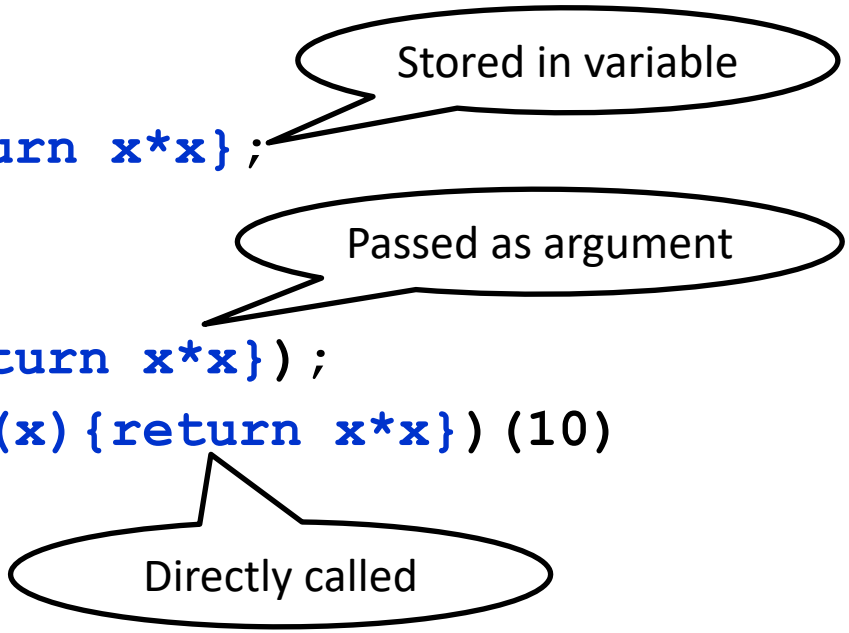


Function Expressions (Literal Functions)

- A literal function is a single-use function definition
  - Scope is limited to the place where the function is defined
  - Name can be omitted

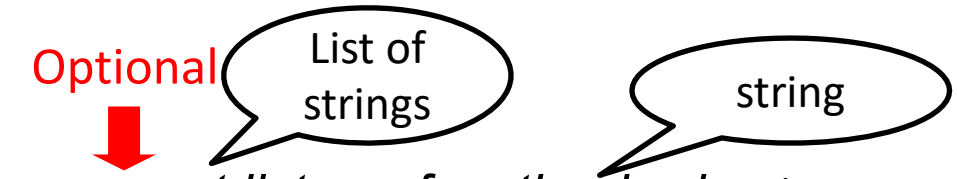
- Examples:

```
var f = function(x){return x*x};
var i = 3.24;
i=f(i);
obj.prop(function(x){return x*x});
var hundred = (function(x){return x*x})(10)
```



The `Function` Constructor

- Can be used to define a function “on the fly” (i.e at runtime)
- Syntax:




```
new Function( <argument list> ,<function body> )
```

- Example:

```
var square = new Function("x", "return x*x");
var i=3.22;
i=square(i);
```

Function call

More about `arguments`

- Other properties of **`arguments`**
  - **`arguments.caller`** name of calling function
  - **`arguments.callee`** name of called function
  - **`arguments.callee.length`** number of arguments (in the definition)
- Example:

```
function check( param ) {
  var actual = arguments.length;
  var expected  = arguments.callee.length;
  if (actual != expected)
      return false;
  else
      return true;
}
```

- The use of **`arguments`** as a property of Function is deprecated (only the variable **`arguments`** should be used)

Some Useful built-in (global) Functions

- **`escape(str)`**
  - Encodes **`str`** using hexadecimal escape sequences for non-ASCII characters so that it can be ported on any platform
- **`unescape(str)`**
  - The inverse of **`escape(str)`**
- **`isFinite(val)`**
  - Returns true if **`val`** is (a number) different from **`NaN`**, **`Number.POSITIVE_INFINITY`**, **`Number.NEGATIVE_INFINITY`**
- **`isNaN(val)`**
  - Returns true if **`val`** is not a number (**`NaN`**).

Some Useful built-in (global) Functions

- **`eval(str)`**
  - Interprets **`str`** as a string containing JavaScript code and executes this code.

More About JavaScript Objects

- Objects exist independently of classes
  - Each object has its own properties and methods
  - Each new object has a fresh copy of properties and methods
- Classes of objects sharing some properties can be created using
  - constructor functions
  - the object prototype (a special built-in property available in every object). More on this later on

Object Creation

- Objects can be created by simply listing their properties and initial values as comma separated *name*:*value* pairs
- Example:

```
var 3D_point = {x:2, y:8.32, z:-2.45};
i = 3D_point.x;
j = 3D_point.y;
k = 3D_point.z;
```

- All properties are public

Adding and Deleting Properties

- A new property can be added by simply assigning it a value
- Example:

```
3D_point.t=30.4 // new property t added
```

- A property can be removed by the **`delete`** operator
- Example:

```
delete 3D_point.x  // the other properties
                   // remain unaffected
```

Adding Methods

- This is just a particular case of property addition
- Example:

```
3D_point.dist=function(){Math.sqrt(
this.x*this.x+this.y*this.y+this.z*
this.z)};
```

Gives access to the properties of the object on which the function is called

- The added method can be invoked only on the object it has been added to

Object Creation Using Constructors

- The object creation method discussed so far requires that properties are specified each time an object is created
- A constructor is a way to specify properties once for all objects of a particular type
- A constructor can be invoked by the **`new`** operator
  - creates a new object with the properties specified by the constructor

Object Creation Using Constructors

- Example: A constructor for objects representing complex numbers
  - Properties:
    - **`re`** real part
    - **`im`** imaginary part
    - **`modulus`** method that computes the modulus
    - **`phase`** method that computes the phase

```
function modulus(){
    return Math.sqrt(this.re*this.re+this.im*this.im)
};
function phase(){
    return Math.atan(this.im/this.re)
};
function complex(x,y) {
    this.re = x;
    this.im = y;
    this.modulus = modulus;
    this.phase = phase;
}
```

```
var num= new complex(-2.1,3.7);
i=num.modulus();
j=num.phase();
```

Other Possible Formulation

```
function complex(x,y) {
    this.re = x;
    this.im = y;
    this.modulus = function() {
      return Math.sqrt(this.re*this.re+this.im*this.im)
    };
    this.phase = function() {
      return Math.atan(this.im/this.re)
    };
}
```

```
var num= new complex(-2.1,3.7);
i=num.modulus();
j=num.phase();
```

Empty Objects

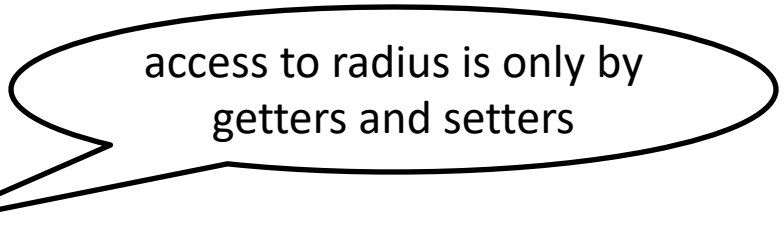
- An empty object (without custom properties) can be created by the Object constructor (built-in):

```
var x = new Object();
```

- Properties can be added to an empty object as already shown

Making Properties Private

- Even if properties are all public, private properties can be simulated by variables declared inside functions
- Example:




```
circle = function(){
    var radius;
    this.setRadius = function(x){radius = x};
    this.getRadius = function(){return radius};
    this.area = function(){
        return radius*radius*Math.PI
    }
}
```

Accessing Properties by Expressions

- The name used to reference a property can be an expression
- Example:

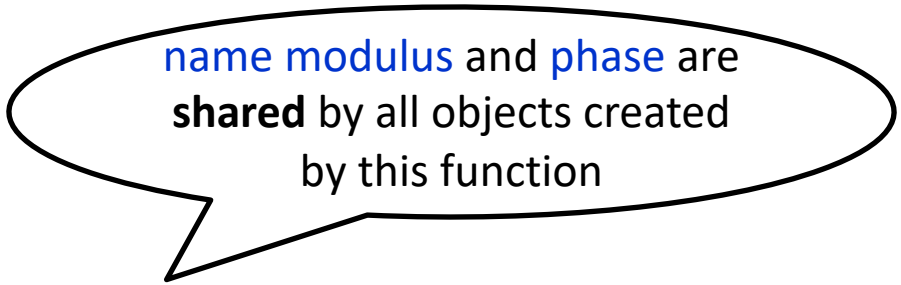
```
var a = {x:-0.33; y:3.14 ;z:6.54};
var i = "z";
height = a[i]; //access to a.z
```

Using Prototypes

- The definition of a constructor is similar to a class definition but all the properties defined in a constructor (including methods) are like instance variables
  - each object created with **`new`** gets a fresh copy of each method (and of each other property)
  - this may waste memory
- Prototypes enable the equivalent of static (class) variables
- Each function has a **`prototype`** property that holds properties that must not be replicated when creating new objects using the function as a constructor
  - a method defined in the prototype is not replicated

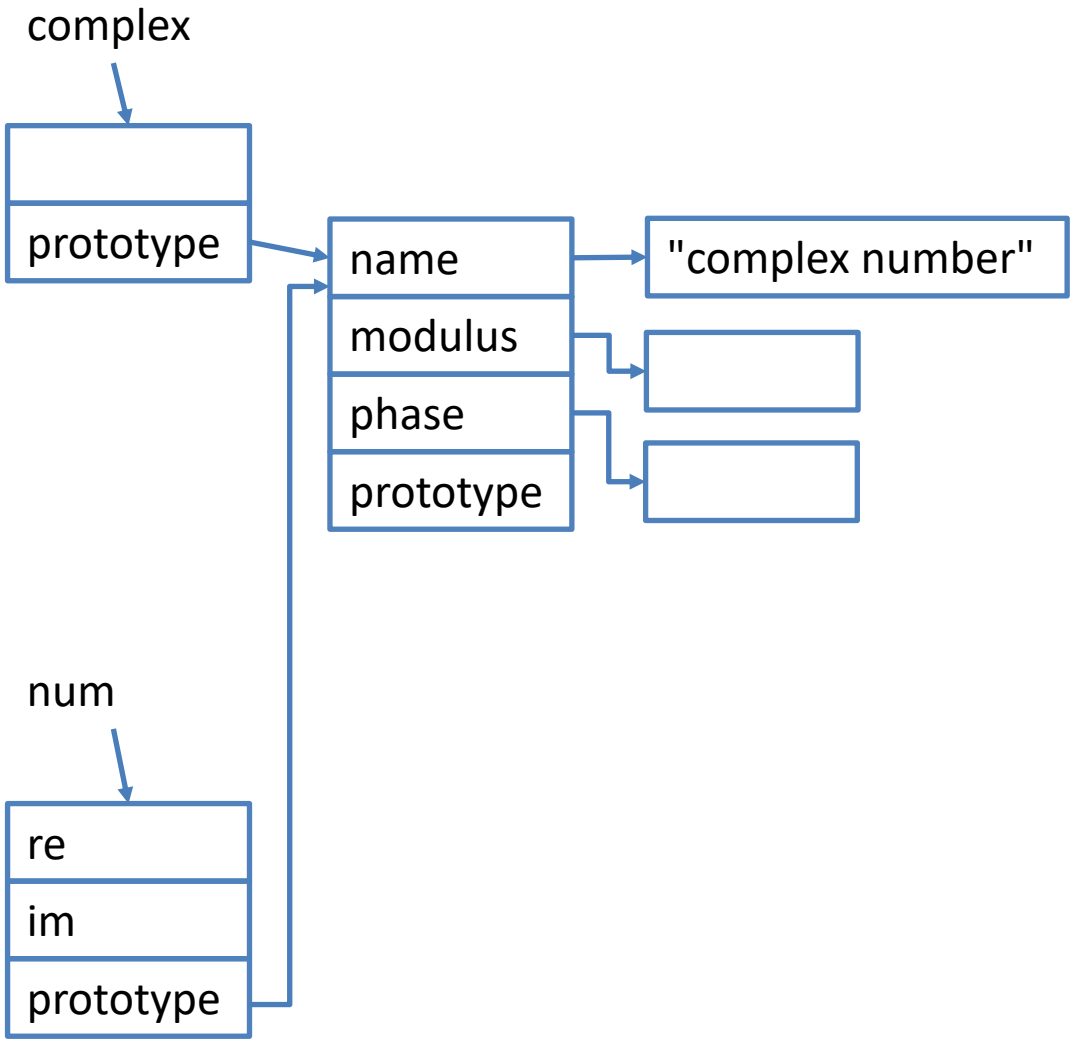
Example

```
function complex(x,y) {
    this.re = x;
    this.im = y;
}
complex.prototype.name = "complex number";
complex.prototype.modulus = function() {
     return Math.sqrt(this.re*this.re+this.im*this.im)
};
complex.prototype.phase = function() {
     return Math.atan(this.im/this.re)
};
```




```
var num= new complex(-2.1,3.7);
i=num.modulus();
j=num.phase();
```

Example (resulting objects)

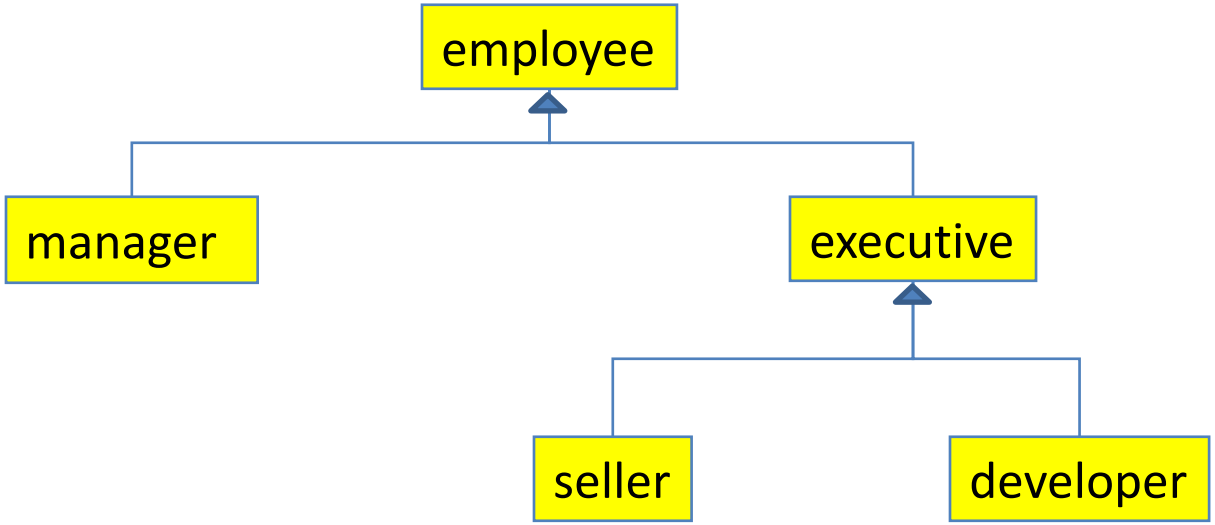



```
function complex(x,y) {
   this.re = x;
   this.im = y;
}
complex.prototype.name = "complex number";
complex.prototype.modulus = function() {
     return
Math.sqrt(this.re*this.re+this.im*this.im)
};
complex.prototype.phase = function() {
     return Math.atan(this.im/this.re)
};
```

```
var num= new complex(-2.1,3.7);
i=num.modulus();
j=num.phase();
```

Inheritance

- The *prototype* property can be exploited even for creating new object constructors (i.e. object classes) by inheritance
- Example: create constructors for the following classes of objects bound by inheritance relationships:



Definitions

Employee

```
function employee(){
    this.name="";
    this.dep="general";
}
```

Manager

```
function manager(){
    this.reports=[];
}
manager.prototype=new employee();
```

Executive

```
function executive(){
    this.projects=[];
};
executive.prototype=new employee();
```

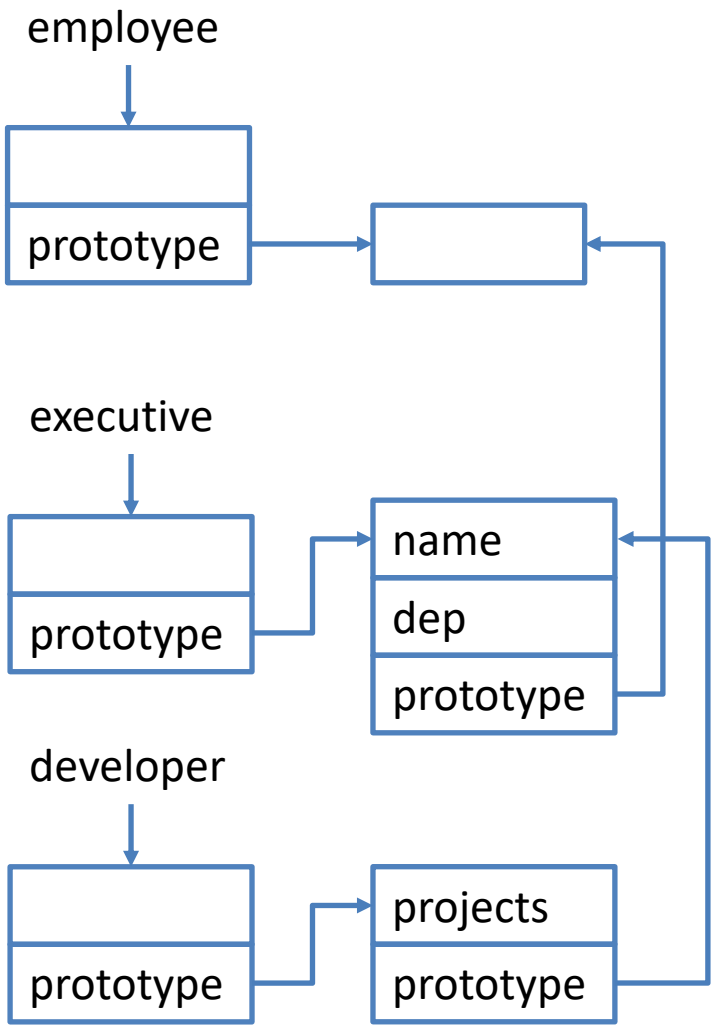
Seller

```
function seller(){
    this.dep="sales";
    this.quote=234;
}
seller.prototype=new executive();
```

Developer

```
function developer(){
    this.machines=[];
    this.dep="technical";
}
developer.prototype=new executive();
```

Resulting Objects



Employee

```
function employee(){
    this.name="";
    this.dep="general";
}
```

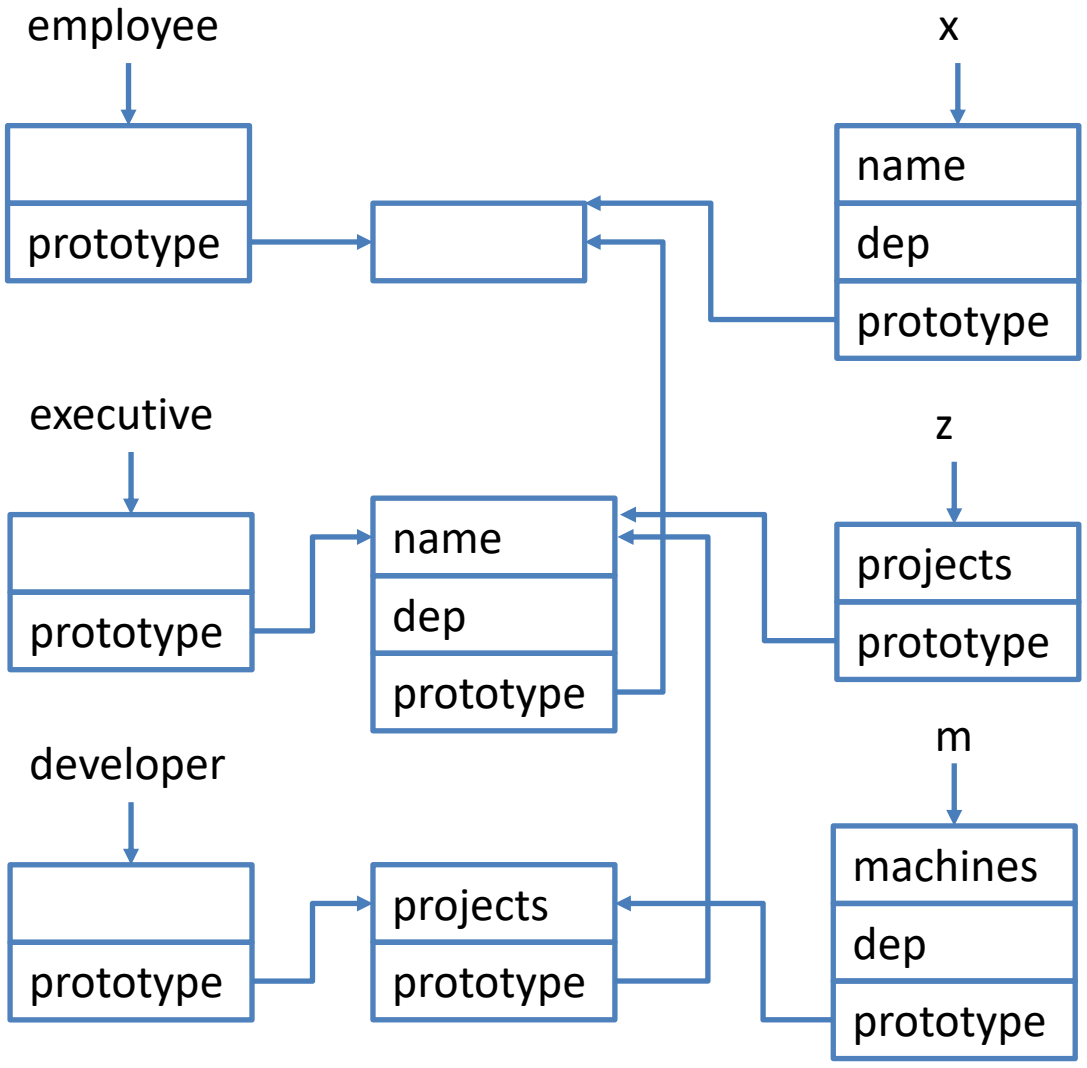
Executive

```
function executive(){
    this.projects=[];
};
executive.prototype=new employee();
```

Developer

```
function developer(){
    this.machines=[];
    this.dep="technical";
}
developer.prototype=new executive();
```

Object Creations and Resulting Objects




```
var x = new employee();
// x.name is ""
// x.dep is "general"
```

```
var z = new executive();
// z.name is ""
// z.dep is "general"
// z.projects is []
```

```
var m = new developer();
// m.name is ""
// m.dep is "technical"
// m.projects is []
// m.machines is []
```

Explicit Classes (Since EcmaScript 6)

- A sort of "syntactic sugar". The underlying prototype-based model of inheritance remains the same.

```
function complex(x,y) {
   this.re = x;
   this.im = y;
}
complex.prototype.modulus =
function() {
     return Math.sqrt(this.re*
      this.re+this.im*this.im)
}
complex.prototype.phase =
function() {
     return Math.atan(this.im/
             this.re)
}
```

```
class complex {
   constructor (x,y) {
     this.re = x;
     this.im = y;
   }
   modulus() {
     return Math.sqrt(this.re*
        this.re+this.im*this.im)
   };
   phase() {
     return Math.atan(this.im/
                this.re)
   };
}
```

Only methods in class

Methods in prototype

Explicit Inheritance

Employee

```
function employee(){
    this.name="";
    this.dep="general";
}
```

Executive

```
function executive(){
    this.projects=[];
};
executive.prototype=new
employee();
```

Employee

```
class employee {
    constructor() {
     this.name="";
     this.dep="general";
    }
}
```

Executive

```
class executive extends employee
{
    constructor() {
      super();
      this.projects=[];
    }
}
```

Static (Class) Methods

- A method declared as static can be invoked on the class only (not on the instance objects of the class)

```
class employee {
    constructor() {
       this.name="";
       this.dep="general";
    }
    static getRoleName() {
       return "Employee";
    }
}

var x=employee.getRoleName();
var y=new employee();
y.getRoleName();
```

Error!

Core Objects

- Let us examine the main properties of the built-in core objects:
  - Array
  - Boolean
  - Function
  - Date
  - Math
  - Number
  - Object
  - String
  - RegExp

Array

- Array objects are unbounded collections of elements, even of different types, indexed by an integer index

  ⇒When creating an array no size nor type are necessary:

```
var arr = new Array();
```

- The current length of an array is given by the **`length`** property:

```
if(arr.length<=3) …
```

Other Constructor Variants

```
var v = new Array(<val0>,…,<valn-1>);
```

```
var vect = new Array(100);
```

if this is not a number, it is interpreted as the only element

```
var a = new Array();
```

```
a[0]=0; a[99]=100;
```

Array with 100 elements only the first and last ones are defined. The other ones have value **`undefined`**

Alternative Constructor Syntax

The following expressions are equivalent:

```
var v = new Array(<val_0>,…,<val_n-1>);
var v = Array(<val_0>,…,<val_n-1>);
var v = [<val_0>,…,<val_n-1>];
```

The following expressions are equivalent:

```
var v = new Array();
var v = Array();
var v = [];
```

Constructors with Multidimensional Arrays

- Straightforward because multidimensional arrays are arrays of arrays
- Example:

```
var mat = Array(
              Array('x','y','z'),
              Array('a','b','c')
          );
```

Checking Array Bounds

- Of course bound checking is up to the programmer
- Example:

```
for(var i=0; i<a.length; i++)
  if(a[i] != undefined) {
  msg = "Position: " + i + " Value: " + a[i];
  document.write(msg);
}
```

Main Array Methods

- **concat**
  - Concatenates one array with one or more other arrays:

```
num1=[1,2,3]
num2=[4,5,6]
num3=[7,8,9]
nums=num1.concat(num2,num3)
// nums is [1,2,3,4,5,6,7,8,9]
```

- **join**
  - returns a string with the elements of the array separated by the comma default separator:

```
nums.join()   // returns the string
              // "1,2,3,4,5,6,7,8,9"
```

Main Array Methods

- `reverse`
  - reverses the elements of the array
- `pop`
  - returns and removes the last element of the array
- `push`
  - appends new element(s) after the last element
  - returns the new size of the array

Main Array Methods

- **`shift`**
  - returns and removes element 0, and shifts the other elements back by one position
- **`unshift`**
  - appends element(s) at the head of the array

```
nums.unshift(10,11,12)
// result is [10,11,12,1,2,3,4,5,6,7,8,9]
```

Main Array Methods

- **`slice(`**<*start*>**`,`**<*end*>**`)`**
  - Creates a new array containing the elements from element <*start*> up to but not including element <*end*>
- **`splice(`**<*start*>**`,`** <*len*>**`,`** <val_0>**`,…,`**<val_n>**`)`**
  - the <*len*> elements starting at index <*start*> are replaced by the next arguments <val_0>,…,<val_n>
  - if there are no enough arguments, the remaining elements are eliminated (become undefined)
- **`sort`**
  - sorts the array (as an optional argument it is possible to pass the comparator function to be used for sorting)

Associative Arrays

- Associative arrays have elements referenced by name rather than by numeric offset
- An associative array can be created by the following syntax:

  { <key_1> : <el_1> , … , <key_n> : <el_n> }

  – where <key_i> is the i-th key and <el_i> is the i-th element
- Example:

```
directory = {"7073" : "Riccardo Sisto" ,
             "1223" : "Mario Rossi" }
for (k in directory)
  document.write(k + " : " + directory[k] + "<br/>"
```

String

- String objects are string containers with string methods
- constant strings are automatically converted to string objects when necessary
- Differences between string constants and objects:

```
s1 = "2 + 2"
s2 = new String("2 + 2") // creates String object
eval(s1) // returns 4
eval(s2) // returns "2 + 2" (a string)
```

- The length of a string object is given by the **`length`** property

Math

- Container for mathematical functions and constants
  - Properties: mathematical constants
  - Methods: mathematical functions
- Differently from other core objects, Math cannot be used as a constructor

Boolean

- The constructor can be used to create boolean objects from other objects
- Example:

```
var boo = new Boolean(val)
```

  - If **`val`** has any of the values **`false, 0, null, ""`**
    then **`boo`** takes value **`false`**
    else **`boo`** takes value **`true`**

RegExp

- A RegExp object represents a regular expression
- RegExp objects are typically used for string matching
- A RegExp object can be created with the syntax:

  /<expr>/

  where <*expr*> is a regular expression. The main syntax is:

expr	matches
.	any single char
*element**	*element* 0 or more times
element+	*element* 1 or more times
element?	*element* 0 or 1 time
[*chars*]	1 char of those in brackets
[^*chars*]	1 char of those not in brackets

expr	matches
left|*right*	either *left* or *right*
l-r	range of chars from *l* to *r*
\d	single digit
\n	newline
\s	whitespace character
\t	tab character
\w	word character [a-zA-Z0-9_]

RegExp

- RegExp objects can be used in methods **`match`**, **`search`**, **`replace`** and **`split`** of **`String`**
- Example:

```
re = /(\w+)\s(\w+)/;
str = "First Second";
newstr=str.replace(re, "$2, $1");
document.write(newstr)//newstr is "Second First"
```

- RegExp objects have the methods **`test, exec`**
- Example:

```
re = /[A-Z][a-z]*/;
if (re.test(str))
    document.write("str is well formed");
```

Date

- Includes utility functions for date and time manipulation
- Several constructors are available:
  - **`Date()`**
  - **`Date(milliseconds)`**
  - **`Date(string)`**
  - **`Date(Y,M,D,H,M,s,ms)`**
    - **`M`** from **`1`** to **`12`**
    - **`D`** from **`1`** to **`31`**
    - **`H`** from **`0`** to **`23`**
    - **`M`** from **`0`** to **`59`**
    - **`s`** from **`0`** to **`59`**
    - **`ms`** from **`0`** to **`999`**

Main Date Methods

- `getDate(),setDate()`
- `getFullYear(),setFullYear()` (4 digits)
- `getHours(),setHours()`
- `getMilliseconds(),setMilliseconds()`
- `getMinutes(),setMinutes()`
- `getMonth(),setMonth()`
- `getSeconds(),setSeconds()`
- `getYear(),setYear()`

`try...catch` Statement

- Errors can be handled by a java-like try-catch statement
- Syntax:

```
try {
  <block1>
} catch(<error_var>)
{<block2>}
```

- when a runtime error occurs in <*block*$_1$> <*error_var*> is set to the **`Error`** object that represents the error and <*block*$_2$> is executed
- note that syntax errors do not trigger the catch block

How to Inspect the Error Object

If `error` is the variable set to an Error object:

- `error.name` is the error class
- `error.message` is the error description

Standard Error Classes

- **`EvalError`** :
  - error in executing **`eval()`**
- **`RangeError`** :
  - a numeric value exceeded its allowable range
- **`ReferenceError`**
  - an invalid reference value (e.g. undefined variable or function) has been detected
- **`SyntaxError`**
- **`TypeError`**
  - the type of an operand is different than the expected type
- **`URIError`**
  - error when using a URI

Example

- js-error-trycatch.html

Custom Errors

- Errors can be generated by the application using the **`throw`** statement
- Syntax:

  `throw` *<error object>*

- An error object of one of the standard classes can be created using the constructor (and defining the message)
- The programmer may want to create custom error classes.

Example (1)

```
function entrycheck(){
  try{
     var agecheck=prompt("How old are you?")
     if (isNaN(parseInt(agecheck)))
       throw new Error("Please enter a valid age")
     else if (agecheck<13)
       throw new Error("You are too young!")
     else alert("Enjoy!")
   }
   catch(e){
     alert(e.name+" "+e.message)
   }
}
```

Example (2)

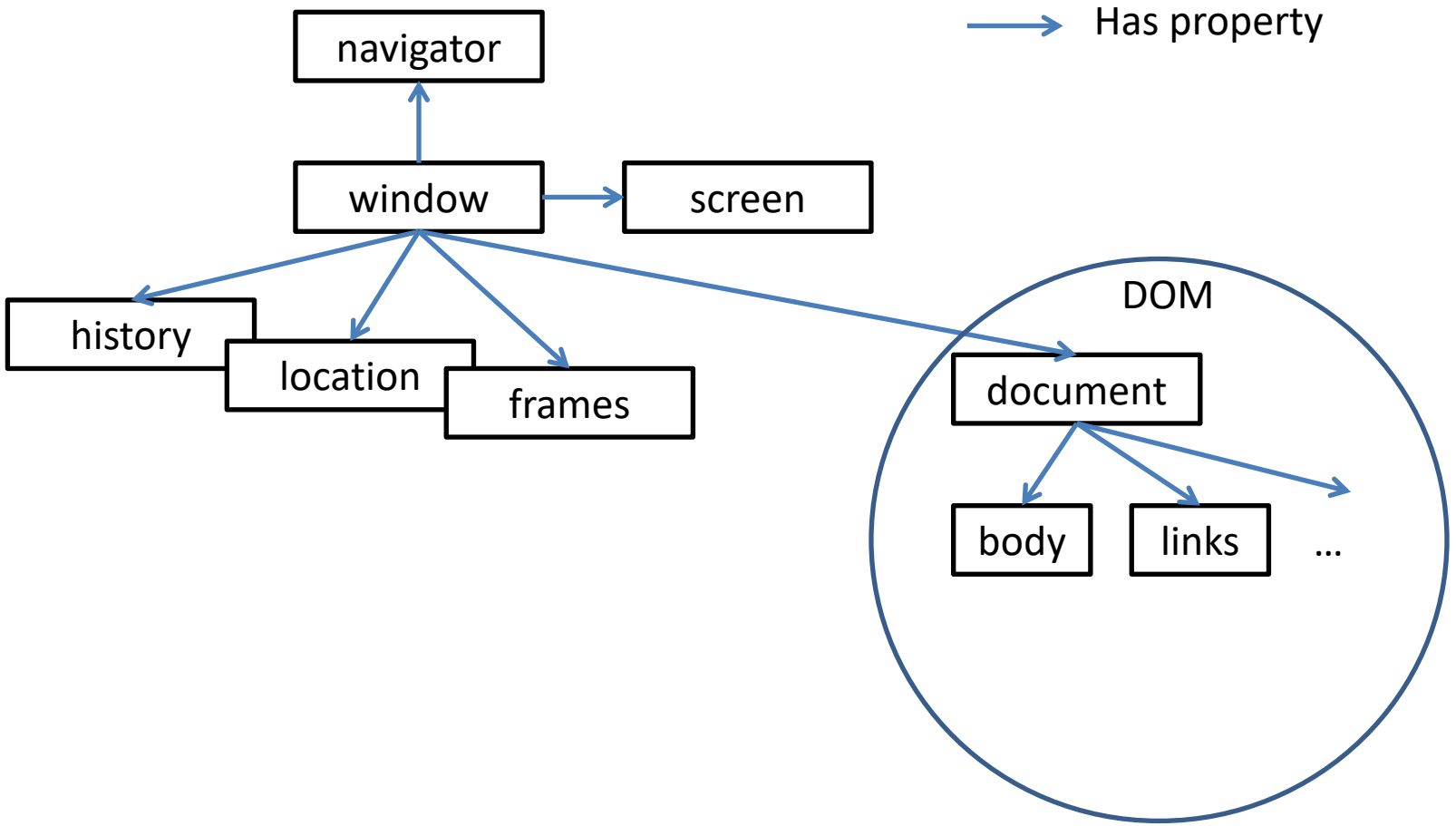
```
<html>
<head>
<script type="text/javascript">
  function entrycheck(){
  …
  }
</script>
</head>
<body>
  <input type="button" value="Check"
         onclick="entrycheck()">
</body>
</html>
```

js-age.html

The Client Environment (I/O)

- We are going to study the following I/O programming elements for JavaScript in the client side:
  - Environment Objects (e.g. `window`): interface for reading browser information and for controlling the browser
  - Document Object Model (DOM): API for manipulating (read/write) the HTML document that is being displayed in a browser window
  - Event Programming: mechanisms for programming reaction to events (e.g. mouse click, mouse double click, mouse pointer entering a certain area, …)
- Important: this part is not included in the ECMA standard
  - We'll study only the features supported by most browsers (look at reference documentation to check browser support)

The Hierarchy of Environment Javascript Object Properties



The `window` Object

- Global object that includes the script being executed
  - Any variable defined in the script also becomes a property of **`window`**
  - When referencing the **`window`** object, the name (**`window`**) can be omitted (is implied)
  - Each **`<FRAME>`** in the document generates a new **`window`** object
  - Initially the referenced window object is the one associated with the **`<FRAME>`** where the script is located
  - There are methods for changing the **`window`** object being referenced
  - The **`<FRAMESET>`** that includes the current frame is referenced by the **`parent`** property.

The `window` Object

- Main properties of **`window`**:
  - **`name`** the name of this window (assigned by **`open()`**)
  - **`self, parent, top`**
  - **`frames[]`** all the frames in the window
  - **`location`** the current URL
  - **`history`** the history of visited pages
  - **`document`** the document displayed in the window
  - **`status`** the text in the status bar of the browser
  - **`opener`** the name of the window that opened this window

The `window` Object

- Main methods of **`window`**
  - **`alert(), prompt(), confirm()`**
  - **`open()`** open new window (or tab)
  - **`close()`** close this window
  - **`moveBy(dx,dy)`** move this window
  - **`moveTo(x,y)`** move this window
  - **`resizeBy(dx,dy)`** resize this window
  - **`resizeTo(x,y)`** resize this window
  - **`focus()`** give focus to this window
  - **`blur()`** take focus out of this window
  - **`print()`** open the printer window

The `open` Method

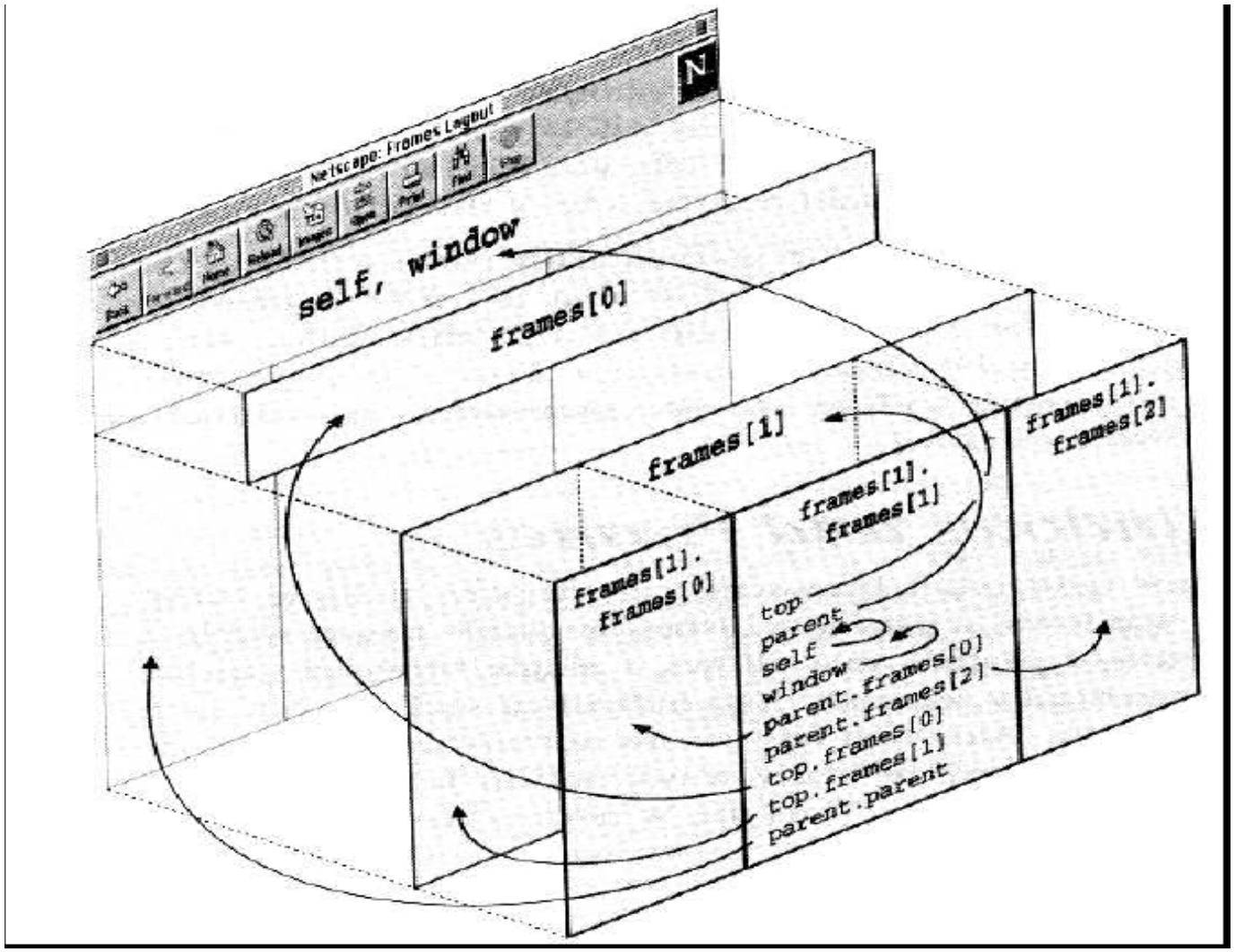
- Returns a reference to the new window (**`opener`** is a reference back to the opener window)
- Syntax:

  `open` **`(`** *<URL>*`,`*<windowName>*`[,`*<windowFeatures>*`]`**`)`**

- Examples:

```
window.open("http://www.polito.it","mywindow",
"status=1,toolbar=1");
window.open("http://www.javascriptcoder.com”,
"mywindow","menubar=1,resizable=1,width=350,
height=250");
mywindow.moveTo(0,0); // move new win to top left
```

Window and Frame References



Example

- In the Parent window:

```
…
<SCRIPT LANGUAGE="javascript" TYPE="text/javascript">
  leftPos = screen.width-225;
  car = "width=225,height=200,left="+leftPos+",top=0"
  newWindow = window.open("js_news.html", "newWin", car);
</SCRIPT>
<BODY>
<CENTER>
<H1>This is the main window</H1>
<H1>Here you will see online newspapers</H1>
</CENTER>
</BODY>
```

Example

- In the New Window (**`js_news.html`**):

```
…
<SCRIPT LANGUAGE="javascript" TYPE="text/javascript">
  function updateParent(newURL)
  {opener.location.href = newURL;}
</SCRIPT>
<CENTER>
<H1>Control Panel</H1>
<H3>
<A HREF="javascript:updateParent('http://www.corriere.it')">
    Corriere della Sera</A><BR>
<A HREF="javascript:updateParent('http://www.lastampa.it')">
    La Stampa</A><BR>
<A HREF="javascript:updateParent('http://www.repubblica.it')">
  La Repubblica;</A>
</CENTER>
…
```

`js-openwindow.html`

The `navigator` Object

- Gives access to browser features
- Main properties of **`navigator`**:
  - **`appCodeName`** Browser code name
  - **`appName`** Browser application name
  - **`appVersion`** Browser application version
  - **`cookieEnabled`** true if cookies are enabled
  - **`platform`** The platform where the browser runs
  - **`userAgent`** The user agent string the browser sends in the HTTP header
  - **`javaEnabled()`** true if java is enabled

The `screen` Object

- Gives access to the features of the screen
- Main properties of **`screen`**:
  - **`availHeight`** height in pixels (excluding application bar)
  - **`height`** total height
  - **`availWidth`** width in pixels (excluding application bar)
  - **`width`** total width
  - **`colorDepth`** color depth in bits per pixel

The `location` Object

- Indicates the URL displayed in a window or frame
- The various parts of the URL (hostname, port, protocol,…) can be accessed separately as sub-properties
- The access is in read/write mode
- Writing a new value starts loading the new URL
- Main properties:
  - **`href`** complete URL
  - **`host`** hostname and port number
  - **`protocol://hostname:port/pathname?search#hash`**

Example

http://www.abc.com:555/catalog/search.php?query=JS&match=2#result

- protocol = "http: "
- hostname = "www.abc.com"
- port = "555"
- host = "www.abc.com:555"
- pathname = "/catalog/search.php"
- search = "?query=JS&match=2"
- hash = "#result"

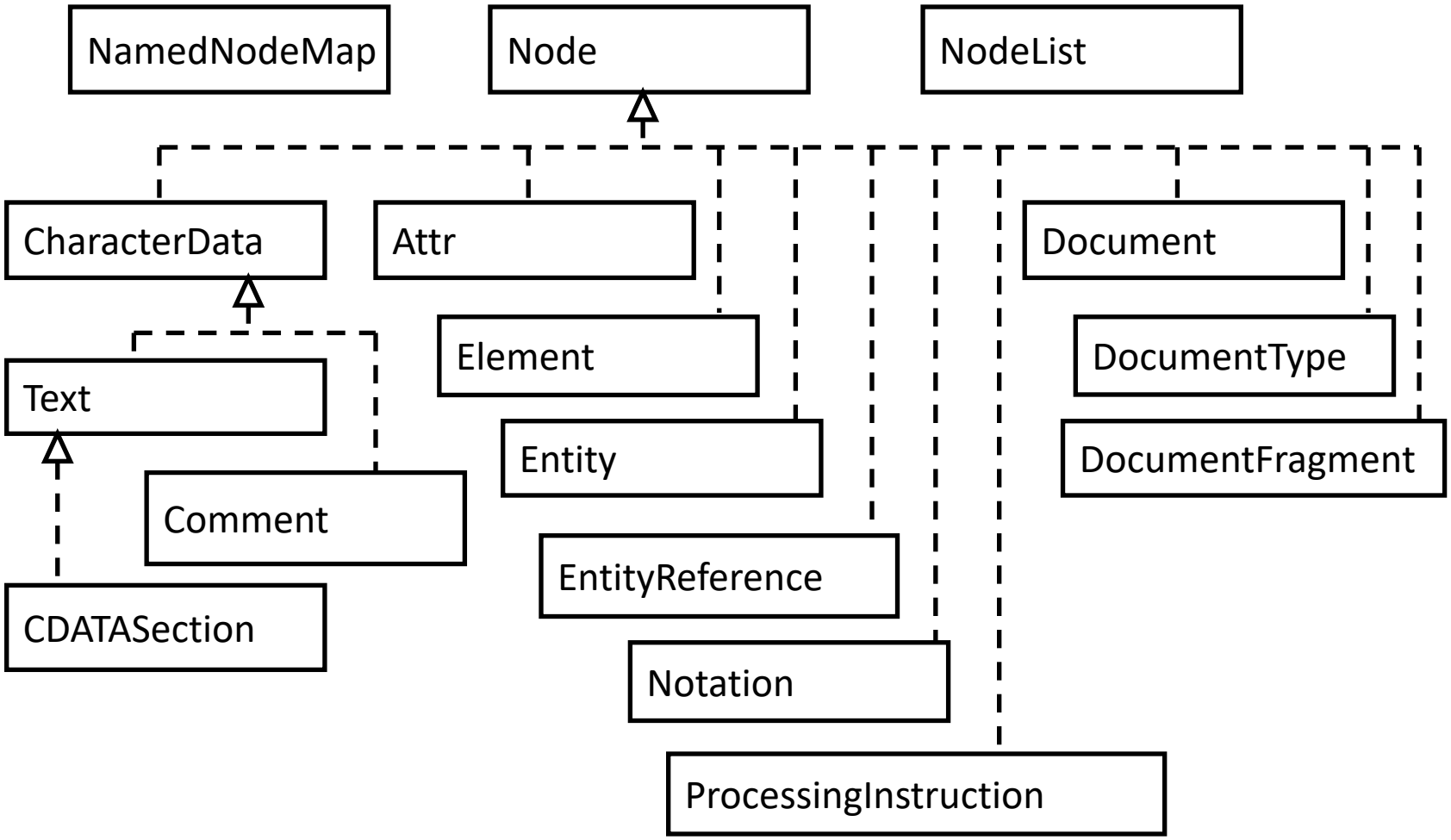
The DOM API

- Standard cross-platform language-independent API for accessing the elements (and attributes) of a document (HTML, XML,…)
- DOM Functionalities are divided into levels:
  - DOM 0 non-standard level including the basic functions that were provided by old browsers (kept only for compatibility)
  - DOM 1 gives r/w access to all the elements of a document
  - DOM 2 adds advanced access functions (including an event model), and access to CSS.
  - DOM 3 adds more features, e.g. xPath support.

W3C Std.

- Besides the standard functions, commercial browsers sometimes offer additional functions
  - Important: avoid them to get portability across browsers

DOM Level 1 Main Classes



The HTML-specific Document (`document` Object)

- Main properties of **`document`**:
  - **`title`** the title of the document
  - **`forms[]`** the form elements in the document
  - **`anchors[]`** the **`<a>`** elements in the document
  - **`links[]`** the **`<link>`** elements in the document
  - **`images[]`** the image elements in the document
  - **`body`** the document body element
- Main methods of **`document`**:
  - **`write()`** writes to the current document position (where rendering has arrived)
  - **`writeln()`** like write but adds a newline at the end

Accessing Document Elements

- The access path may be very long. For example:
  - `parent.frames[0].document.forms[0].elements[3].button[2].value`
- Access to elements can be simplified by giving id or name attributes to the elements
- Of course id or name must be unambiguous

Example

```
<html>
<head>
<script type="text/javascript">
var i=1;
function change (){
  if (i==0) {document.images["banner"].src="questions.jpg";  i=1}
  else      {document.images["banner"].src="caravaggio.jpg"; i=0}
}
</script>
</head>
<body>
<img src="questions.jpg" name="banner" height=200 width=200>
<input type="button" value="Change" onclick="change()">
</body>
</html>
```

js-swap.html

Other Examples

```
<FORM NAME="myform">
<INPUT TYPE="TEXT" NAME="text">
</FORM>
…
document.forms["myform"].elements["text"].value = "New Text";
…
```

```
<FORM>
<INPUT TYPE="TEXT" id="text">
</FORM>
…
document.getElementById("text").value = "New Text";
…
```

Reacting to Events

- The browser can detect the occurrence of certain events
- A function that reacts to the event (handler) can be associated with each kind of event

Event Kinds

- Abort
- Blur
- Change
- Click
- DblClick
- Error
- Focus
- KeyDown
- KeyPress
- KeyUp
- Load
- MouseDown
- MouseMove
- MouseOut
- MouseOver
- MouseUp
- Move
- Reset
- Resize
- Select
- Submit
- Unload

Specifying Event Handlers

- An event handler can be associated with an event kind and with an HTML element by an attribute named after the event kind
- Syntax:

<*TagName*> **on**<*Event*>="<*statement*>">

- Example:

```
<SCRIPT TYPE="text/javascript">
  function hello() { alert("You entered the image"); }
  function bye() { alert("You left the image"); }
</SCRIPT>
<IMG SRC="questions.jpg"  border="0"
        onMouseOver="hello()"
        onMouseOut="bye()">
```

js-mouse.html

Other Example

```
<head>
<script type="text/javascript">
var w;
function myOpenWindow() {
  w=window.open('','', 'width=100,height=100');
  w.focus();
}
function myResize() {
  w.resizeTo(500,500);
  w.focus();
}
</script>
</head>
<body>
<button onclick="myOpenWindow()">Create window</button>
<button onclick="myResize()">Resize window</button>
</body>
```

js-resize.html

Timeout

- The timing of script actions can be controlled by using timeouts.
- The methods that control timeouts are:
  - **`setTimeout`**`(`<*statement*>`,` <*ms*>`)`
    - Starts a timer and sets the timeout after <*ms*> milliseconds
    - Returns a reference to the timeout
    - On timeout expiration <*statement*> will be executed
  - **`clearTimeout`**`(`<*timeoutId*>`)`
    - Cancels the timeout referenced by <*timeoutId*> (if not yet expired)

Timeout Example

- **HTML:**

```
<IMG name= "image" src="questions.jpg"
 height=200 width=200 >
<FORM name="myform">
In how many seconds do you want to change image?
 
<INPUT TYPE="text" name="seconds" size="2">
 
<INPUT TYPE="button" value="Change"
 onClick="setTimer()">    
<INPUT TYPE="button" value="Cancel"
 onClick="cancelTimer()">
</FORM>
```

Timeout Example

- **JavaScript:**

```
var tID = 0;
function change() {
  document.image.src="Caravaggio.jpg";
};
function setTimer() {
  var sec =
      parseInt(document.myform.seconds.value);
  if(!tID)
     tID= setTimeout("change()",sec*1000);
}
function cancelTimer() {
  if (tID) {
     clearTimeout(tID);  tID=0;
  }
};
```

js-timeout.html

Other Example

```
<input type="button" name="clickMe"
       value="Click and wait!“
       onclick="setTimeout('alert(\‘Hello!\')',
       5000)"
/>
```

Periodic Execution

- The periodic execution of a script can be programmed by the methods:
  - **`setInterval`**`(`<*statement*>`,` <*ms*>`)`
    - Causes the execution of <*statement*> every <*ms*> milliseconds
    - Returns a reference to the programmed interval
  - **`setInterval`**`(`<*function*>`,` <*ms*>`,` <par_1>`,…,` <par_n>`)`
    - Causes the execution of <*function*> with parameters <par_1> … <par_n> every <*ms*> milliseconds
    - Returns a reference to the programmed interval
  - **`clearInterval`**`(`<*Intervald*>`)`
    - Cancels the action of the interval referenced by <*Intervald*>

Example (1)

- **HTML:**

```
<TABLE> <TR>
<TD> <IMG SRC="a.gif" height="200"
NAME="image" border="0">
<TD>
<FORM>
<INPUT TYPE="button" VALUE="Start"
     onClick="start()"><P>
<INPUT TYPE="button" VALUE="Stop"
     onClick="stop()">
</FORM>
</TABLE>
```

Example (2)

- **JavaScript:**

```
<SCRIPT TYPE="text/javascript">
var intID = 0; var variable = 0;
var images = new Array();
var counter=0;
for(i=0;i<4;i++)images[i] =
    new Image();
images[0].src ="questions.jpg";
images[1].src = "Caravaggio.jpg";
images[2].src = "pyramids.jpg";
images[3].src = "Renoir.jpg";
</SCRIPT>
```

Example (3)

JavaScript Functions:

```
function start() {
  intID = setInterval("change()",1000);
}

function change() {
  counter = (++counter)%4;
  document.image.src = images[counter].src;
}

function stop() {
  clearInterval(intID);
}
```

js-interval.html

More about Error Handling

- The event handler **`window.onerror`** is an alternative to try-catch for error handling
- Not supported by all browsers
- The handler function receives 3 parameters from the browser
  - Error type (string)
  - The document where the error occurred (url)
  - The line number where the error occurred

Example

```
window.onerror = handleError;
function handleError(error, url, line) {
  var msg = ""
  msg = "Error type: " + error + "\n";
  msg = msg + "Document: " + url + "\n";
  msg = msg + "Line: " + line;
  alert(msg);
}
```

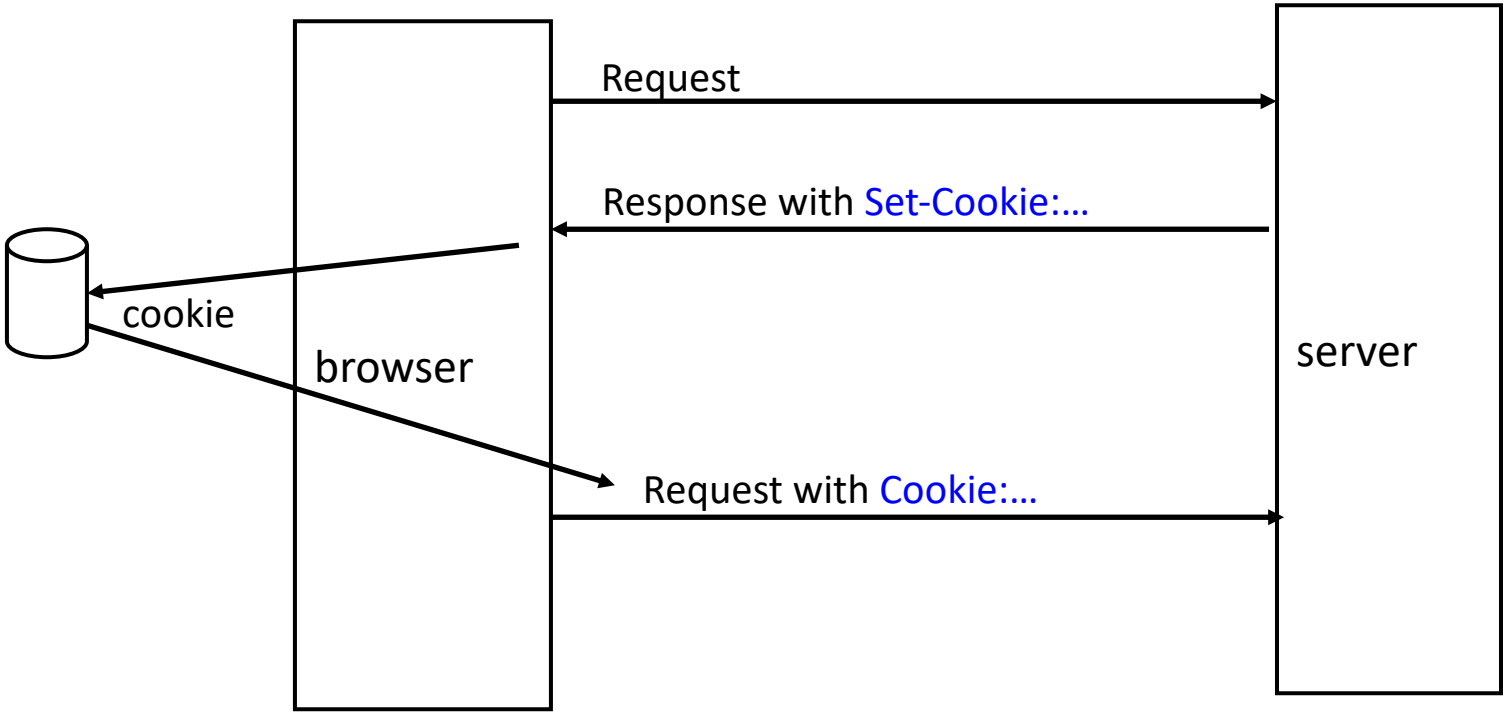
Cookies

- Cookies are short textual data packets that a browser can store persistently
- Generally cookies are generated by the server and sent to the browser (using the **`set-cookie`** header) but client-side scripts can set cookies by themselves
- A browser can send back a cookie to a server (and even change it before sending).
- Typical uses of cookies:
  - User identification,
  - User profiling
  - Storage of user data (e.g. preferences) without server-side management

Cookie Standardization

- Initially introduced by Netscape, the cookies mechanism has been later standardized as RFC:
  - Rfc 2965: HTTP State Management Mechanism
  - Rfc 2964: Use of HTTP State Management

How HTTP Cookies Work



Set-Cookie Syntax

`Set-Cookie:` *<name>=<value>;* *<optionalArgs>*

`expires=`*<date>*`;` **`path=`***<path>*`;` **`domain=`***<domain>*`;` **`secure`**

- *<name>*, *<value>*: **cookie name and value**
- *<date>*: **expiry date**. If not specified, the cookie is deleted when the browser session terminates
- *<domain>*, *<path>*: the lists of **domains and paths** the cookie will have to be sent to (if not specified, they are the ones of the current request)
- **`secure`**: if present requires that cookies are sent only on secure (HTTPS) channels

What Cookies Does a Browser Send?

- Browsers normally send cookies automatically (users may disable cookies)
- At each request, the browser selects the cookies to send by looking at their DOMAIN and PATH attributes:
  - A cookie can be sent only if its DOMAIN matches the *final* part of the destination hostname

    Example: if DOMAIN="polito.it", the cookie can be sent to hosts www.polito.it, www.webservices.polito.it, etc.
  - A cookie can be sent only if its PATH attribute matches the *initial* part of the destination path

    Example: if PATH="/foo", the cookie can be sent when the destination paths are /food/, /foo/bar.html, etc.

Sending Cookies

- Cookies are sent by adding the HTTP header

  `Cookie:` *<name1>=<value1>; <name2>=<value2>; …*

- Cookie names and values cannot include space , ; " \

- In Javascript
  - A cookie can be added/modified or read by the method **`document.cookie`**
  - Strings used as cookie values should be encoded with **`escape()`** and decoded with **`unescape()`**

Example: Reading Cookies

```
var cook = document.cookie; /* reads all cookies */
var i=cook.indexOf("par="); /* search for cookie that
                               matches "par=" */
if (i!=-1) {  // found
  var k=i+4; // start of value
  var end=cook.indexOf(";",k);
  if(end=-1) end=cook.length;
  var value=cook.substring(k,end);
  value=unescape(value);
```

…

Choosing Cookie Names

- The name can be used for storing information about the meaning of a cookie or any other information associated with the cookie
- The format is free

Example: Writing Cookies

```
var cook;
cook="Date="+ escape(document.lastModified);
var expiry=new Date();
// set expiry in 1 year
expiry.setFullYear= expiry.getFullYear+1;
// convert to GMT date
expire="expires="+expiry.toGMTString()+";";
// write cookie
document.cookie=cook+";"+expire;
```

Example: Deleting Cookies

- A cookie can be cancelled by simply setting its expiration date to a past date
- Example:

```
var cook=document.cookie;
var i=cook.indexOf("expires=");
if(i!=-1) {
    i+=8;//advance after expires=
    var k=cook.indexOf(";",i);
    if (k=-1) k=cook.length;
    var expiration=new Date(1930,12,1);
    substr=cook.slice(i,k);
    cook=cook.replace(substr,
          escape(expiration.toGMTString()));
}
```

Javascript and CSS

- DOM 2 includes functions for CSS handling
- Not yet fully supported by all browsers

- CSS handling functions operate on element objects
- Element objects can be found by their id:

```
var elem=getElementById("foto1");
```

Changing CSS Properties

- Style properties have same names as CSS properties
- Examples:

```
var elem=getEelementById("text1");
elem.style.top="223px";
elem.style.color="darkred";
elem.style.fontSize="12px"
```

- Other example: Change visibility

```
elem.style.visibility="hidden";
elem.style.visibility="visible";
```

Simple Animations

- Can be implemented setting **`interval`** calls
  - Style properties of some elements are changed periodically
- Example:

  `js-animation.html`

Example: Style

```
<style name="first" type="text/css">
#banner
{
  left:0px;top:0px;font-size:x-medium;
  font-family:Roman;
  color:#FF00FF;width:300px;
  position:relative;
}
</style>
```

Example: HTML

```
<body>
<div id="banner" > Hello!</div>
<br><br> <br>
<img src="logo_poli.png" id="logo" height=300 width=300>
<br>
<form name=myform>
<input type=button onclick=startBanner() value="Start banner">
<input type=button onclick=stopBanner() value="Stop banner">
<br>
<input    type=button    onclick=startBlinking()    value="Start
  blinking">
<input type=button onclick=stopBlinking() value="Stop blinking">
</body>
```

Javascript (1)

```
<script type="text/javascript">
var xmin=0; var x=0;
var xmax=300;
var deltax=5;
var intBlink=0;
var intBanner=0;
function move() {
  var elem=document.getElementById("banner");
  if (x>=xmax) x=0
  else x+=10;

  elem.style.left=x+"px";
}
```

Javascript (2)

```
function blink() {
  var elem=document.getElementById("logo");
  if(elem.style.visibility=="hidden")
    elem.style.visibility="visible";
  else
    elem.style.visibility="hidden";
};

function startBanner() {
  if (!intBanner)
    intBanner=setInterval(move,40);
};

function stopBanner() {
  clearInterval(intBanner);
  intBanner=0;
};
```

Javascript (3)

```
function startBlinking() {
  if (!intBlink)
    intBlink=setInterval(blink,500);
};

function stopBlinking() {
  clearInterval(intBlink);
  intBlink=0;
};
</script>
```

Other Graphic Effects

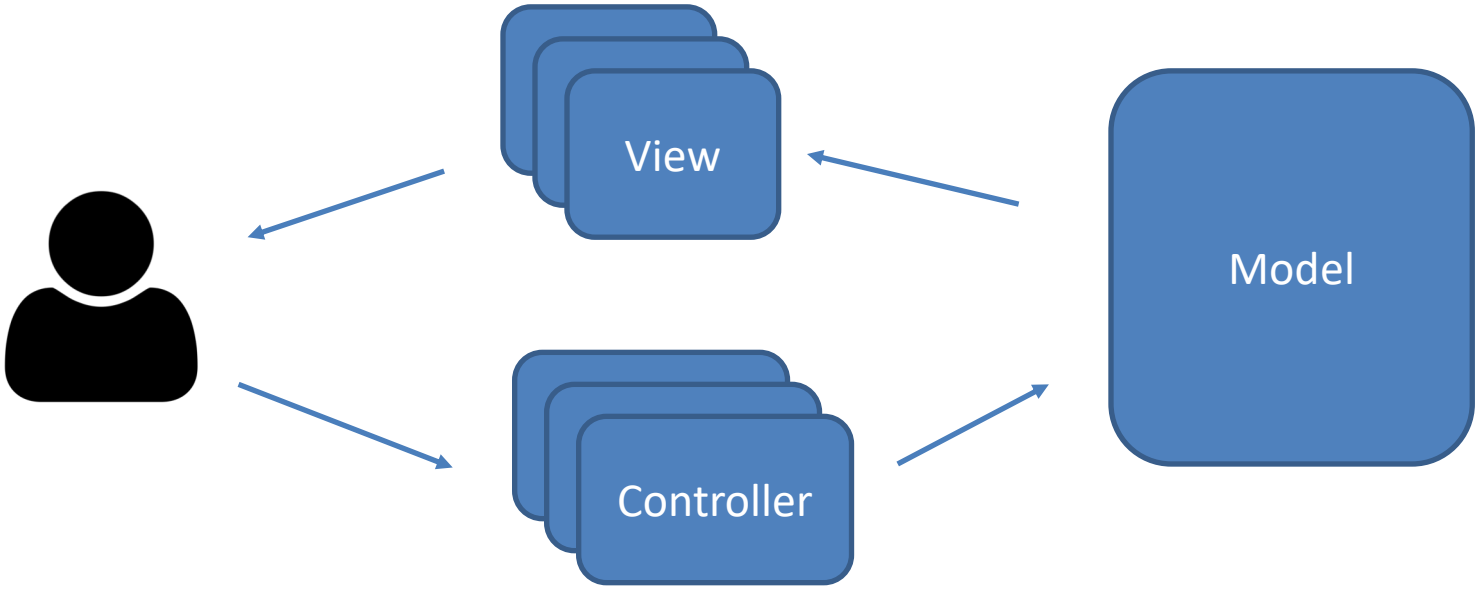
- Acting on style elements, timers and intervals it is possible to build several graphic elements, such as
  - Pull down menus
  - Callouts (page elements that appear when passing over other elements)
  - …

Full Example

- Aim: create an oversimplified spreadsheet using Javascript and CSS only
  - no file saving, just working in memory

The MVC Pattern

- Typically used for Graphical User Interfaces



The MVC version of the Spreadsheet Example

- Aim: re-organize the spreadsheet example code according to the MVC pattern, using object-oriented programming

Other APIs Introduced with HTML5

- WebSockets
  - low latency bi-directional communication over a single TCP connection
- Web Storage
  - Persistent, large-capacity client-side storage in the browser (not sent to the server as cookies)
- ...