ID1354
Internet Applications

JavaScript

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Overview of JavaScript

- Originally developed by Netscape, as LiveScript
- Became a joint venture of Netscape and Sun in 1995, renamed JavaScript
- Now standardized by the European Computer Manufacturers Association as ECMA-262 (also ISO 16262)
- The only relathionship between JavaScript and Java is similar syntax.

Overview of JavaScript (Cont'd)

- JavaScript is the language for client-side behavior in web applications.
- Can be use also on server, not covered in this course.
- Can handle user interaction through forms.
- Possible to change HTML documents using the Document Object Model, DOM, covered in coming lecture.

Object Orientation and JavaScript

- JavaScript has some support for object-orientation, but less and different from Java.
  - No class-based inheritance
  - No polymorphism
  - Can be used for procedural programming (like C) without using objects at all.
- JavaScript objects are collections of properties, which can be fields or functions.

How to Include JavaScript Code

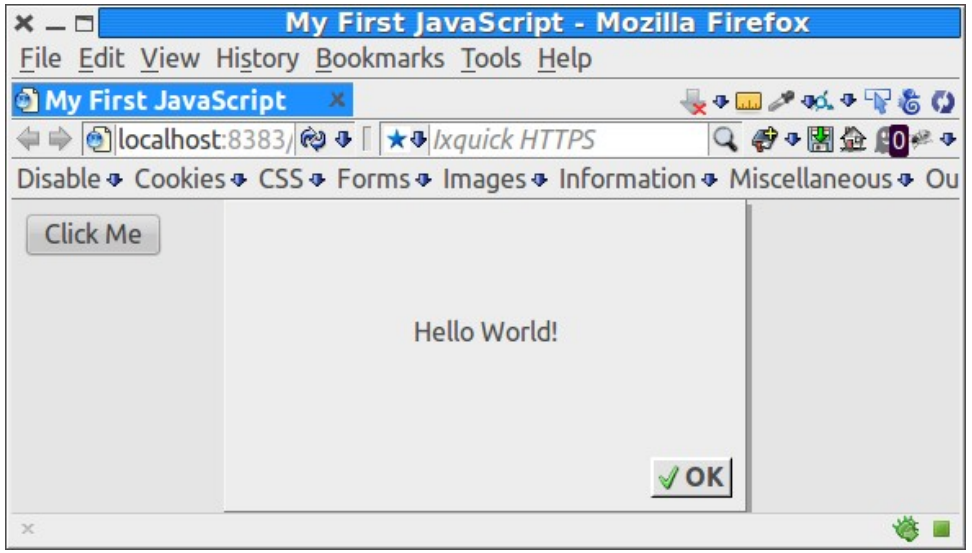
- Write JavaScript in separate files, with the extension `.js`
- Include a JavaScript file with the `src` attribute of the `<script>` element in the HTML file where it is used:

```
<script src = "myscript.js"></script>
```

The First Example

```
<!DOCTYPE html>
<html>
    <head>
        <title>My First JavaScript</title>
        <meta charset="UTF-8">
        <script src="hello-world.js"></script>
    </head>
    <body>
        <button type="button" onclick="greeting()">Click Me</button>
    </body>
</html>
```

```
function greeting() {
    alert("Hello World!");
}
```



Syntax

- Identifiers begin with a letter or underscore, followed by any number of letters, underscores, and digits.
- Case sensitive
- Statements are separated with semicolon.
- Reserved words are: abstract, arguments, boolean, break, byte, case, catch, char, class, const, continue, debugger, default, delete, do, double, else, enum, eval, export, extends, false, final, finally, float, for, function, goto, if, implements, import, in, instanceof, int, interface, let, long, native, new, null, package, private, protected, public, return, short, static, super, switch, synchronized, this, throw, throws, transient, true, try, typeof, var, void, volatile, while, with, yield
  - Comments: single-line, `//`, and multiple-line, `/* some comment */`

Code Conventions

- Always use the same naming convention for all your code, preferrably:
  - Variable and function names written as camelCase.
  - Global variables written in UPPERCASE.
  - Constants (like PI) written in UPPERCASE
- Write declarations at the beginning of the scope.

Variables

- JavaScript is dynamically typed, type is never declared and variables change type when needed.

```
year = "in the eighties";
year = 84;
```

year is a **string**.
year is a **number**.

- Global variables can be declared either implicitly, just write the variable name, or explicitly, variable name preceeded with **var**.

```
var sum = 0;
today = "Monday";
flag = false;
```

Local Variables Must Be Declared With `var`

- Local variables must be explicitly declared with the `var` keyworld.
- Here, c is a local variable:

```
function myFunction(a, b) {
  var c = 4;
  return a + b + c;
}
```

- Here, c is a global variable:

```
function myFunction(a, b) {
  c = 4;
  return a + b + c;
}
```

Hoisting

- JavaScript hoists all declarations, which means they are moved to the top of the current scope (function or script).
- However, initializations are not hoisted.

```
var x = 5;
var sum = x + y;
var y = 7;
```

  is hoisted to

```
var x = 5;
var y;
var sum = x + y;
y = 7;
```

  which does not make sense since y has no value when it is used.
- Always write declarations at the beginning of the scope, since that is how they are interpreted by JavaScript.

Primitive Values

- All primitive values have one of the five primitive types: Number, String, Boolean, Undefined, Null.
- Number, String, and Boolean have wrapper objects (**`Number`**, **`String`**, and **`Boolean`**), just like Java.
- For **`Number`** and **`String`**, primitive values and objects are coerced back and forth, therfore, primitive values can be treated as objects.

Strings

- String literals are delimited by either `'` or `"`.
- Quotes can be used inside strings if they don't match the quotes surrounding the string:

```
"He is called 'Johnny'";
'He is called "Johnny"';
```

- Strings can include escape sequences, e.g., `\t` or `\n`. Note that these will not cause tabs or line breaks in a HTML page since they are not HTML tags.

Numbers

- Numbers can be with or without decimals:

```
var pi = 3;
var pi = 3.14;
```

- Numbers are represented in double-precision 64-bit format, meaning the range is **±1.7976931348623157e+308** to **±-5e-324**

Boolean, Null, Undefined

- A Boolean can have the value **`true`** or **`false`**
- The only Undefined value is **`undefined`**. It is the value of a variable that has never been set to any value.
- The only Null value is **`null`**. It is used to unset a variable:

```
name = "Sara";  Name has the value "Sara".
name = null;    Name has the value null.
```

Assignment Operators

- Assignment operators are the same as in Java, `=`, `+=`, `-=`, etc

Bitwise Operators

- Bitwise operators are and, &; or, |; not, ~; xor, ^; left shift, <<; right shift, >>
- Bit operators work on 32 bits numbers.
- Any numeric operand in the operation is converted into a 32 bit number and the result is converted back to a JavaScript number.

Arithmetic Operators

- Numeric operators are the same as in Java, **+ +**, **- -**, **+**, **-**, *****, **/**, **%**
- All operations are in double precision.
- Same precedence and associativity as Java

Number Utilities

- The **`Math`** object provides functions like **`floor`**, **`round`**, **`max`**, **`min`**, trigonometric functions, etc
- The **`Number`** object has useful properties like **`MAX_VALUE`**, **`MIN_VALUE`**, **`POSITIVE_INFINITY`**, **`NEGATIVE_INFINITY`**, **`PI`** and **`NaN`**.
  - **`NaN`** represents an illegal number, for example the result of an overflow.
  - It is not equal to any other number, not even itself. Test for it with the **`isNaN()`** function.

Concatenation and Conversion

- The string concatenation operator is the same as in Java, **+**
- Concatenation coerces numbers to strings.
- Numeric operators, other than **+**, coerce strings to numbers.
- If either operand of **+** is a string, it becomes a concatenation operator.
- Explicit conversions are as follows:

1. Use the **`String`** and **Number** constructors
2. Use **`toString`** method:

```
var a = 10;
a = a.toString();
```

3. Use **`parseInt`** and **`parseFloat`** methods:

```
var a = "10";
a = parseInt(a);
```

`Typeof` Operator

- The **`typeof`** operator returns the type of a variable or expression.
- It returns **`"number"`**, **`"string"`**, or **`"boolean"`** for Number, String, or Boolean, **`"undefined"`** for Undefined, **`"function"`** for a function, **`"object"`** for objects, and **`"object"`** also for **`null`**

`typeof 10` returns the string **`"number"`**

The `Date` Object

- The `Date` Object

  - Create one with the `Date` constructor (no params)
  - Local time methods of `Date`:

    `toLocaleString` – returns a string of the date

    `getDate` – returns the day of the month

    `getMonth` – returns the month of the year (0 – 11)

    `getDay` – returns the day of the week (0 – 6)

    `getFullYear` – returns the year

    `getTime` – returns the number of milliseconds since Jan 1, 1970

    `getHours` – returns the hour (0 – 23)

    `getMinutes` – returns the minutes (0 – 59)

    `getMilliseconds` – returns the millisecond (0 – 999)

- Example: **`new Date().getDate();`**

The `String` Object

- Some `String` properties and methods:
  - `length` e.g., `var len = str1.length;` (a property, not a function)
  - `charAt(position)` e.g., `str.charAt(3)`
  - `indexOf(string)` e.g., `str.indexOf('B')`
  - `substring(from, to)` e.g., `str.substring(1, 3)`
  - `toLowerCase()` e.g., `str.toLowerCase()`

Output using the **`Document`** Object

- The **`document`** object represents the current HTML Document, an **`Element`** object represents a HTML element.
  - The **`document`** object is always present in a HTML page.
- The following line returns the HTML element with id **`elemid`**:

```
document.getElementById("elemid");
```

- The following line sets the HTML code of the element with id **`elemid`**:

```
document.getElementById("demo").innerHTML =
     ”Some output <br/>”;
```

Output Using the Console

- The **`console`** object has methods for writing to the JavaScript console, for example **`console.log("a message");`**
- This is useful when debugging a JavaScript program.

IO Using the `alert`, `confirm` and `prompt` methods.

1. `alert("Hej! \n");`

   - Parameter is plain text, not HTML

   - Opens a dialog box which displays the parameter string and an **`OK`** button.

2. `confirm("Do you want to continue?");`

   - Opens a dialog box and displays the parameter and two buttons, **`OK`** and **`Cancel`**.

3. `prompt("What is your name?", "");`

   - Opens a dialog box and displays its string parameter, along with a text box and two buttons, **`OK`** and **`Cancel`**

   - The second parameter is for a default response if the user presses **`OK`** without typing a response in the text box.

Control Statements

- **`if`** statements, **`for`** loops and **`while`** loops are similar to Java.
- There are three kinds of conditions: primitive values, relational expressions and compound expressions.

1. Primitive values
   - If it is a string, it is **`true`** unless it is the empty string.
   - If it is a number, it is **`true`** unless it is zero

`if (“hej”)` enters the if block.
`if (“”)` does not enter the if block.

Control Statements (Cont'd)

2. Relational Expressions

- The usual six comparision operators: `==`, `!=`, `<`, `>`, `<=`, `>=`
- Operands are coerced if necessary
  - If one operand is a string and one is a number, the string is coerced to a number.
  - If one operand is a boolean and the other is not, the boolean is coerced to a number (1 or 0)

- The unusual two comparision operators: `===` and `!==`
  - Same as `==` and `!=`, except that no coercions are done. The expression can only be true if the operands have the same type.

Control Statements (Cont'd)

2. Relational Expressions (Cont'd)

   - Comparisons of references to objects compare addresses, not values.

3. Compound Expressions

   - The logical operators are: and, **&&**; or, **||**; not, **!**

```
(x < 10 && y > 1)
```

Functions

- Functions are declared, much the same way as in Java, but prefixed with the `function` keyword.
- Since JavaScript is dynamically typed, neither parameters nor return value has a type:

```
function sum(a, b) {
  return a + b;
}
```

Anonymous Functions

- An anonymous function is defined in an expression, instead of a declaration.
- The reference to the anonymous function is stored in a variable, which can then be used to invoke the function.

```
var myFunc = function(a, b) {return a + b};
myFunc(4, 3); //Returns 7
```

Function Hoisting

- Functions are hoisted the same way as variables, therefore, a function can be called before it is declared:

```
square(5);
function square(y) {
    return y * y;
}
```

Function Parameters

- Parameters are passed by value, like in Java.
- The number of arguments is not checked.

Missing Arguments

- Missing arguments are set to **undefined**.
  - If undefined variables are not desired, assign default values in the function:

```
function myFunction(x, y) {
  if (y === undefined) {
    y = 0; //default value
  }
  ...
}
```

  - Can also be written like this:

```
function myFunction(x, y) {
  y = y || 0;
  ...
}
```

Function Parameters (Cont'd)

- Extra arguments have no name, but can be read from the **`arguments`** array, which is a built-in object:

```
x = sumAll(1, 123, 500, 115, 44);

function sumAll() {
    var i, sum = 0;
    for(i = 0; i < arguments.length;
        i++) {
       sum += arguments[i];
    }
    return sum;
}
```

Arrays

- Arrays are normally created with the array literal:
  ```
  var myList = [24, "bread", true];
  ```
- Elements are accessed by referring to index number, **`myList[0]`** has the value **`24`**. The first element is at index **`0`**.
- The **`length`** property is always set to the number of elements in the array.

Arrays (Cont'd)

- Elements can be added at index **`length`**:
  `myList[myList.length] = ”Stina”;`
- Elements can be iterated with a for loop:

```
var index;
var fruits = ["Banana", "Orange", "Apple"];
for (index = 0; index < fruits.length; index++)
{
     alert(fruits[index]);
}
```

Some Array Methods

- **`join`** Joins all elements of an array into a string.
- **`sort`** Coerces elements to strings and puts them in alphabetical order.
- **`concat`** Joins two or more arrays, and returns a copy of the joined arrays.
- **`push`** Appends elements to the end.
- **`pop`** Removes the last element.
- **`unshift`** Prepends elements to the beginning.
- **`shift`** Removes the first element.

The Object Model

- The object model is quite different from Java.
- JavaScript is prototype-based. Inheritance is performed by cloning existing objects that serve as prototypes.
- No classes, class-based inheritance, interfaces or polymorphism. These features can be mimicked, but they are not built-in as in Java.

Properties

- Like in Java, objects can have properties (variables).
- An object is a collection of properties, a bit like an array with named elements.
- Properties can be accessed the following ways:

```
objectName.property      e.g., person.age
objectName["property"]   e.g., person["age"]
objectName[expression]   e.g., x = "age";
                               person[x]
```

Instantiating an Object

- There are three ways to create an object.

1. Specify a list with a name:value pair for each property. Such a list is called an object literal.

```
var person = {firstName : "Nisse", age : 50};
```

2. Use the **new** keyword.

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

3. Write a constructor. The constructor is a plain function.

```
function Person(first, age) {
  this.firstName = first;
  this.age = age;
}
var myMother = new Person("Sara", 48);
```

- Use number one for collections of data, use number three for more complex objects, avoid number two.

Instantiating an Object (Cont'd)

- ```
  function Person(first, age) {
    this.firstName = first;
    this.age = age;
  }
  var myMother = new Person("Sara", 48);
  ```
- What actually happens when the constructor is called is:
  1. The **new** operator creates an object.
  2. The object is passed to the **Person** constructor as the value of this.
  3. The constructor creates the properties **firstName** and **age** in the object.
  4. The object's reference is stored in **myMother**.
  ```

By Reference

- A variable that holds an object is a reference to that object.

```
var person = {firstName : "Nisse", age : 50};
var samePerson = person;
samePerson.age = 40; //Updates also person.
```

for-in loop

- Properties can be iterated with the for-in loop:

```
var person = {name:"Stina", age:25};
var x;
for (x in person) {
    ...
}
```

Add and Delete Properties

- A Property is added by assigning a value to it.

```
var person = {firstName : "Stina", age : 50};
person.lastName = ”Svensson”;
```

- A Property is deleted with the keyword **`delete`**.

```
var person = {firstName : "Stina", age : 50};
delete person.age; //person.age is now
                   //undefined.
```

Methods

- Methods are functions defined as properties.
- Method calls have the same syntax as in Java,
  `objectName.methodName();`

Defining Methods

- Methods can be defined in constructors.

```
function Person(firstname) {
    this.name = firstname;
    this.changeName = function changeName(name) {
        this.name = name;
    }
}

var person = new Person("Olle");
person.changeName("Pelle");
```

- Like properties, methods can also be added with the object literal or added to existing objects.

The `this` keyword

- In previous examples, **`this`** has been used like we would use it in Java.
- That is not a good practice, since **`this`** might point to wrong object when a method is called from an event handler, for example as a consequence of the user clicking a button.

The `this` keyword

- A solution is to store `this` in a variable in the constructor.

```
function Person(firstname) {
    var self = this;
    self.name = firstname;
    self.changeName =
        function changeName(name) {
        self.name = name;
    }
}
```

Closures

- How could the previous example work? The variable **`self`** is referenced from the function **`changeName`** after the function **`Person`** has terminated.
- This is a programming construct call a closure.
- In languages supporting closures, nested functions can access variables in the outer function after it is closed.
- Those variables, like **`self`**, will have the value they had when the outer function created the nested function.

Object Prototype

- All objects have a prototype, from which it inherits properties and methods.
- The prototype is also an object.
- An object created from its own constructor, inherits from its own prototype.
- Objects created with the object literal, or with `new Object()`, inherit from the prototype of the object `Object`.

Prototype Chain

- Each object has a prototype chain, the top of which is `Object.prototype`.
- Objects inherits properties from all prototypes in the prototype chain.
- When looking for a prototype, the whole chain is followed until the prototype is found or the top is reached.
  - This is slow for long chains.

Inheritance

- To inherit an object, set the prototype to the object that shall be inherited:

```
function Person(name) {
   this.name = name;
}

function Employee(name, salary) {
   this.parent = Person;
   this.parent(name);
   this.salary = salary;
}
Employee.prototype = new Person();

var sara = new Employee(”Sara”, 1200);
```

Inheritance (Cont'd)

- The **Employee** constructor from previous slide:

```
function Employee(name, salary) {
    this.parent = Person;
    this.parent(name);
    this.salary = salary;
}
```

- Assigning **Person** to the **parent** property means that property is actually the **Person** function.
- When **this.parent** is called, **Person** executes and adds the **name** property to the object indicated by this, namely the newly created **Employee** object.

Inheritance (Cont'd)

- Much can be said about pros and cons of this and other ways to inherit.
- Much can also be said about implementing polymorphism and other object-oriented constructs.
- However, that is outside the scope of this course.

Regular Expressions

- Both HTML and HTTP are string based.
- Web applications often contain a lot of code searching and manipulating strings.
- Regular expressions is a powerful tool for this.
- A regular expression is a sequence of characters that forms a search pattern.

Regexp Syntax

- A regular expression has the form /pattern/modifiers, for example **`/stina/i`**.
  - The **`i`** modifier means the expression is case insensitive.

Methods Often Used for Regexps.

- The `search` and `replace` methods in the `string` object are good candidates for using regular expressions.

```
var str = "Hi, My name is Sara";
var n = str.search(/sara/i); //n is 15

var str = "Hi, my name is Olle";
var res = str.replace(/olle/i,
                      "a secret");
//res is ”Hi, my name is a secret”
```

- Note that the regexp is not a string. In fact, it is a `RegExp` object.

Regular Expression Characters

- There are two categories of characters in a regexp pattern:
  - Metacharacters have special meanings in patterns and do not match themselves. The following are metacharacters:

    `\ | ( ) [ ] { } ^ $ * + ? .`
  - Normal characters that do match themselves. All characters except the metacharacters are normal characters.
- A metacharacter is treated as a normal character if it is preceeded by a backslash, `\`.

Character Classes

- `[abc]` means any of the characters a, b or c.
- `[a-z]` means any character in the range a-z.
- A caret at the left end of a class definition means not. `[^0-9]` means any charcter not in the range 0-9
- The character order when defining ranges is the Unicode order.

Predefined Character Classes

There are many predefined character classes with abbreviations.

Abbr.	***Equiv. Pattern***	***Matches***
`\d`	`[0-9]`	a digit
`\D`	`[^0-9]`	not a digit
`\w`	`[A-Za-z_0-9]`	a word character
`\W`	`[^A-Za-z_0-9]`	not a word character
`\s`	`[\r\t\n\f]`	a whitespace character
`\S`	`[^\r\t\n\f]`	not a whitespace character

Quantifiers

Quantifier	Meaning
`{n}`	exactly n occurences of the preceeding pattern
`{m,}`	at least m occurences
`{m, n}`	at least m but not more than n occurences
`+`	at least one occurrence
`*`	any number of occurences
`?`	zero or one occurrence

Anchors

- The pattern is forced to match only at the beginning with **^**
  /^Lee/ matches **"Lee Ann"** but not **"Mary Lee Ann"**
- The pattern is forced to match only at the end with **$**
  /Lee$/ matches **"Mary Lee"**, but not **"Mary Lee Ann”**

Handling Errors

- Error handling is done much the same way as in Java, using try-catch blocks.

```
try {
    // Block of code.
} catch(err) {
    // Handle errors from the try block.
}
```

Throwing Exceptions

- The JavaScript interpreter will throw an exception if there is an error in the code.
  - The first `alert` statement below throws an exception since `x` is not defined.

```
try {
  alert(x);
} catch (err) {
  alert(err);
}
```

- Exceptions can also be thrown with the `throw` statement:

```
throw "Error message";
```

`finally` Block

- A `finally` block is always executed when leaving the try/catch blocks.

```
try {
    // Block of code.
} catch(err) {
    // Handle errors from the try block.
} finally {
    // Always executed.
}
```

Best Practices

- Avoid using global variables.
- Declare local variables with the `var` keyword, otherwise they become global variables.
- Always treat numbers, strings, and booleans as primitive values, never as objects.
  - Objects are slower and comparisions may fail when mixing objects and primitives.
- Use `===` and `!==` instead of `==` and `!=`

  `0 == ""` is true

  `0 === ""` is false