CS144: JavaScript

- Started as a simple script in a Web page that is interpreted and run by the browser
  - Supported by most modern browsers
  - Allows dynamic update of a web page
  - More generally, allows running an arbitrary code inside a browser!
    * Both a blessing and a curse
- Now, JavaScript can run anywhere, phone, tablet, desktop, server, not just in a browser

History

- 1995 Netscape Navigator added a support for a simple scripting language named “LiveScript”
  - Renamed it to “JavaScript” in 1996
  - JavaScript has nothing to do with Java!
- 1997 ECMA International standardized the language submitted by Netscape
  - ECMAScript: Official name of the standard
  - Javascript: What people call it
- 1998 ECMAScript 2, 1999 ECMAScript 3
- ECMAScript 4 abandoned due to disagreement
- 2009 ECMAScript 5
- 2015 ECMAScript 6 (= ECMAScript 2015)
  - Yearly release of new standard from ECMAScript 2015
- We learn syntax based on ECMAScript 2015
  - Most books and online tutorials are based on ECMAScript 5
  - A lot of ECMAScript 5 legacy code exist today
  - Our syntax may be different from these
  - But the newer standard removes much ugliness of old JavaScript

Basic keywords and syntax

- Syntax is very close to java/c
  - if (cond){ stmt; } else if (cond){ stmt; }
- switch (a){ case 1: break; ... default: ...; }
- while (i < 0){ stmt; }
- for (i=0; i < 10; i++){ stmt; }
- for (e of array){ stmt; } //loop over array-like elements
  * Note “of”, “in” operator checks the existence of a property
- try { throw 1; } catch (e){ stmt; } finally { stmt; }

- JavaScript is **case sensitive**
- But HTML is **NOT**. This discrepancy sometimes causes confusion.

- Variables
  - let name=value; // variable type is dynamic
  - A variable can be used without an explicit let declaration
    * becomes a global variable
    * But this is **strongly** discouraged
  - Constant: const n = 42; //n cannot be reassigned or redeclared
  - Before ECMAScript 2015, var was used instead of let with some differences
    (more on var later)

- Function declaration statement

  ```javascript
  function func_name(param1, param2,...)
  {
    ... function body ...
    return value;
  }
  ```

- JavaScript identifiers (like variable or function name) may have letters, numbers, _, and $.

- Comparison operators
  - == /= true if operands have the same value (after type conversion)
  - === /= true only if operands have the same value and type (no automatic type conversion)
  * 3 == "3" vs 3 === "3"
  - When operands are objects, == /= returns true only if both operands reference the same object (more on this later)
  - Logical AND and OR operators: && and ||
Primitive Types

- JavaScript is a dynamically-typed language
  - Variables do not have a static type. Types may change over time.

```javascript
let a = 10; // a is number type
a = "good"; // a is string type
```

- Types are either "primitive type" or "object type"
- `typeof` operator returns the current type of the variable
  - But not exactly according to the standard due to legacy code. More on this later.
- Primitive data types
  - `number, string, boolean (and null and undefined)`

**number type**

- All numbers are represented as a floating point number (double in C). No separate "integer" type
  - Bitwise operators (`&, |, ~, >>, <<`) represent a number as a 32-bit integer after truncating subdecimal digits
- `NaN` and `Infinity` are valid numbers

**boolean type**

- `true` or `false`
- Other "falsy" values: 0, "", `null`, `undefined`, `NaN`

**string type**

- Single or double quotes: `'John'` or `"John"
- `length` property returns the length of the string
- Many useful string functions exist: `charAt()`, `substring()`, `indexOf()`, ...

```javascript
let a = "abcdef";
b = a.substring(1, 4); // b = "bcd"
```
numbers and string are automatically type converted to each other

- “3”*“4” = 12
- 1+“2” = “12”

For explicit type conversion, use Number(), String(), Boolean(), parseFloat(), parseInt(), ...

undefined and null type

- undefined: the type of the value undefined
  - A variable has the value undefined before initialization
- null: the type of the value null
  - null is mainly used to represent the absence of an object
  - For legacy reasons, most systems return object as the type of null value
- undefined and null are often interchangeably used, but they are different in principle

```javascript
undefined == null; // true
undefined === null; // false
```

- typeof null is object for legacy issues

Object Type

- All non-primitive types in JavaScript are object type
- Object: data with a set of “properties”

```javascript
let o = { x: 1, y: "good" };  
let c = o.x + o["y"];  
```

- Note: o["x"] is identical to o.x. Objects are essentially an associative array.

- Object can be nested

```javascript
let o = { x: 1, y: 2, z:{ x: 3, y: 4 } };  
```
• Properties can be dynamically added, removed, and listed

```javascript
let o = new Object();
o.x = 10;
o.y = 30;
delete o.x;
Object.keys(o);
```

• Object assignment is *by copying the reference*, not by copying the whole object

```javascript
let o = { x: 10, y: 20 };
let p = o;
o.x = 30;
console.log(p.x);
```

• Object comparison is *by reference* not by value

```javascript
let o = { x: 10 };
let p = { x: 10 };
console.log(o === p);
```

**Array**

• Array is a special object with integer-indexed items

• Created with `new Array()`, or `[ 1, 2, 3 ]`

```javascript
let a = new Array(1, 2, 3);
let b = [1, 2];
console.log(a.length);
```

• `length` property returns the size of the array
  – Can be used to resize array by setting its value

• Array can be sparse and its elements types may be heterogeneous

```javascript
let a = new Array();
a[0] = 3;
a[2] = "string";
```
let b = [1, "good", , [2, 3]];
console.log(a.length)

- Size of an array automatically increased whenever needed

- Array manipulation functions
  - **Mutators**: modifies input array directly
    * reverse, sort, push, pop, shift, unshift, splice
  - **Accessors**: input array stays in tact. new output array is created
    * concat, slice, filter, map

let a = [1, 2, 3, 4];
let b = a;
console.log(b);
a[1] = 5;
console.log(b);

let a = [1, 2, 3, 4];
let b = a.slice(1, 3); // slice is an accessor
console.log(b);
a[1] = 5;
console.log(b);

let a = [1, 2, 3, 4];
let b = a;
console.log(b);
a = ["a", "b", "c"];
console.log(b);

**Regular expression**

- **RegExp** is a special object that describes a pattern to search for in a string

let r = /a?b*c/;

- Can be used in the following functions
  - String: search(), match(), replace(), split()
- RegExp: `exec()`, `test()`

• Examples

```
/ABC/.test(str); // true if str has substr ABC
/ABC/i.test(str); // i ignores case
/[Aa]B[C-E]/.test(str);
'123abbbc'.search(/ab*c/); // 3 (position of 'a')
'12e34'.search(/[\^d]/); // 2 [^x]: except x, \d: digit
```

**Function**

• In Javascript, functions are objects!
  - Functions can be assigned to a variable
  - Functions can be passed as a parameter

  - Functions can have properties

```
let square = function (x) { return x*x; }; // anonymous function
// function definition expression

square(10);

function myfunc(x, func) {
  return func(x);
}
myfunc(10, square);
myfunc(10, function (x) { return x * 2; });
myfunc.a = 20;
```

• Arrow function expression (ECMAScript 2015)
  - Shorthand notation for function definition expression

```
* (param1, ..., paramN)=> { statements }
* (param1, ..., paramN)=> expression
* singleParam => expression
```
* () => { statements }

```javascript
let square = x => x*x;
console.log(square(10));
```

- Very convenient to pass a function as a parameter in Node, Express, etc.
- Strictly speaking, a function is an object type according to the standard, but `typeof` returns "function".

**Object-Oriented Programming (OOP)**

- Objects can have methods

```javascript
let o = new Object();
o.x = 1;
o.doubleX = function () { this.x *= 2; }
console.log(o.x);
```

- Inside inside an object’s method, `this` points to the object
  - **Note**: Differently from `function (){...}`, arrow functions does not have its own `this`
    - * `this` from the surrounding context is used
    - * Do not use arrow functions for an object method or a constructor!

**Class**

- ECMAScript 2015 added more elegant syntax for classes and inheritance

```javascript
class Shape {
    // Constructor
    constructor(color) {
        this.color = color;
    }

    // Method
    printColor() {
        console.log(this.color);
    }
}
```
class Rectangle extends Shape {
    // Constructor
    constructor(color, width, height) {
        super(color); // super refers to the parent class
        this.width = width;
        this.height = height;
    }
    // Getter
    get area() {
        return this.width * this.height;
    }
    // Setter
    set x(v) { this.coordX = v; console.log("this.coordX = " + v); } 
};
let r = new Rectangle("red", 2, 3);
r.printColor();
console.log(r.area);
r.x = 1;

Scope

- Global vs local scope
  - A variable declared with let inside a block is valid only within the block: block-scope local variable
  - A variable declared outside of any block has global scope.
  - A variable that is assigned to a value without an explicit let declaration has global scope.
    * A variable created this way becomes a property of the global object (in case of browser, window)
    * It is strongly recommended not to create global variables this way.
let a = "a"; // global vs local?
b = "b"; // global vs local?

function f() {
    c = "c"; // global vs local?
    let d = "d"; // global vs local?
}

- **let vs var**
  - let was introduced only in ECMAScript 2015.
  - Before let, var was used with the following difference
    * function scope (not block scope)
    * hoisting (vs no hoisting)
      - declaration is “moved” to the top of its scope

```javascript
var a = 10; // global vs local?
function f() {
    b = 10; // global vs local?
    console.log(b);
    var b;
}
f();
console.log(b);
```

- Use of let produces much cleaner code! So use it
  - Unfortunately, many existing codes and examples still use var

- Functions can be nested
  - *lexical scope* (not dynamic scope) is used to determine the scope of local variables

```javascript
function f() {
    let a = 1;
    let b = 2;

    function g() {
```

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```javascript
console.log(a); // a =
console.log(b); // b =

b = 3;
}

if (a > 0) {
    let b = 4;
    g();
    console.log(b); // b =
}

custom.log(b); // b =
}

f(); // what will be printed?
```

**Keyword `this`**

- The meaning of `this` is a source of great confusion and bug in JavaScript
- Inside browser, `window` object becomes the *global object*
  - Any variable assigned without declaration becomes a property of the global object
- Interpretation of `this`
  - At the top-most block (outside of any function call), `this` = global object
  - Inside a method call on an object (including constructor), `this` = the object
  - When called as an event handler inside a browser, `this` = DOM element to which the event handler was set
  - Inside all other function calls, `this` = the global object
- But arrow functions (`( ) => {}`) does not provide their own `this` binding
  - It retains the `this` value of the enclosing lexical context

```javascript
x = 10;

function_printx = function() { console.log(this.x); }
arrow_printx = () => console.log(this.x)

o = { x: 20 };
o.printx_f = function_printx;
```
```javascript
var o = { x: 11, y: 3, z: 4, w: 3 };

o.printx_a = arrow_printx;

// What will be printed?
console.log(this.x);
function_printx();
arrow_printx();

o.printx_f();

o.printx_a();
```

- **Note**
  - Do not use arrow functions to define a class method/constructor
  - Except inside class definition, use `this` only if it is absolutely necessary

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## Modules

### ECMAScript 2015 Module

- ECMAScript 2015 added support for modules
  - One module <-> One JavaScript file
  - Everything in a module stays local unless declared `export`
  - `export` entities can be `imported` and used by another JavaScript code

### Multiple named export example

```javascript
// ------ lib.js ------
export function square(x) {
  return x * x;
}
export function dist(x, y) {
  return Math.sqrt(square(x) + square(y));
}

// ------ main.js ------
import { square, dist } from './lib';
square(11);
dist(4, 3);
```
// ---- main2.js ------
import * as lib from './lib';
lib.square(11);
lib.dist(4, 3);

- Single default export

// ---- myFunc.js ------
export default function () {
...
}

// ---- main1.js ------
import myFunc from 'myFunc';
myFunc();

JavaScript Object Notation (JSON)

- The standard syntax to represent literal objects in JavaScript (with some restrictions)
  - e.g., [{ "x": 3, "y": "Good"}, { "x": 4, "y": "Bad"}]
  - Q: What does the this notation mean in JavaScript?
  - Compared to JavaScript, the main differences are
    * Object property names require double quotes
    * Strings need double quotes, not single quotes
    * JSON values cannot be functions or undefined

- JSON-related functions:
  - JSON.stringify(obj): JavaScript object -> JSON string
  - JSON.parse(str): JSON string -> JavaScript object

- Example

```javascript
let x = '[[ { "x" : 3, "y" : "Good" }, { "x" : 4, "y" : "Bad" } ]]';
let o = JSON.parse(x);
let n = o[0].x + o[1].x;
console.log(n);
```

- JSON has become one of the two most popular data-exchange format on the Web
Based on JavaScript
- Easy to understand

References

- Javascript: The Definitive Guide by David Flanagan
  - Strongly recommended if you plan to code in JavaScript extensively
- ECMAScript standard: ECMA 262 https://www.ecma-international.org/ecma-262/
  - The ultimate reference on what is really correct
  - But very boring to read and learn from
  - Browser support is a few generations behind
- Summary of new features in ECMAScript 2015: http://es6-features.org/
- JSON standard: ECMA 404 http://www.json.org/