

JavaScript

Lecture 4b (Closure)

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JavaScript Introduction

Topics discussed this presentation

- Scope
- Closure

Scope

Global variables

Variables declared **inside** function

- Visible throughout function
- Invisible outside function

Variables declared **outside** function

- These are **global** variables
- Content both files visible program-wide.
- Avoid using global variables

```
//file: script1.js  
velocity = 10;
```

```
//file: script2.js  
function square(x) {  
  return x * x;  
}
```

```
//velocity visible here because global  
console.log(square(velocity)); // 100
```

Scope

Global variables

Code below left generates error in *strict* mode:

- Uncaught ReferenceError: velocity is not defined

```
// Invalid code: undeclared global  
'use strict';  
velocity = 10;
```

```
// Valid code: declared global  
'use strict';  
let velocity = 10;  
const speed = 10;  
var acceleration = 10;
```

Scope

Global variables

Variables defined but not declared **inside function**

- Are global variables
- Referred to as *implied global*
- Dangerous practice - avoid
- Use ES6 strict disallows

```
let circle;  
function requestReport() {  
    center = circle.getCenter();  
}
```

circle is a global variable
center is (implied) global variable

Scope

Implied Globals

Defined but not declared in function

- `velocity` is implied global
- Visible program-wide once `f()` invoked
- Alert box displays 100
- Illegal in strict mode
- **ReferenceError: `velocity` is not defined**

```
function f() {  
    velocity = 100;  
}
```

```
f();  
alert(velocity);
```

100

OK

Scope

Function scope

Defined but not declared in function

- `velocity` is implied global
- Visible program-wide once `f()` invoked
- Alert box displays 100
- Illegal in strict mode
- **ReferenceError: `velocity` is not defined**

```
function f() {  
    velocity = 100;  
}
```

```
f();  
alert(velocity);
```

100

OK

JavaScript

Global Object

In the browser, the global object is the **window** object

```
javascript.html x
<!DOCTYPE html>
<html>
  <head>
    <meta charset="UTF-8">
    <title>JavaScript</title>
  </head>
  <body>
    <script src="javascript1.js"></script>
    <script src="javascript2.js"></script>
  </body>
</html>
```

2 script files loaded
into global space

Both arguments **x** are **this** reference to Window object
Observe that contents of both files loaded into same
global space.
This is a major weakness in JavaScript design.

```
javascript1.js x
var cars = ['Ford', 'Honda', 'Nissan', 'Peugeot'];

var functionOne = function (x) {
  console.log(x);
};

functionOne (this);
```

```
javascript2.js x
var trucks = ['Volvo', 'Saab', 'Mercedes'];

var functionTwo = function (x) {
  console.log(x);
};

functionTwo(this);
```

```
javascript2.js x
var trucks = ['Volvo', 'Saab', 'Mercedes'];

var functionTwo = function (x) {
  console.log(x);
};

functionTwo(this);
```

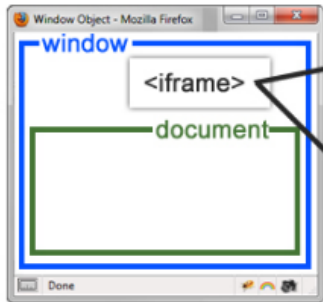
▶ x: Window
▶ x.trucks: Array[3]
▶ x.cars: Array[4]

JavaScript

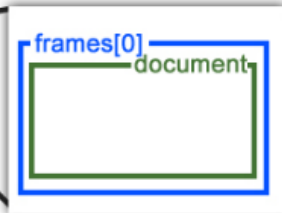
Global Object

Window and document objects

`window.document.{property}`



`{window}`
↓
`window.frames[0].{window property}`



Javascript Window Object with Iframe

JavaScript

Global Abatement

Define global variable for app

- `const MyApp={}`
- This becomes container for app

```
const MYAPP = {};  
  
MYAPP.square = function (x) {  
  return x * x;  
};  
  
console.log(MYAPP.square(val));
```

Global Abatement

Using Immediately Invoked Function Expression (IIFE)

```
(function () {  
  // code here  
  // objects declared here not visible outside function  
})();
```

Global Abatement

Using Immediately Invoked Function Expression (IIFE)

javascript.html x

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="UTF-8">
    <title>JavaScript</title>
  </head>
  <body>
    <script src="javascript1.js"></script>
    <script src="javascript2.js"></script>
  </body>
</html>
```

Immediately invocable function expression (IIFE)

2 script files loaded into global space

trucks & cars objects no longer polluting global namespace.

```
{function() {
  var cars = [ 'Ford', 'Honda', 'Nissan', 'Peugot' ];

  var functionOne = function (x) {
    console.log(x);
  };

  functionOne(this);
}());

(function() {
  var trucks = [ 'Volvo', 'Saab', 'Mercedes'];

  var functionTwo = function (x) {
    console.log(x);
  };

  functionTwo(this);
}());
```

```
1 (function() {
2   var trucks = [ 'Volvo', 'Saab', 'Mercedes']; trucks = ["Volvo", "Saab", "M
3
4   var functionTwo = function (x) { x = Window {external: Object, chrome: Obj
5     console.log(x);
6   };
7
8   functionTwo(this);
9 }());
```

Watch

- x: Window
- x.trucks: undefined
- x.cars: undefined

Call Stack

functionTwo javascript2.js:5

Global Abatement

IIFE pattern used for global abatement

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset='UTF-8'>
    <title>AbateGlobals</title>
  </head>
  <body>
    <button type='button' onclick='clickMe()'>Click Me</button>
    <script src='abateglobals.js'></script>
  </body>
</html>
```

Global Abatement

IIFE pattern used for global abatement

Function *clickMe* invoked on button press:

```
(function (context) {  
  const bar = 100;  
  context.clickMe = function () {  
    foo();  
    alert('hey, it\'s me');  
  };  
  
  function foo() {  
    alert('in foo');  
  }  
})(this);
```

jQuery

IIFE and document ready interaction

```
(function () { // <= IIFE
  // Do something that doesn't require DOM to be ready.
  console.log('within IIFE');
  $(function () { // <= same as $(document).ready(function () {
    // Do something involving DOM manipulation.
    console.log($('#p'));
  });
}($)); // <= jQuery is IIFE parameter.
```

Scope

Global abatement

```
// myapp.js
MYAPP = (function () {

  function square(x) {
    return x * x;
  }

  function cube(x) {
    return x * square(x);
  }

  return {
    square,
    cube,
  };
})();
```

```
<!DOCTYPE html>
<html>
<head>
...
</head>
<body>
  <script src="myapp.js"></script>
  <script src="calculator.js"></script>
</body>
</html>
```

```
// calculator.js
let x2 = MYAPP.square(10); // 100
let x3 = MYAPP.cube(10); // 1000
```


Java

Block Scope

Java has *block scope*:

- Variable **y** out of scope (invisible) outside its block

```
public void scope() {  
    int x = 10;  
    {  
        int y = 100;  
    }  
    System.out.println('x : ' + x); // ok: x in scope  
    System.out.println('y : ' + y); // compile-time error: y out of scope  
}
```

JavaScript function scope

Hoisting

- Declaration of **y** *hoisted* to top of function.
- Initialization of **y** takes place as shown.

```
function scopeExample()
{
  console.log('y : ', y); // undefined
  var x = 10;
  {
    var y = 100;
  }

  console.log('x : ', x); // 10
  console.log('y : ', y); // 100
};

scopeExample();
```

JavaScript block scope

ES6 variables **let** and **const**

- *var* replaced by *let*
- **ReferenceError: y is not defined**
- *let* and *const* have block scope.

```
function scopeExample()
{
  console.log('y : ', y); // ReferenceError
  let x = 10;
  {
    let y = 100;
  }

  console.log('x : ', x); // 10
  console.log('y : ', y); // 100
};

scopeExample();
```

JavaScript block scope

Test your knowledge

- What is the console output here?

```
var x = 'outer scope';  
  
function f() {  
  console.log('x : ', x);  
  var x = 'inner scope';  
}  
  
f();
```

JavaScript block scope

Test your knowledge

- One change has been made: `var x = ...` commented out.
- What is the console output now?

```
var x = 'outer scope';  
  
function f() {  
  console.log('x : ', x);  
  // var x = 'inner scope';  
}  
  
f();
```

JavaScript block scope

Test your knowledge

- Final change: replace *var* *x* with *let*.
- How does this influence the output?

```
var x = 'outer scope';  
  
function f() {  
  console.log('x : ', x);  
  let x = 'inner scope';  
}  
  
f();
```

Scope

Temporal dead zone (TDZ)

- Already encountered TDZ above.
- **let** and **const** are hoisted.
- Values **undefined** until initialized.
- In meantime, are in TDZ:
 - Attempted access before initialization generates error
 - **ReferenceError: x is not defined**

```
let x = 'outer scope';  
function f() {  
  console.log('x : ', x); // <= x in TDZ, value undefined  
  let x = 'inner scope';  
}  
  
f();
```

Scope

this variable

```
let calculator = {  
  result: 0,  
  multiply: function (number, multiplier) {  
    let _this = this; // this is bound to calculator object  
    let helper = function (x, y) {  
      _this.result = x * y; // this is bound to global object  
    };  
  
    helper(number, multiplier);  
    return _this;  
  },  
  
  getResult: function () {  
    return this.result;  
  },  
};  
  
console.log(calculator.multiply(9, 4).result); // => 36
```


Scope

this variable problem solved by using arrow function

```
let calculator = {
  result: 0,
  multiply: (number, multiplier) => {
    let helper = function (x, y) {
      this.result = x * y;
    };

    helper(number, multiplier);
    return this;
  },

  getResult: function () {
    return this.result;
  },
};

console.log(calculator.multiply(9, 4).result); // => 36
```

JavaScript Closure

A Powerful Feature

An inner function that has access to

- its own variables,
- the outer enclosing function's variables,
- the global variables.

This holds even when outer function has returned.

```
function favouriteBook(title, author) {  
  const intro = 'My favourite book is '  
  return function book() {  
    return intro + title + ' by ' + author;  
  };  
};  
  
const favourite = favouriteBook('Eloquent JavaScript', 'Marijn Haverbeke');  
console.log(favourite());
```

JavaScript Closure

A Powerful Feature

```
function favouriteBook(title, author) {  
  let intro = 'My favourite book is '  
  return function book() {  
    return intro + title + ' by ' + author;  
  };  
};
```

title and **author** are local variables of outer function. They persist even when outer function exits.

outer enclosing function **favouriteBook**

inner function **book**
returned by outer function

```
let book = favouriteBook('True Believer', 'Hoffer');  
console.log(book());
```

variable **book** is a reference to the inner function also called, optionally, book.

JavaScript Closure

A Powerful Feature

A closure example from Eloquent JavaScript

```
// @see page 50 http://eloquentjavascript.net/Eloquent\_JavaScript.pdf
function multiplier(factor) {
  return function (number) {
    return number * factor;
  };
}

const twice = multiplier(2);
const result = twice(5);
console.log(result); // => 10

const thrice = multiplier(3);
result = thrice(5);
console.log(result); // => 15
```

JavaScript Closure

A Powerful Feature

A closure example from w3schools

```
// @see http://www.w3schools.com/js/js\_function\_closures.asp
const add = (function () {
  let counter = 0;
  return function () {
    return counter += 1;
  };
})();

console.log(add()); // => 1
console.log(add()); // => 2
console.log(add()); // => 3
```

JavaScript Closure

A Powerful Feature

```
let add = (function () {  
  let counter = 0;  
  return function () {  
    return counter += 1;  
  };  
})();
```

Immediately Invoked Function Expression (IIFE)

When invoked, the variable **counter** initialized to zero and anonymous inner function returned and assigned to variable **add**.

```
console.log(add()); // => 1  
console.log(add()); // => 2  
console.log(add()); // => 3
```

counter variable persists at zero when IIFE exits.
On first invocation of **add**, **counter** increments to 1.
On second invocation **counter** is incremented to 2.
On third invocation **counter** is incremented to 3.

JavaScript Closure

Final Example

```
myObject =  
(function() {  
  let value = 0;  
  return {  
    increment : function(inc) {  
      value += typeof inc === 'number' ? inc : 1;  
    },  
    getValue : function() {  
      return value;  
    }  
  };  
})();
```

Immediately invocable
function expression (IIFE)

return value is object

```
myObject.increment();  
console.log(myObject.getValue()); // => 1  
myObject.increment(2);  
console.log(myObject.getValue()); // => 3
```

JavaScript Inheritance

ES5 inheritance example

```
const shape = {  
  xPosition: 0.0,  
  yPosition: 0.0,  
};  
  
const circle = Object.create(shape);  
  
circle.area = function () {  
  return Math.round(Math.PI * Math.pow(this.radius, 2));  
};  
  
circle.xPosition = 100;  
circle.radius = 50;  
  
console.log('area ' + circle.area()); // 7854  
console.log('xPosition ' + circle.xPosition); // 100  
console.log('yPosition ' + circle.yPosition); // 0 (default)
```


JavaScript Inheritance

ES6 simulates classical inheritance

```
class Shape {  
  constructor(xPosition, yPosition) {  
    this.xPosition = xPosition;  
    this.yPosition = yPosition;  
  }  
}  
  
class Circle extends Shape {  
  constructor(xPosition, yPosition, radius) {  
    super(xPosition, yPosition);  
    this.radius = radius;  
  }  
  
  area() {  
    return Math.round(Math.PI * Math.pow(this.radius, 2));  
  }  
}  
  
const circle = new Circle(100.0, 100.0, 50.0);  
console.log('area ' + circle.area()); // 7854
```

JavaScript

Presentation summary

- Globals
 - Avoid use global variables.
 - Avoid polluting global namespace.
 - Use global abatement technique(s).
- Scope
 - Pre ES6 - only function scope.
 - ES6 adds block scope.
- Closure
 - A powerful language feature.



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