

JavaScript Programming

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How do you program in JavaScript?

From Wikipedia:

...

... supporting **object-oriented**, **imperative**, and **functional programming**

...

- Originally programming conventions (i.e. patterns) rather than language features
 - ECMAScript adding language features (e.g. `class`, `=>`, etc.)

Object-oriented programming: methods

- With first class functions a property of an object can be a function

```
var obj = {count: 0};  
obj.increment = function (amount) {  
  this.count += amount;  
  return this.count;  
}
```

- Method invocation: calls function and binds `this` to be object

```
obj.increment(1); // returns 1  
obj.increment(3); // returns 4
```

this

- In methods `this` will be bound to the object

```
var o = {oldProp: 'this is an old property'};
o.aMethod = function() {
  this.newProp = "this is a new property";
  return Object.keys(this); // will contain 'newProp'
}
o.aMethod(); // will return ['oldProp', 'aMethod', 'newProp']
```

- In non-method functions:
 - `this` will be the global object
 - Or if "use strict"; `this` will be undefined

functions are objects - can have properties

```
function plus1(value) {  
    if (plus1.invocations == undefined) {  
        plus1.invocations = 0;  
    }  
    plus1.invocations++;  
    return value + 1;  
}
```

- `plus1.invocations` will be the number times function is called
- Acts like static/class properties in object-oriented languages

function are objects: Have methods

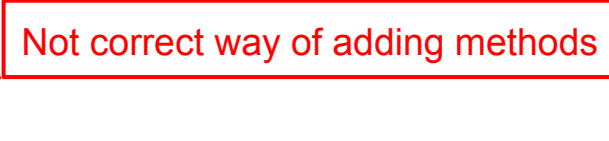
```
function func(arg) { console.log(this,arg); }
```

- `toString()` method - return function as source string
 - `func.toString()` returns `'function func(arg) { console.log(this,arg); }'`
- `call()` method - call function specifying `this` and arguments
 - `func.call({t: 1}, 2)` prints `'{ t: 1 } 2'`
 - `apply()` like `call()` except arguments are passed as an array - `func.apply({t: 2}, [2])`
 - `this` is like an extra hidden argument to a function call and is used that way sometimes
- `bind()` method - creates a new function with `this` and arguments bound
 - `let newFunc = func.bind({z: 2}, 3);`
 - `newFunc()` prints `'{ z: 2 } 3'`

Object-oriented programming: classes

Functions are classes in JavaScript: Name the function after the class

```
function Rectangle(width, height) {  
    this.width = width;  
    this.height = height;  
    this.area = function() { return this.width*this.height; }  
}  
var r = new Rectangle(26, 14);    // {width: 26, height: 14}
```



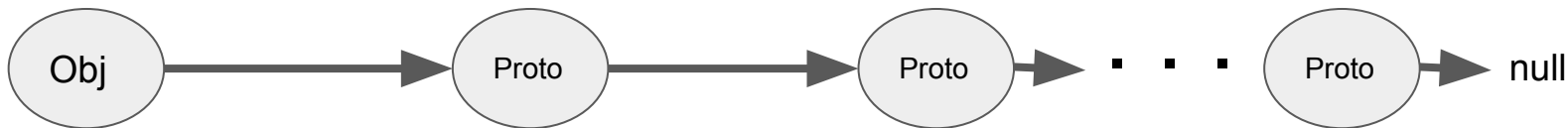
Functions used in this way are called **constructors**:

```
r.constructor.name == 'Rectangle'
```

```
console.log(r): Rectangle { width: 26, height: 14, area: [Function] }
```

Object-oriented programming: inheritance

- Javascript has the notion of a **prototype** object for each object instance
 - Prototype objects can have prototype objects forming a **prototype chain**



- On an object property read access JavaScript will search the up the prototype chain until the property is found
 - Effectively the properties of an object are its **own** property in addition to all the properties up the prototype chain. This is called prototype-based inheritance.
- Property updates are different: always create property in object if not found

Using prototypes

```
function Rectangle(width, height) {
    this.width = width;
    this.height = height;
}
Rectangle.prototype.area = function() {
    return this.width*this.height;
}
var r = new Rectangle(26, 14);    // {width: 26, height: 14}
var v = r.area();                // v == 26*14
Object.keys(r) == [ 'width', 'height' ] // own properties
```

Note: Dynamic - changing prototype will cause all instances to change

Prototype versus object instances

```
var r = new Rectangle(26, 14);
```

Understand the difference between:

```
r.newMethod = function() { console.log('New Method called'); }
```

And:

```
Rectangle.prototype.newMethod =  
    function() { console.log('New Method called'); }
```

Inheritance

```
Rectangle.prototype = new Shape(...);
```

- If desired property not in `Rectangle.prototype` then JavaScript will look in `Shape.prototype` and so on.
 - Can view prototype objects as forming a **chain**. Lookups go up the prototype chain.
- Prototype-based inheritance
 - Single inheritance support
 - Can be dynamically created and modified

ECMAScript version 6 extensions

```
class Rectangle extends Shape { // Definition and Inheritance
  constructor(height, width) {
    super(height, width);
    this.height = height;
    this.width = width;
  }
  area() { // Method definition
    return this.width * this.height;
  }
  static countRects() { // Static method
    ...
  }
}

var r = new Rectangle(10,20);
```

React.js example class

```
class HelloWorld extends React.Component {  
  constructor(props) {  
    super(props);  
    ...  
  }  
  render() {  
    return (  
      <div>Hello World</div>  
    );  
  }  
}
```

React.js example class

```
class HelloWorld extends React.Component {
  constructor(props) {
    super(props);
    this.clickHandler = this.clickHandler.bind(this); // What does this do?
    ...
  }
  clickHandler() {
    ...
  }
  render() {
    return (
      <div onClick={this.handleClick}>Hello World</div>
    );
  }
}
```

Functional Programming

- Imperative:

```
for (var i = 0; i < anArr.length; i++) {  
    newArr[i] = anArr[i]*i;  
}
```

- Functional:

```
newArr = anArr.map(function (val, ind) {  
    return val*ind;  
});
```

- Can write entire program as functions with no side-effects

```
anArr.filter(filterFunc).map(mapFunc).reduce(reduceFunc);
```

Functional Programming - ECMAScript 6

- Imperative:

```
for (var i = 0; i < anArr.length; i++) {  
    newArr[i] = anArr[i]*i;  
}
```

- Functional:

```
newArr = anArr.map((val, ind) => val*ind); // Arrow function
```

- Can write entire program as functions with no side-effects

```
anArr.filter(filterFunc).map(mapFunc).reduce(reduceFunc);
```

Arrow functions don't redefine `this`

We can mostly but not totally avoid functional style

- Asynchronous events done with callback functions

Browser:

```
function callbackFunc() { console.log("timeout"); }  
setTimeout(callbackFunc, 3*1000);
```

Server:

```
function callbackFunc(err, data) { console.log(String(data)); }  
fs.readFile('/etc/passwd', callbackFunc);
```

- Node.js programming: Write function for HTTP request processing
- React's JSX prefers functional style: `map()`, `filter()`, `?:`

Closures

An advanced programming language concept you need to know about

```
var globalVar = 1;
function localFunc(argVar) {
  var localVar = 0;
  function embedFunc() {return ++localVar + argVar + globalVar;}
  return embedFunc;
}
```

```
var myFunc = localFunc(10); // What happens if a call myFunc()? Again?
```

- myFunc **closure** contains argVar, localVar and globalVar

Using Scopes and Closures

- Consider effect on the scopes of:

```
var i = 1;
. . .
function f() {
  i++;
  return i;
}
```

Versus

```
(function () {
  var i = 1;
  . . .
  function f() {
    i++;
    return i;
  }
  return f;
})();
```

Using closures for private object properties

```
var myObj = (function() {  
    var privateProp1 = 1;  var privateProp2 = "test";  
    var setPrivate1 = function(val1) { privateProp1 = val1; }  
    var compute = function() {return privateProp1 + privateProp2;}  
    return {compute: compute, setPrivate1: setPrivate1};  
})();
```

```
typeof myObj;           // 'object'  
Object.keys(myObj);    // [ 'compute', 'setPrivate1' ]
```

What does myObj.compute() return?

Beware of this and nested functions

```
'use strict';
function readFileMethod() {
    fs.readFile(this.fileName, function (err, data) {
        if (!err) {
            console.log(this.fileName, 'has length', data.length);
        }
    });
}
var obj = {fileName: "aFile"; readFile: readFileMethod};
obj.readFile();
```

- Generates error on the console.log state since this is undefined

Beware of this and nested functions - work around

```
'use strict';
function readFileMethod() {
    fs.readFile(this.fileName, (err, data) => {
        if (!err) {
            console.log(this.fileName, 'has length', data.length);
        }
    });
}
var obj = {fileName: "aFile"; readFile: readFileMethod};
obj.readFile();
```

- Works since an arrow function doesn't smash this

Closures can be tricky with imperative code

```
// Read files './file0' and './file1' and return their length
for (var fileNo = 0; fileNo < 2; fileNo++) {
  fs.readFile('./file' + fileNo, function (err, data) {
    if (!err) {
      console.log('file', fileNo, 'has length', data.length);
    }
  });
}
```

- Ends up printing two files to console both starting with:

file 2 has length

Why?

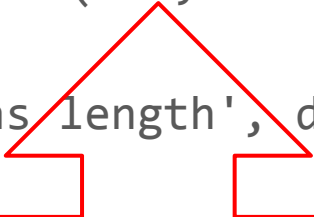
Stepping through the execution

```
for (var fileNo = 0; fileNo < 2; fileNo++) {  
  fs.readFile('./file' + fileNo, function (err, data) {  
    if (!err) {  
      console.log('file', fileNo, 'has length', data.length);  
    }  
  });  
}
```

Execution starts here: fileNo= 0

Stepping through the execution

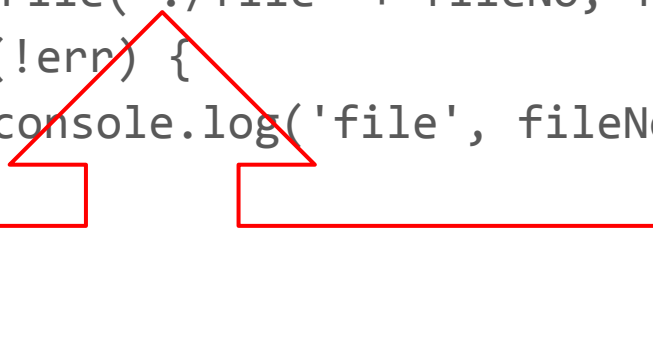
```
for (var fileNo = 0; fileNo < 2; fileNo++) {  
  fs.readFile('./file' + fileNo, function (err, data) {  
    if (!err) {  
      console.log('file', fileNo, 'has length', data.length);  
    }  
  });  
}
```



Call the function `fs.readFile`, before we can we must evaluate the arguments: the first argument results from the string concatenation operation forming `./file0`, the second argument is a function which is passed as a function and its closure containing the variables accessed by the function. In this case only `fileNo` is accessed by the function so the closure contains `fileNo` (which is currently 0).

Stepping through the execution

```
for (var fileNo = 0; fileNo < 2; fileNo++) {  
  fs.readFile('./file' + fileNo, function (err, data) {  
    if (!err) {  
      console.log('file', fileNo, 'has length', data.length);  
    }  
  });  
}
```



Note that `fs.readFile` returns after it has started reading the file but before it has called the callback function. The execution does the `fileNo++` and calls back to `fs.readFile` with an argument of `"./file1"` and a new closure and function. The closure has only `fileNo` (which is currently 1).

Stepping through the closure example

```
for (var fileNo = 0; fileNo < 2; fileNo++) {  
  fs.readFile('./file' + fileNo, function (err, data) {  
    if (!err) {  
      console.log('file', fileNo, 'has length', data.length);  
    }  
  });  
}
```

After creating two function with closures and calling `fs.readFile` twice the `for` loop finishes. Some time later in the execution the file reads will finish and `fs.readFile` will call the functions we passed. Recall that `fileNo` is now 2.


Sometime later: file0 read finishes...

```
for (var fileNo = 0; fileNo < 2; fileNo++) {  
  fs.readFile('./file' + fileNo, function (err, data) {  
    if (!err) {  
      console.log('file', fileNo, 'has length', data.length);  
    }  
  });  
}
```

'./file0' is read so our callback starts executing err is falsy so we go to the console.log statement.

Running callbacks....

```
for (var fileNo = 0; fileNo < 2; fileNo++) {  
  fs.readFile('./file' + fileNo, function (err, data) {  
    if (!err) {  
      console.log('file', fileNo, 'has length', data.length);  
    }  
  });  
}
```



When evaluating the arguments to `console.log` we go to the closure and look at the current value of `fileNo`. We find it as 2. The result is we print the correct `data.length` but the wrong file number. The same thing happens for the `'./fileNo1'` callback.

Broken fix #1 - Add a local variable

```
for (var fileNo = 0; fileNo < 2; fileNo++) {  
    var localFileNo = fileNo;  
    fs.readFile('./file' + localFileNo, function (err, data) {  
        if (!err) {  
            console.log('file', localFileNo, 'has length', data.length);  
        }  
    });  
}
```

Closure for callback now contains `localFileNo`. Unfortunately when the callback functions run `localFileNo` will be `1`. Better than before since one of the printed lines has the correct fileNo. 😊

A fix - Make a private copy of fileNo using a call

```
function printFileLength(aFileNo) {
    fs.readFile('./file' + aFileNo, function (err, data) {
        if (!err) {
            console.log('file', aFileNo, 'has length', data.length);
        }
    });
}
for (var fileNo = 0; fileNo < 2; fileNo++) {
    printFileLength(fileNo);
}
```

Note: This works but sometimes it prints the `file0` line first and sometimes it prints the `file1` line first.

Another fix - Make a private copy of fileNo with let

```
for (var fileNo = 0; fileNo < 2; fileNo++) {  
  let localFileNo = fileNo;  
  fs.readFile('./file' + localFileNo, function (err, data) {  
    if (!err) {  
      console.log('file', localFileNo, 'has length', data.length);  
    }  
  });  
}
```

Note: Same out-of-order execution as previous fix

JavaScript Object Notation (JSON)

```
var obj = { ps: 'str', pn: 1, pa: [1, 'two', 3, 4], po: { sop: 1}};
```

```
var s = JSON.stringify(obj) =  
    '{"ps":"str","pn":1,"pa":[1,"two",3,4],"po":{"sop":1}}'
```

```
typeof s == 'string'
```

```
JSON.parse(s) // returns object with same properties
```

- JSON is the standard format for sending data to and from a browser

JavaScript: The Bad Parts

Declaring variables on use - Workaround: Force declarations

```
var myVar = 2*typeoVar + 1;
```

Automatic semicolon insertion - Workaround: Enforce semicolons with checkers

```
return
```

```
"This is a long string so I put it on its own line";
```

Type coercing equals: `==` - Workaround: Always use `===`, `!==` instead

```
("" == "0") is false but (0 == "") is true, so is (0 == '0')
```

```
(false == '0') is true as is (null == undefined)
```

`with`, `eval` - Workaround: Don't use

Some JavaScript idioms

- Assign a default value

```
hostname = hostname || "localhost";  
port = port || 80;
```

- Access a possibly undefined object property

```
var prop = obj && obj.propname;
```

- Handling multiple this:

```
fs.readFile(this.fileName + fileNo, function (err, data) {  
    console.log(this.fileName, fileNo); // Wrong!  
});
```

Some JavaScript idioms

- Assign a default value

```
hostname = hostname || "localhost";  
port = port || 80;
```

- Access a possible undefined object property

```
var prop = obj && obj.propname;
```

- Handling multiple this: self

```
var self = this;  
fs.readFile(self.fileName + fileNo, function (err, data) {  
    console.log(self.fileName, fileNo);  
});
```

Some JavaScript idioms

- Assign a default value

```
hostname = hostname || "localhost";  
port = port || 80;
```

- Access a possible undefined object property

```
var prop = obj && obj.propname;
```

- Handling multiple this:

```
fs.readFile(this.fileName + fileNo, (err, data) =>  
    console.log(this.fileName, fileNo)  
);
```