ECMAScript 6

Dr. Axel Rauschmayer

2ality.com

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About me

Axel Rauschmayer:

- Editor of JavaScript Weekly
- Blogger at 2ality.com
- Co-organizer of MunichJS (JavaScript user group)

I have written about ECMAScript 6 since early 2011.

JavaScript: big and dangerous

Black rhinoceros: mammal with highest rate of mortal combat (males: 50%).

JavaScript: Used for much more than it was originally created for. Let's make it better for those tasks...

ECMAScript 6

ECMAScript 6: next version of JavaScript (current: ECMAScript 5).

This talk:

- Why (goals)?
- How (design process)?
- What (features)?

Warning

All information is preliminary, features can and will change.

Background

Glossary

Important terms:

- **TC39 (Ecma Technical Committee 39):** the committee evolving JavaScript.
  - Members: companies (all major browser vendors etc.).
  - Meetings attended by employees and invited experts.
- **JavaScript:** colloquially: the language; formally: one implementation
  - **ECMAScript:** the language standard
- **ECMAScript Harmony:** improvements after ECMAScript 5 (ECMAScript 6 and 7)
  - **ECMAScript.next:** code name for upcoming version, subset of Harmony
  - **ECMAScript 6:** the final name of ECMAScript.next (probably)

Goals for ECMAScript 6

One of several official goals [1]: make JavaScript better

- for complex applications
- for libraries (possibly including the DOM)
- as a target of code generators

How ECMAScript features are designed

Avoid "design by committee":

- Design by "champions" (groups of 1–2 experts)
- Feedback from TC39 and the web community
- TC39 has final word on whether/when to include

Stages [2]:

- Strawman proposal
- TC39 is interested ⇒ proposal
- Field-testing via one or more implementations, refinements
- TC39 accepts feature ⇒ included in ECMAScript draft
- Included in final spec ⇒ Standard

Variables and scoping

Block-scoped variables

Function scope (var)

```
function order(x, y) {
    console.log(tmp);
        // undefined

    if (x > y) {
        var tmp = x;
        x = y;
        y = tmp;
    }
    return [x, y];
}
```

Block scope (let, const)

```
function order(x, y) {
    console.log(tmp);
        // ReferenceError:
        // tmp is not defined
    if (x > y) {
        let tmp = x;
        x = y;
        y = tmp;
    }
    return [x, y];
}
```

Destructuring: objects

Extract data (more than one value!) via patterns:

```
let obj = { first: 'Jane', last: 'Doe' };

let { first: f, last: l } = obj;
console.log(f + ' ' + l);  // Jane Doe
```

Usage:

- variable declarations
- assignments
- parameter definitions

Destructuring: arrays

```
let [x, y] = [ 'a', 'b' ];
// x='a', y='b'

let [x, y, ...rest] = [ 'a', 'b', 'c', 'd' ];
// x='a', y='b', rest = [ 'c', 'd' ]

[x,y] = [y,x];  // swap values
```

Destructuring: refutable by default

- **Refutable (default):** exception if match isn't exact.

```
{ a: x, b: y } = { a: 3 }; // fails
```

- **Irrefutable:** always match.

```
{ a: x, ?b: y } = { a: 3 }; // x=3, y=undefined
```

- **Default value:** use if no match or value is `undefined`

```
{ a: x, b: y=5 } = { a: 3 }; // x=3, y=5
```

Arrow functions

Arrow functions: less to type

Compare:

```
let squares = [1, 2, 3].map(function (x) {return x * x});
```

```
let squares = [1, 2, 3].map(x => x * x);
```

Arrow functions: lexical `this`, no more that=this

```
function UiComponent {
    var that = this;
    var button = document.getElementById('#myButton');
    button.addEventListener('click', function () {
        console.log('CLICK');
        that.handleClick();
    });
}
UiComponent.prototype.handleClick = function () { ... };
```

```
function UiComponent {
    let button = document.getElementById('#myButton');
    button.addEventListener('click', () => {
        console.log('CLICK');
        this.handleClick();
    });
}
```

Arrow functions: versions

General form:

```
(arg1, arg2, ...) => expr
(arg1, arg2, ...) => { stmt1; stmt2; ... }
```

Shorter version – single parameter:

```
arg => expr
arg => { stmt1; stmt2; ... }
```

Parameter handling

Parameter handling 1: parameter default values

Use a default value if parameter is missing.

```
function func1(x, y=3) {
    return [x,y];
}
```

Interaction:

```
> func1(1, 2)
[1, 2]
> func1(1)
[1, 3]
> func1()
[undefined, 3]
```

Parameter handling 2: rest parameters

Put trailing parameters in an array.

```
function func2(arg0, ...others) {
    return others;
}
```

Interaction:

```
> func2(0, 1, 2, 3)
[1, 2, 3]
> func2(0)
[]
> func2()
[]
```

Eliminate the need for the special variable `arguments`.

Spread operator (...)

Turn an array into function/method arguments:

```
> Math.max(7, 4, 11)
11
> Math.max(...[7, 4, 11])
11
```

- The inverse of a rest parameter
- Mostly replaces `Function.prototype.apply()`
- Also works in constructors

Parameter handling 3: named parameters

Use destructuring for named parameters `opt1` and `opt2`:

```
function func3(arg0, { opt1, opt2 }) {
    return return [opt1, opt2];
}
// {opt1,opt2} is same as {opt1:opt1,opt2:opt2}
```

Interaction:

```
> func3(0, { opt1: 'a', opt2: 'b' })
['a', 'b']
```

Object-orientation and modularity

Object literals

```
// ECMAScript 6
let obj = {
    __proto__: someObject,  // special property
    myMethod(arg1, arg2) {  // method definition
        ...
    }
};
```

```
// ECMAScript 5
var obj = Object.create(someObject);
obj.myMethod = function (arg1, arg2) {
    ...
};
```

Object literals: property value shorthand

Shorthand: `{x,y}` is the same as `{ x: x, y: y }`.
⇒ Convenient for multiple return values.

```
function computePoint() {
    let x = computeX();
    let y = computeY();
    return { x, y };  // shorthand
}

let {x,y} = computePoint();  // shorthand
```

Symbols

- Inspired by Lisp, Smalltalk etc.
- A new kind of primitive value:

```
> let sym = Symbol();
> typeof sym
'symbol'
```

- Each symbol is unique.

Symbols: enum-style values

```
let red = Symbol();
let green = Symbol();
let blue = Symbol();

function handleColor(color) {
    switch(color) {
        case red:
            ...
        case green:
            ...
        case blue:
            ...
    }
}
```

Symbols: property keys

```
let specialMethod = Symbol();
let obj = {
    // computed property key
    [specialMethod]: function (arg) {
        ...
    }
};
obj[specialMethod](123);
```

Shorter – method definition syntax:

```
let obj = {
    [specialMethod](arg) {
        ...
    }
};
```

Symbols: property keys

- Advantage: No name clashes!
- Configure objects for ECMAScript and frameworks

  $\Rightarrow$ publically known symbols

Classes

```
class Point {
    constructor(x, y) {
        this.x = x;
        this.y = y;
    }
    toString() {
        return '('+this.x+', '+this.y+')';
    }
}
```

```
function Point(x, y) {
    this.x = x;
    this.y = y;
}
Point.prototype.toString = function () {
    return '('+this.x+', '+this.y+')';
};
```

Classes: sub-type

```
class ColorPoint extends Point {
    constructor(x, y, color) {
        super(x, y);  // same as super.constructor(x, y)
        this.color = color;
    }
    toString() {
        return this.color+' '+super();
    }
}
```

```
function ColorPoint(x, y, color) {
    Point.call(this, x, y);
    this.color = color;
}
ColorPoint.prototype = Object.create(Point.prototype);
ColorPoint.prototype.constructor = ColorPoint;
ColorPoint.prototype.toString = function () {
    return this.color+' '+Point.prototype.toString.call(this);
};
```

Static methods

```
class Point {
    static zero() {
        return new Point(0, 0);
    }
    constructor(x, y) {
        this.x = x;
        this.y = y;
    }
}
let p = Point.zero();
```

Private properties

Hiding some properties from external access (object literals, classes):

- Still under discussion.
- Possibly: via a special kind of symbol.

Modules: overview

```
// lib/math.js
let notExported = 'abc';
export function square(x) {
    return x * x;
}
export const MY_CONSTANT = 123;
```

```
// main.js
import {square} from 'lib/math';
console.log(square(3));
```

Alternatively:

```
import 'lib/math' as math;
console.log(math.square(3));
```

Modules: features

More features [3]:

- Rename imports
- Concatenation: put several modules in the same file
- Module IDs are configurable (default: paths relative to importing file)
- Programmatic (e.g. conditional) loading of modules via an API
- Module loading is customizable:
  - Automatic linting (think: JSLint, JSHint)
  - Automatically translate files (CoffeeScript, TypeScript)
  - Use legacy modules (AMD, Node.js)

Syntax is still in flux!

Template strings

Template strings: string interpolation

Invocation:

```
templateHandler`Hello ${first} ${last}!`
```

Syntactic sugar for:

```
templateHandler(['Hello ', ' ', '!'], first, last)
```

Two kinds of tokens:

- Literal sections (static): `'Hello'`
- Substitutions (dynamic): `first`

Template strings: raw strings

Multiple lines, no escaping:

```
var str = raw`This is a text
with multiple lines.

Escapes are not interpreted,
\n is not a newline.`;
```

Template strings: other use cases

- Regular expressions (XRegExp: multi-line, ignoring whitespace)
- Query languages
- Text localization
- Templating
- etc.

Standard library

Maps

Data structure mapping from arbitrary values to arbitrary values (objects: keys must be strings).

```
let map = new Map();
let obj = {};

map.set(obj, 123);
console.log(map.get(obj)); // 123
console.log(map.has(obj)); // true

map.delete(obj);
console.log(map.has(obj)); // false
```

Also: iteration (over keys, values, entries) and more.

Sets

A collection of values without duplicates.

```
let set1 = new Set();
set1.add('hello');
console.log(set1.has('hello')); // true
console.log(set1.has('world')); // false

let set2 = new Set([3,2,1,3,2,3]);
console.log(set2.values());  // 1,2,3
```

Object.assign

Merge one object into another one.

```
class Point {
    constructor(x, y) {
        Object.assign(this, { x, y });
    }
}
```

Similar to Underscore.js `_.extend()`.

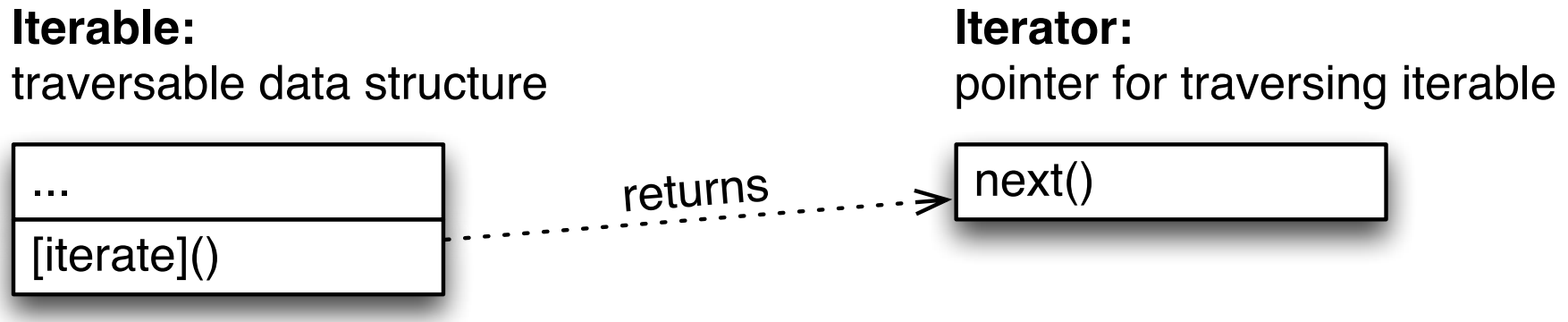
Various other additions to the standard library

```
> 'abc'.repeat(3)
'abcabcabc'
> 'abc'.startsWith('ab')
true
> 'abc'.endsWith('bc')
true
```

And more!

Loops and iteration

Iterables and iterators



Examples of iterables:

- Arrays
- Results produced by tool functions and methods (`keys()`, `values()`, `entries()`).

Iterators

```
import {iterate} from '@iter';  // symbol
function iterArray(arr) {
    let i = 0;
    return {  // both iterable and iterator
        [iterate]() {  // iterable
            return this;  // iterator
        },
        next() {  // iterator
            if (i < arr.length) {
                return { value: arr[i++] };
            } else {
                return { done: true };
            } } } }
for (let elem of iterArray(['a', 'b'])) {
    console.log(elem);
}
```

for-of: a better loop

Current looping constructs:

- for-in:
  - Basically useless for arrays
  - Quirky for objects
- `Array.prototype.forEach()`:
  - doesn't work with iterables

for-of loop: iterables

Looping over iterables (incl. arrays).

```
let arr = [ 'hello', 'world' ];
for (let elem of arr) {
    console.log(elem);
}
```

Output – elements, not indices:

```
hello
world
```

for-of loop: objects

```
let obj = { first: 'Jane', last: 'Doe' };
```

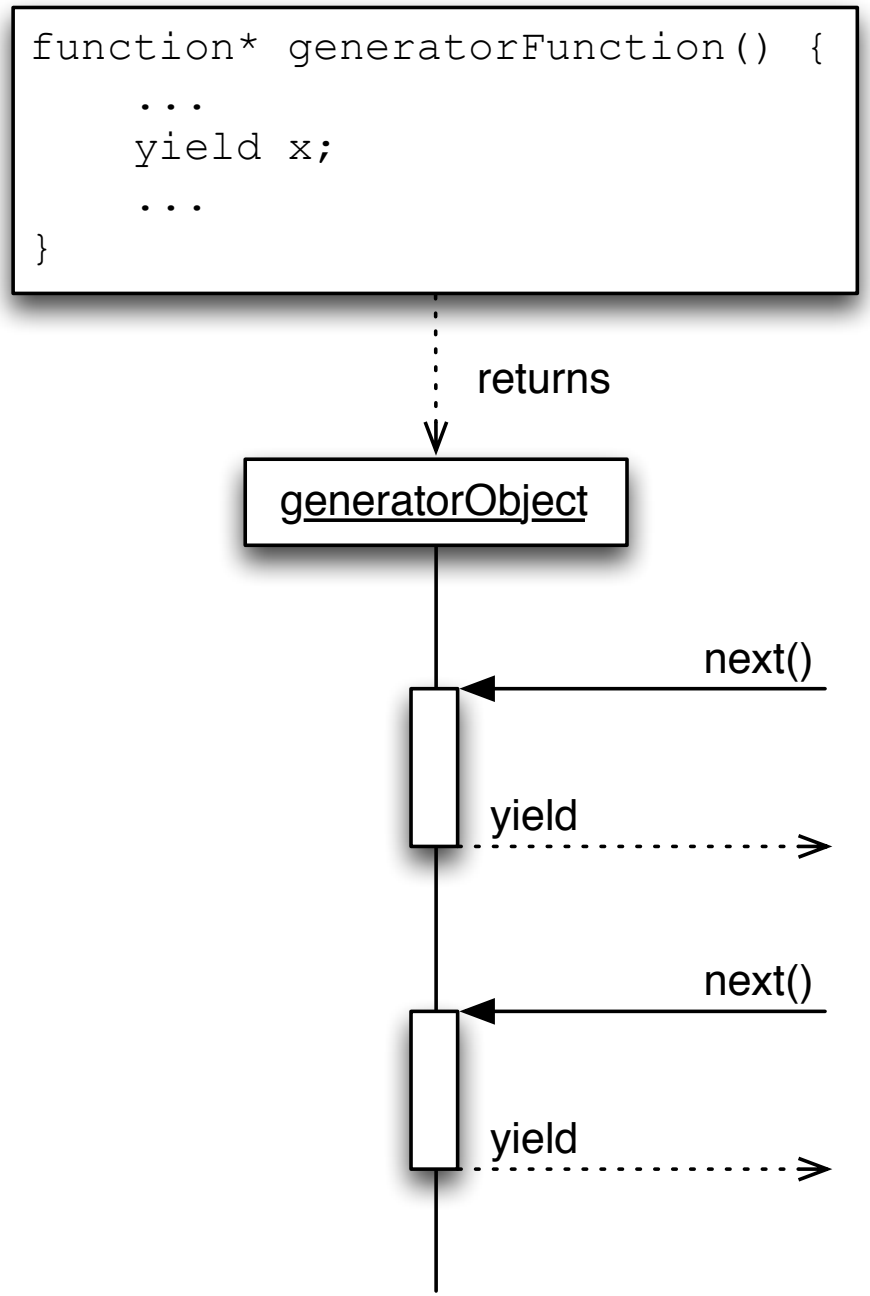
Iterate over properties:

```
import {entries} from '@iter';  // returns an iterable
for (let [key, value] of entries(obj)) {
    console.log(key + ' = ' + value);
}
```

Iterate over property names:

```
import {keys} from '@iter';  // returns an iterable
for (let name of keys(obj)) {
    console.log(name);
}
```

Generators



Generators: suspend and resume a function

- Shallow coroutines [4]: only function body is suspended.
- Uses: iterators, simpler asynchronous programming.

Generators: example

Suspend via `yield` ("resumable return"):

```
function* generatorFunction() {
    yield 0;
    yield 1;
    yield 2;
}
```

Start and resume via `next()`:

```
let genObj = generatorFunction();
console.log(genObj.next());  // 0
console.log(genObj.next());  // 1
console.log(genObj.next());  // 2
```

Generators: implementing an iterator

An iterator for nested arrays:

```
function* iterTree(tree) {
    if (Array.isArray(tree)) {
        // inner node
        for(let i=0; i < tree.length; i++) {
            yield* iterTree(tree[i]); // recursion
        }
    } else {
        // leaf
        yield tree;
    }
}
```

Difficult to write without recursion.

Generators: asynchronous programming

Using the task.js library:

```
spawn(function* () {
    try {
        var [foo, bar] = yield join(
            read("foo.json"), read("bar.json")
        ).timeout(1000);
        render(foo);
        render(bar);
    } catch (e) {
        console.log("read failed: " + e);
    }
});
```

Wait for asynchronous calls via `yield` (internally based on promises).

Comprehensions

Array comprehensions produce an array:

```
let numbers = [1,2,3];
let squares = [for (x of numbers) x*x];
```

Generator comprehensions produce a generator object (an iterator):

```
let squares = (for (x of numbers) x*x);
```

Conclusion

Time table

ECMAScript specification:

- November 2013: final review of draft
- July 2014: editorially complete
- December 2014: Ecma approval

Using ECMAScript 6 today

- First features are already in engines [5]
- Traceur by Google: compiles ECMAScript 6 to ECMAScript 5.
  - dynamically (on the fly)
  - statically (e.g. via tools)
- TypeScript by Microsoft:
  - ECMAScript 6 + optional static typing (at development time)
  - compiles to ECMAScript 5
- es6-shim by Paul Miller: features of the ES6 standard library, backported to ES5.

Thank you!

Annex

References

1. ECMAScript Harmony wiki
2. “The Harmony Process” by David Herman
3. “ES6 Modules” by Yehuda Katz
4. “Why coroutines won’t work on the web” by David Herman
5. “ECMAScript 6 compatibility table” by kangax [features already in JavaScript engines]

Resources

- ECMAScript 6 specification drafts by Allen Wirfs-Brock
- ECMAScript mailing list: es-discuss
- TC39 meeting notes by Rick Waldron
- "A guide to 2ality's posts on ECMAScript 6" by Axel Rauschmayer
- Continuum, an ECMAScript 6 virtual machine written in ECMAScript 3.

(Links are embedded in this slide.)

Bonus: proxies

Proxies

Observe operations applied to object `proxy`, via handler `h`:

```
let target = {};
let proxy = Proxy(target, h);
```

Each of the following operations triggers a method invocation on `h`:

```
proxy['foo']              → h.get(target, 'foo', p)
proxy['foo'] = 123        → h.set(target, 'foo', 123, p)
'foo' in proxy            → h.has(target, 'foo')
for (key in proxy) {...}  → h.enumerate(target)
```

Proxies in the prototype chain

```
let child = Object.create(proxy);
```

Operations on `child` can still trigger handler invocations (if the search for properties reaches `proxy`):

```
child['foo']                → h.get(target, 'foo', ch)
child['foo'] = 123          → h.set(target, 'foo', 123, ch)
'foo' in child              → h.has(target, 'foo')
for (key in child) {...}    → h.enumerate(target)
```

Proxy: example

```
let handler = {
    get(target, name, receiver) {
        return (...args) => {
            console.log('Missing method '+name
                        + ', arguments: '+args);
        }
    }
};
let proxy = Proxy({}, handler);
```

Using the handler:

```
> let obj = Object.create(proxy);
> obj.foo(1, 2)
Missing method foo, arguments: 1, 2
```

Use cases for proxies

Typical meta-programming tasks:

- Sending all method invocations to a remote object
- Implementing data access objects for a database
- Data binding
- Logging

More bonus slides

Template strings: regular expressions

ECMAScript 5 (XRegExp library):

```
var str = '/2012/10/Page.html';
var parts = str.match(XRegExp(
    '^ # match at start of string only \n' +
    '/ (?<year> [^/]+ ) # capture top dir as year \n' +
    '/ (?<month> [^/]+ ) # capture subdir as month \n' +
    '/ (?<title> [^/]+ ) # file name base \n' +
    '\\.html? # file name extension: .htm or .html \n' +
    '$ # end of string',
    'x'
));

console.log(parts.year); // 2012
```

XRegExp features: named groups, ignored whitespace, comments.

Template strings: regular expressions

ECMAScript 6:

```
let str = '/2012/10/Page.html';
let parts = str.match(XRegExp.rx`
    ^ # match at start of string only
    / (?<year> [^/]+ ) # capture top dir as year
    / (?<month> [^/]+ ) # capture subdir as month
    / (?<title> [^/]+ ) # file name base
    \.html? # file name extension: .htm or .html
    $ # end of string
`);
```

Advantages:

- Raw characters: no need to escape backslash and quote
- Multi-line: no need to concatenate strings with newlines at the end