Control Flow Goodness

in ECMAScript 2015 and beyond

Tom Van Cutsem

jsconf.be 2016

@tvcutsem

Talk Outline

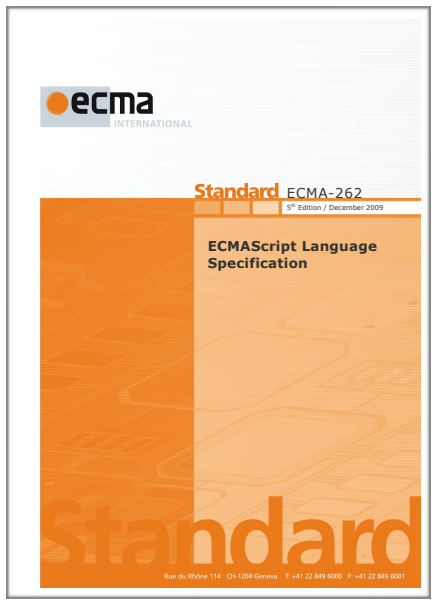
- Part I: the ECMAScript standards process && ES7 sneak peek
- Part II: ECMAScript 6 implementation progress
- Part III: Control flow goodness in ES6
- Part IV: Control flow goodness beyond ES6
- Wrap-up

Part I
The ECMAScript standards process && ES7 sneak peek

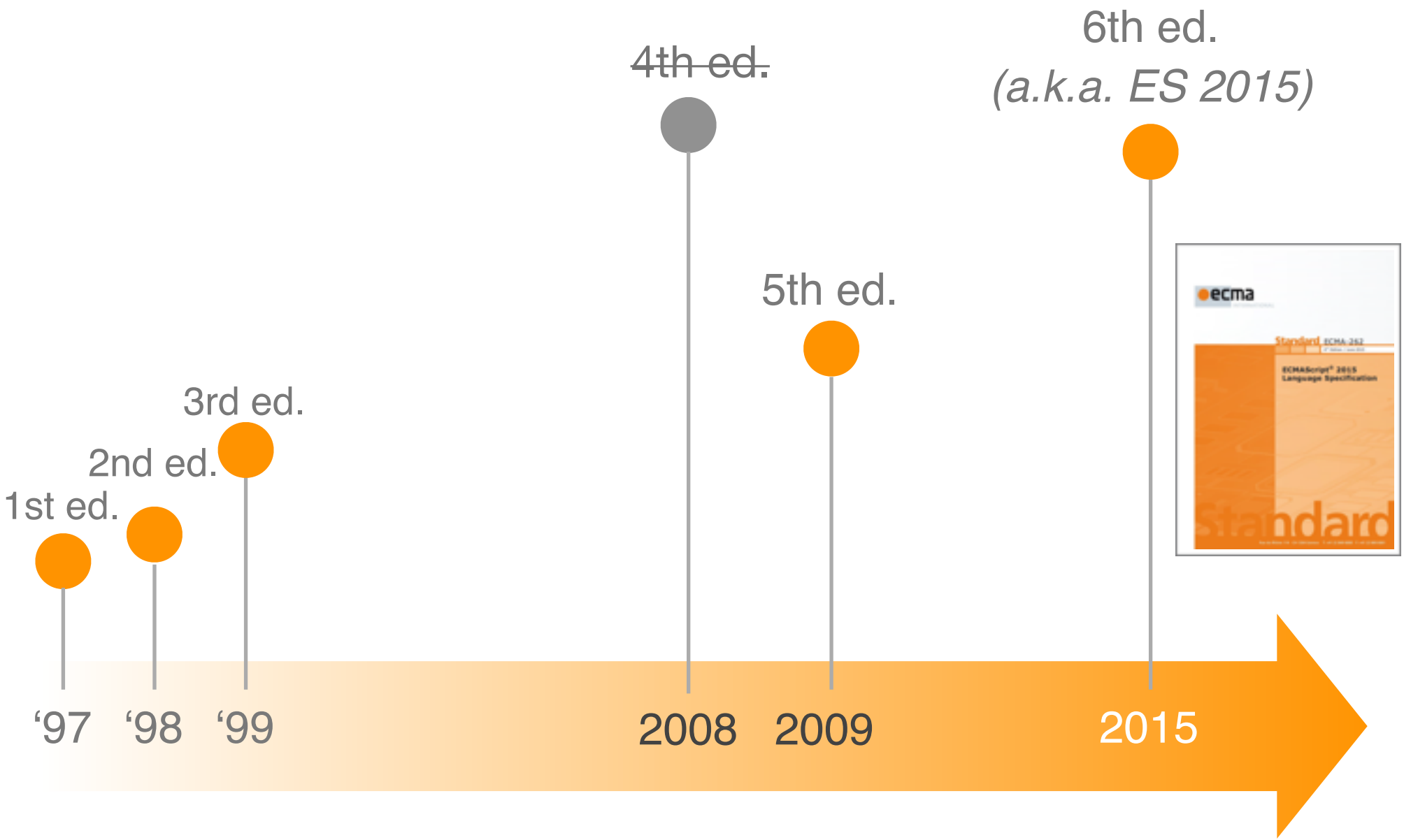
TC39: the JavaScript “standardisation committee”

- Representatives from major Internet companies, browser vendors, web organisations, popular JS libraries and academia. Meets bi-monthly.
- Maintains the ECMA-262 specification.
- The spec is a handbook mainly intended for language implementors.

Allen Wirfs-Brock,
ECMA-262 technical editor (5th & 6th ed.)



A brief history of the ECMAScript spec



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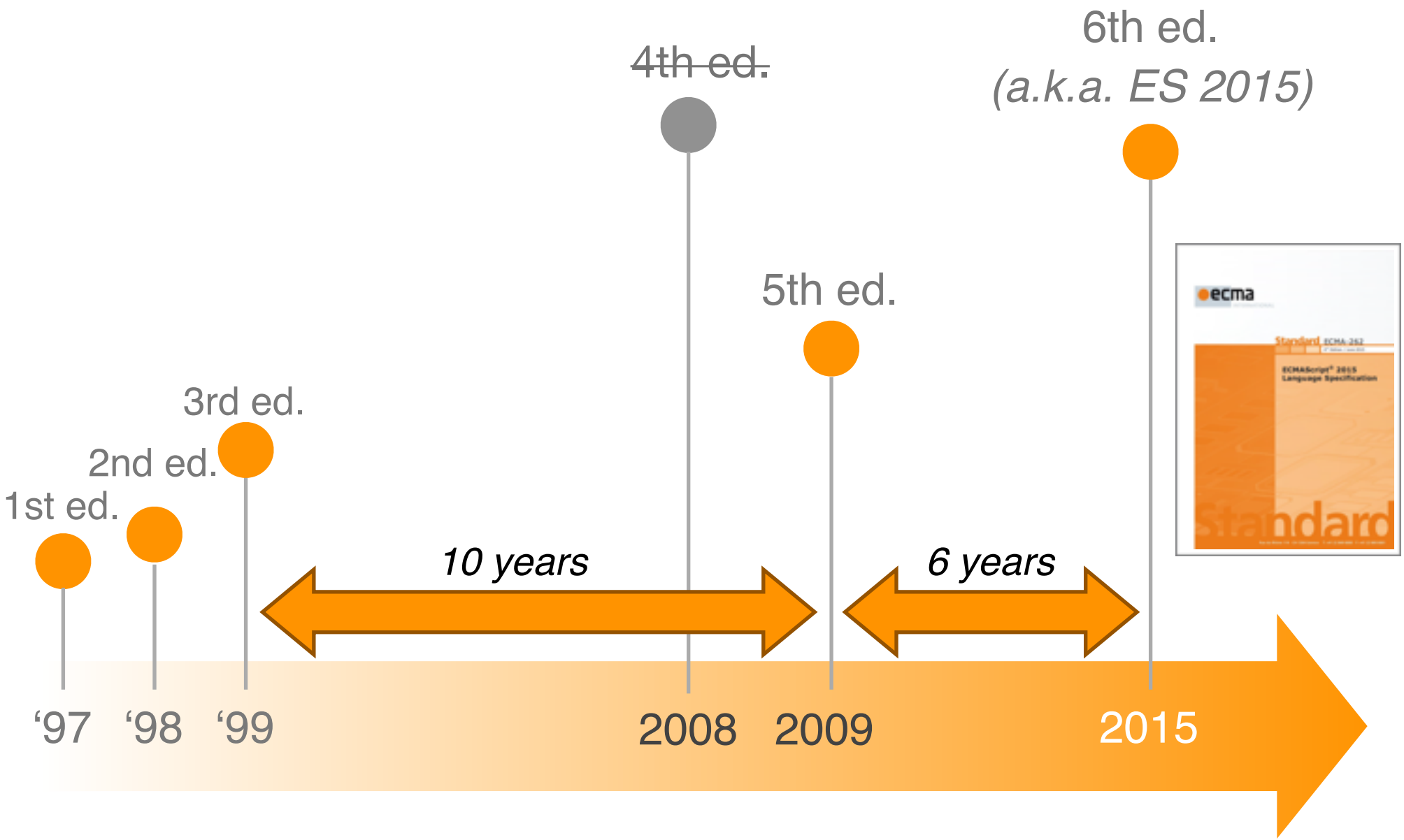
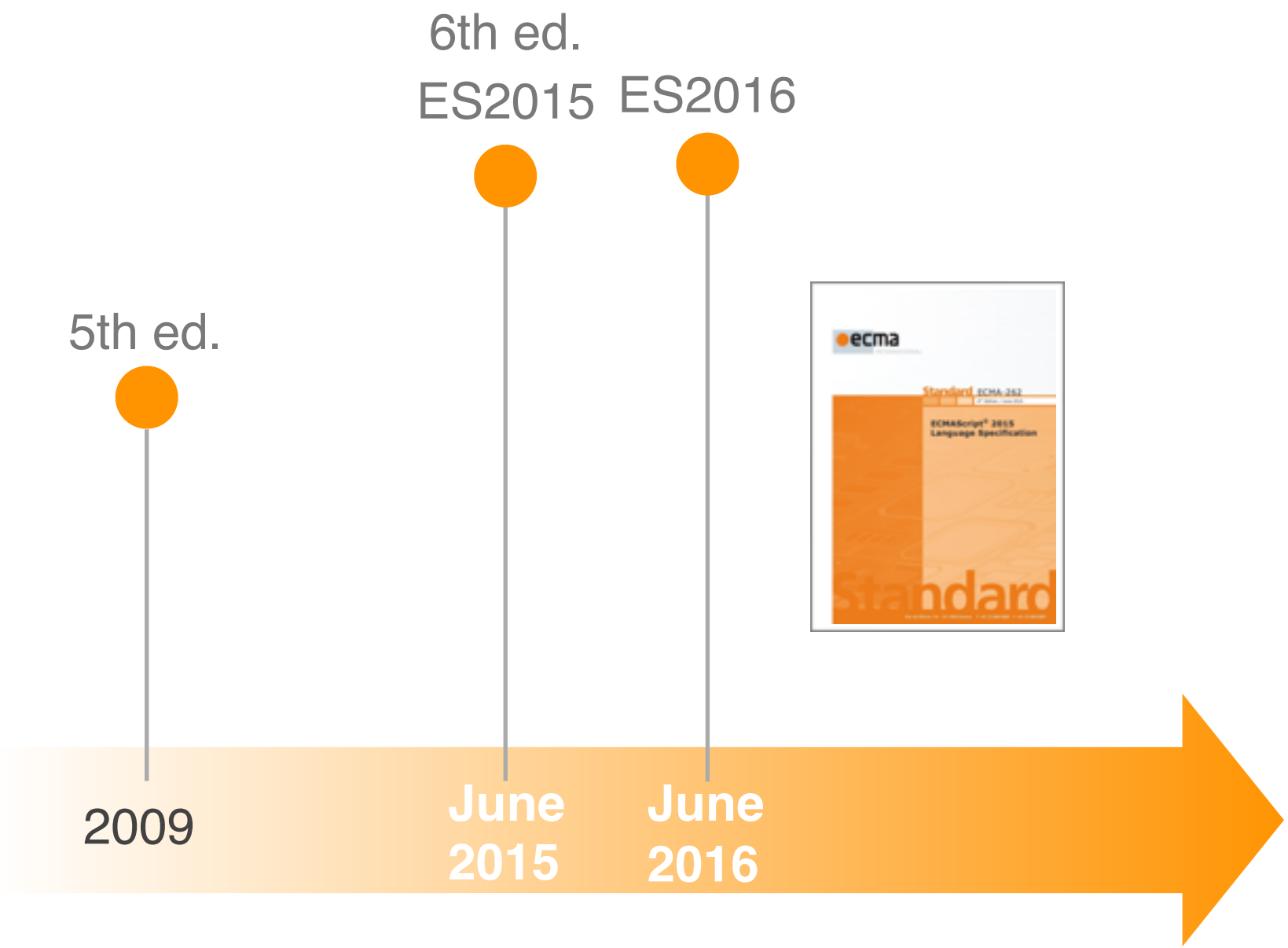


Beyond ECMAScript 6: timeline



ES2016 Completed Features

ES2016 feature

- Few fancy new features included in the spec in the last year
- Exponentiation operator: `x ** y`
- Array.prototype.includes: `[1,2,3].includes(1) === true`
- Bug fixes and minor details

ES2017 and beyond: proposals on the table

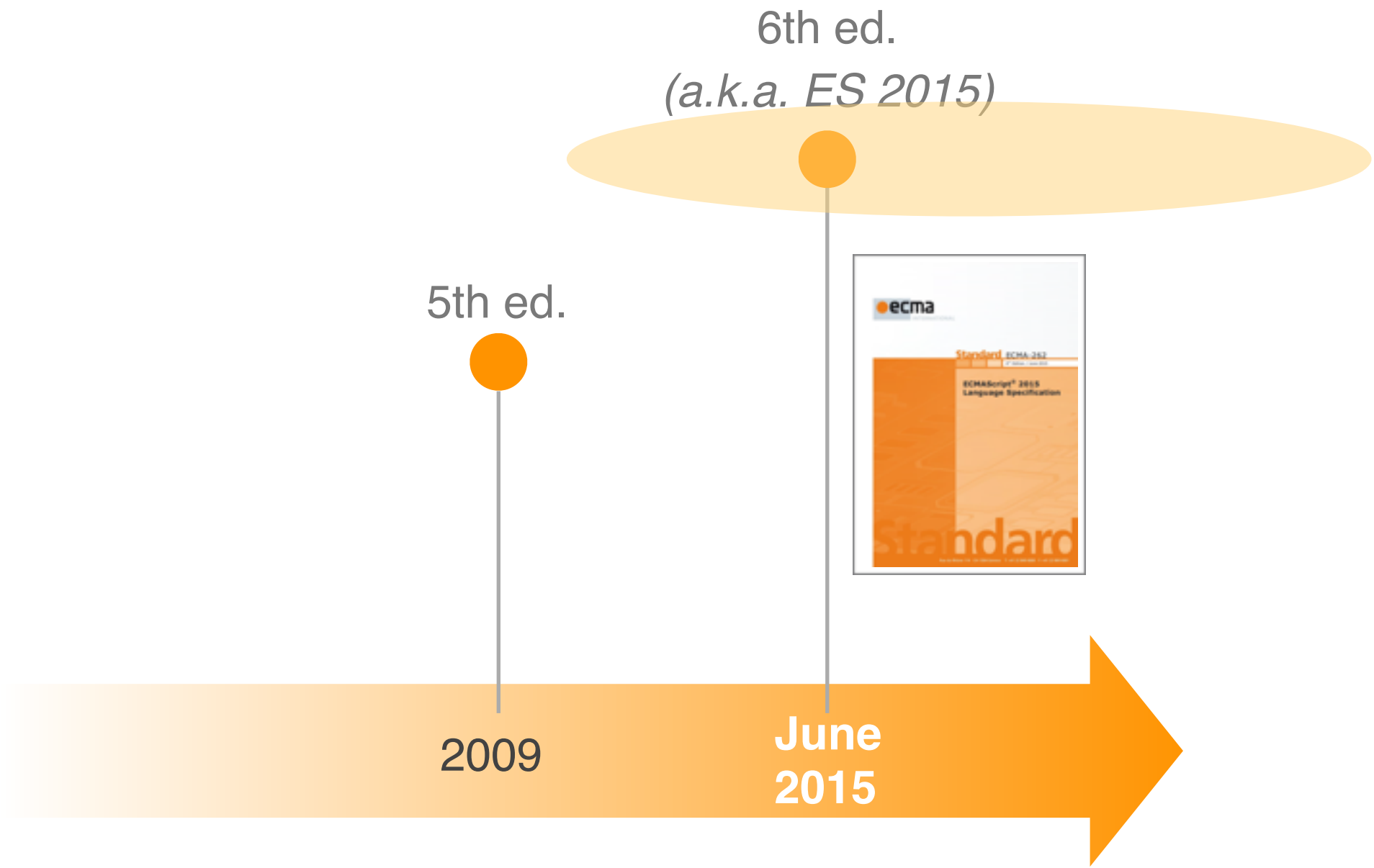
- Draft and Candidate proposals:

🚀	Proposal	Champion	Stage
	Object.values/Object.entries	Jordan Harband	4
	SIMD.JS - SIMD APIs + polyfill	John McCutchan, Peter Jensen, Dan Gohman, Daniel Ehrenberg	3
	Async Functions	Brian Terlson	3
	String padding	Jordan Harband & Rick Waldron	3
	Trailing commas in function parameter lists and calls	Jeff Morrison	3
	Object.getOwnPropertyDescriptors	Jordan Harband & Andrea Giammarchi	3
	`Function.prototype.toString` revision	Michael Ficarra	3
	Asynchronous Iterators	Kevin Smith	2
	function.sent metaproperty	Allen Wirfs-Brock	2
	Rest/Spread Properties	Sebastian Markbage	2
	Shared memory and atomics	Lars T Hansen	2
	System.global	Jordan Harband	2

See https://github.com/tc39/ecma262 for full list

Part II
ECMAScript 6: implementation progress

ECMAScript 6: timeline

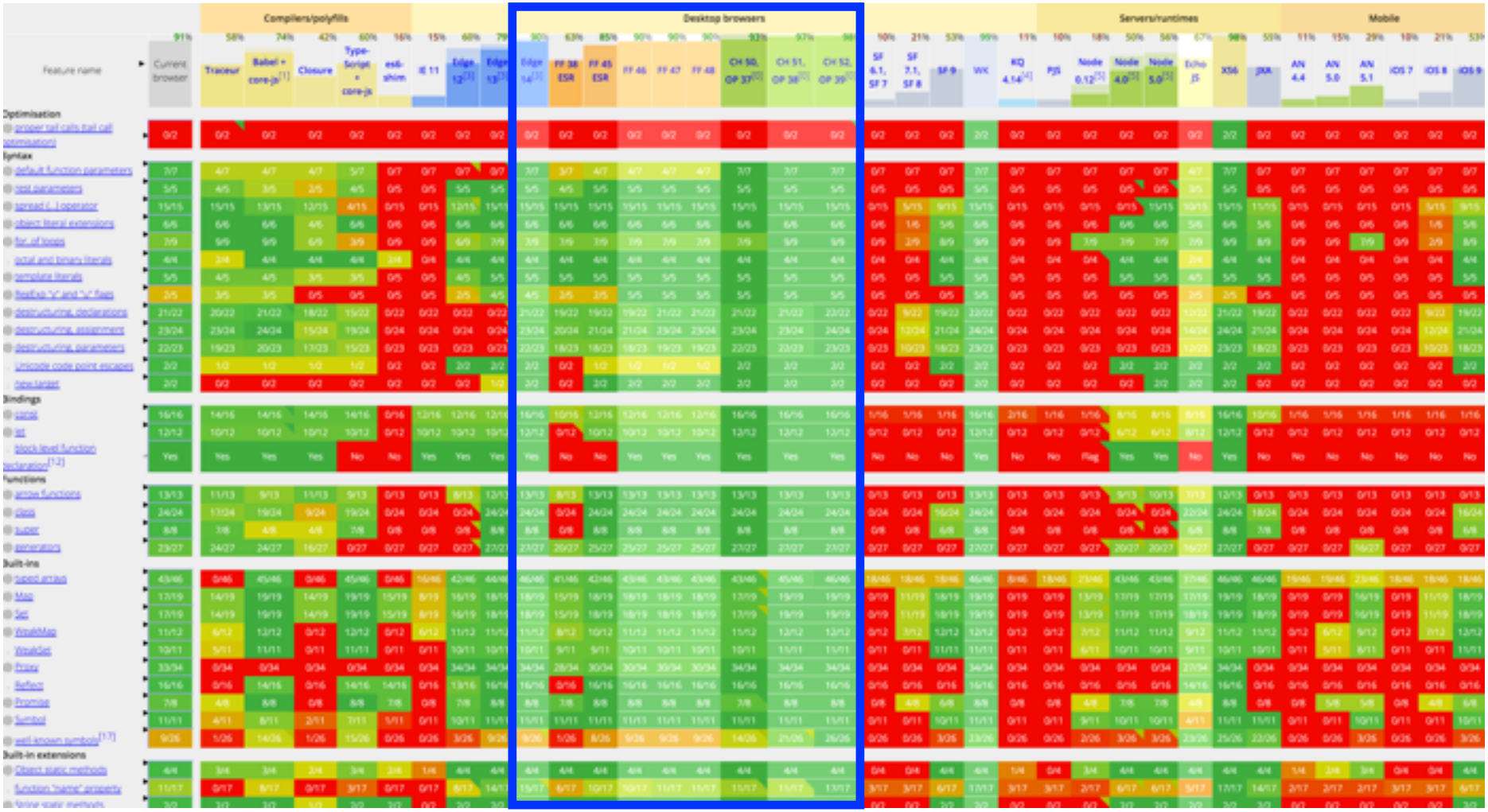


ECMAScript 6 support (april 2016)

(Source: Juriy Zaytsev (kangax)
http://kangax.github.io/es5-compat-table/es6)

COMPAT ES

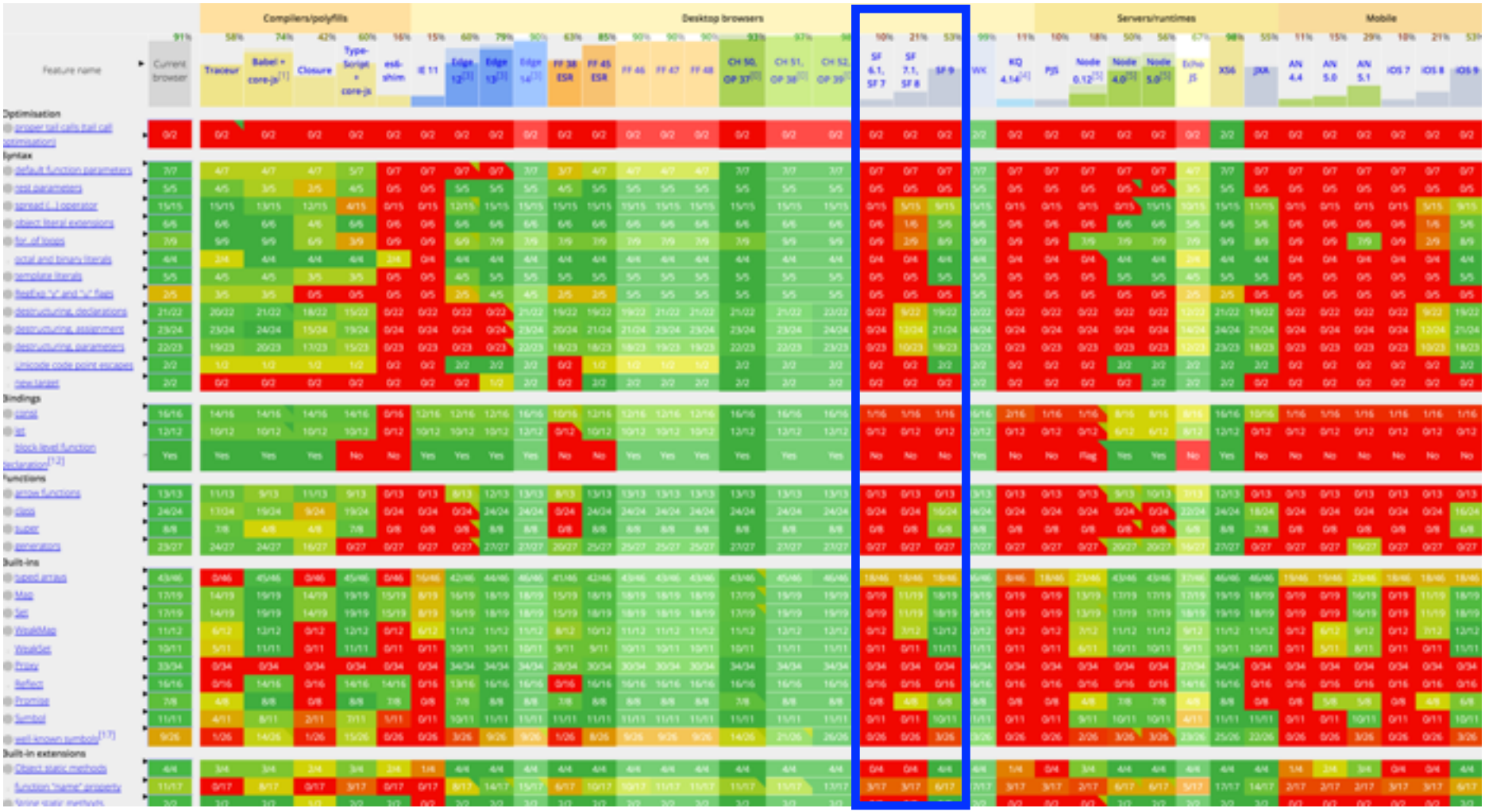
ECMAScript 6 support (april 2016)



Desktop browsers support nearly all of ES6…

COMPAT ES

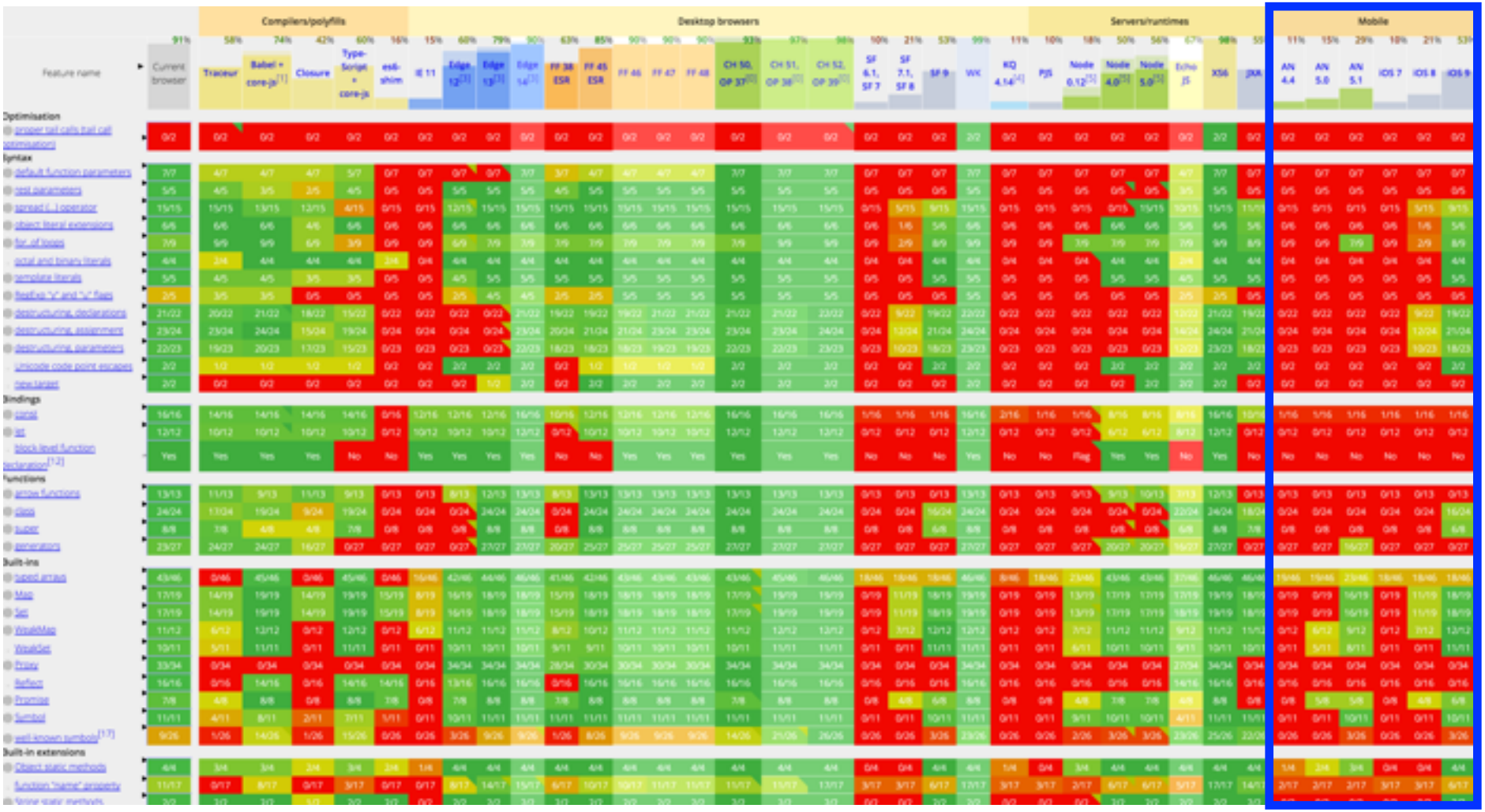
ECMAScript 6 support (april 2016)



… except for Safari (v9 at 53%)

COMPAT ES

ECMAScript 6 support (april 2016)



Mobile browsers are lagging behind…

COMPAT ES

ECMAScript 6 compilers

- Compile ECMAScript 6 to ECMAScript 5
- **Babel**: focus on producing readable (as-if hand-written) ES5 code. Supports JSX as well.

- Microsoft **TypeScript**: technically not ES6 but roughly a superset of ES6. Bonus: type inference and optional static typing.

ECMAScript 6: server, desktop and mobile

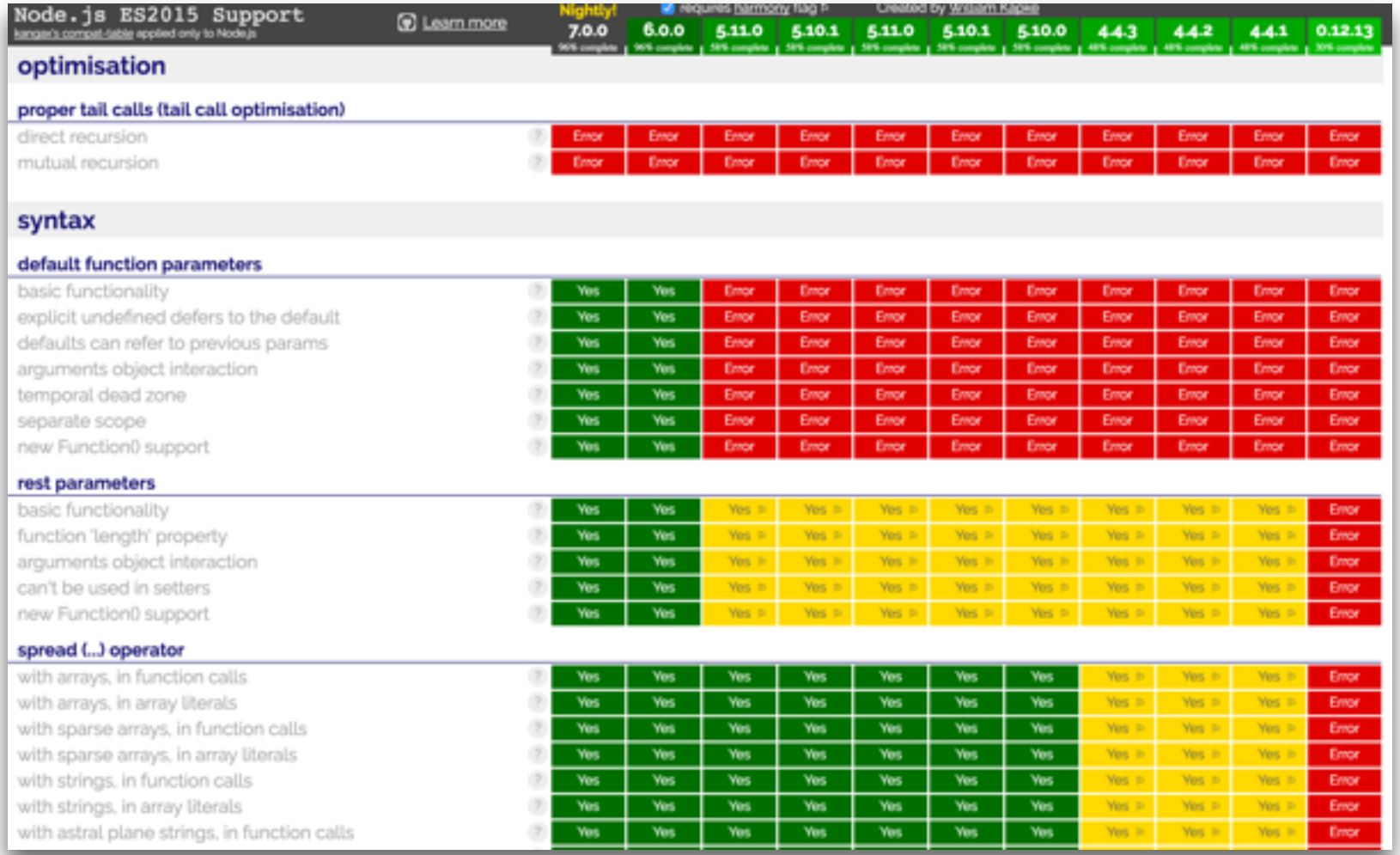
- V8 5.0 (March 2016) implements over 93% of ES6

- Server: **node.js** v6.0.0 released 26th of April uses V8 5.0 and so is ES6-ready!

- Desktop: **NW.js** and **Electron** use node v5.x

- Mobile: **React-native** has Babel integration by default [on top of Safari's JSC]

ECMAScript 6: server, desktop and mobile



Node.js ES2015 Support

kangax's compat-table applied only to Node.js

Learn more

Nightly! 7.0.0 (96% complete) | 6.0.0 (96% complete) | 5.11.0 (58% complete) | 5.10.1 (58% complete) | 5.11.0 (58% complete) | 5.10.1 (58% complete) | 5.10.0 (58% complete) | 4.4.3 (48% complete) | 4.4.2 (48% complete) | 4.4.1 (48% complete) | 0.12.13 (30% complete)

Requires harmony flag

Created by William Kapke

optimisation

proper tail calls (tail call optimisation)

	7.0.0	6.0.0	5.11.0	5.10.1	5.11.0	5.10.1	5.10.0	4.4.3	4.4.2	4.4.1	0.12.13
direct recursion	Error	Error	Error	Error	Error	Error	Error	Error	Error	Error	Error
mutual recursion	Error	Error	Error	Error	Error	Error	Error	Error	Error	Error	Error

syntax

default function parameters

	7.0.0	6.0.0	5.11.0	5.10.1	5.11.0	5.10.1	5.10.0	4.4.3	4.4.2	4.4.1	0.12.13
basic functionality	Yes	Yes	Error	Error	Error	Error	Error	Error	Error	Error	Error
explicit undefined defers to the default	Yes	Yes	Error	Error	Error	Error	Error	Error	Error	Error	Error
defaults can refer to previous params	Yes	Yes	Error	Error	Error	Error	Error	Error	Error	Error	Error
arguments object interaction	Yes	Yes	Error	Error	Error	Error	Error	Error	Error	Error	Error
temporal dead zone	Yes	Yes	Error	Error	Error	Error	Error	Error	Error	Error	Error
separate scope	Yes	Yes	Error	Error	Error	Error	Error	Error	Error	Error	Error
new Function() support	Yes	Yes	Error	Error	Error	Error	Error	Error	Error	Error	Error

rest parameters

	7.0.0	6.0.0	5.11.0	5.10.1	5.11.0	5.10.1	5.10.0	4.4.3	4.4.2	4.4.1	0.12.13
basic functionality	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
function 'length' property	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
arguments object interaction	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
can't be used in setters	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
new Function() support	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error

spread (...) operator

	7.0.0	6.0.0	5.11.0	5.10.1	5.11.0	5.10.1	5.10.0	4.4.3	4.4.2	4.4.1	0.12.13
with arrays, in function calls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
with arrays, in array literals	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
with sparse arrays, in function calls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
with sparse arrays, in array literals	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
with strings, in function calls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
with strings, in array literals	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error
with astral plane strings, in function calls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Error

http://node.green

Part III
Control flow goodness in ECMAScript 6

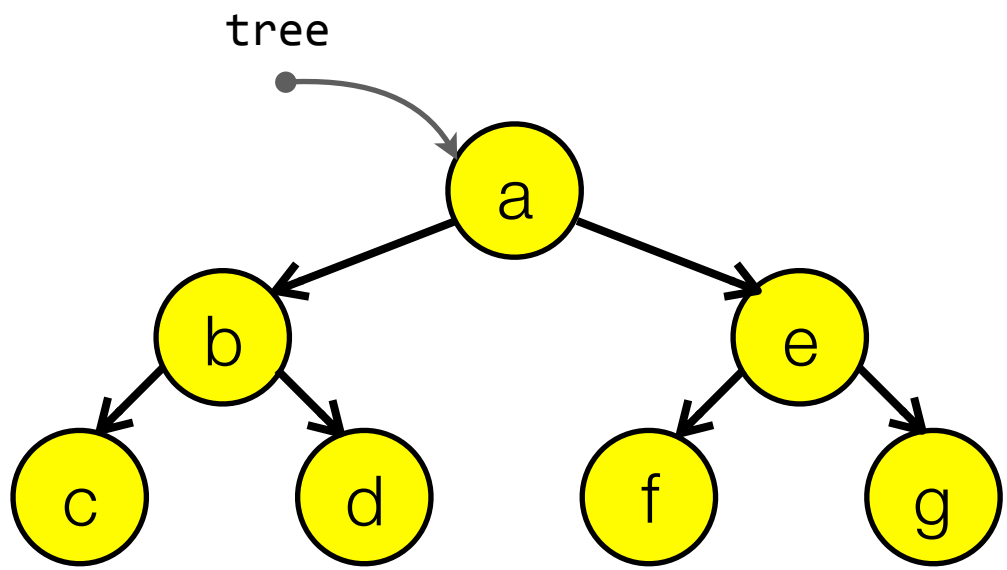
New control flow features

- Iterators
- Generators
- Promises

Computer Science 101: binary trees

```
interface Tree<T> {
  key    : T,
  left?  : Tree<T>,
  right? : Tree<T>
}
```

```
let tree: Tree<string> = {
  key: "a",
  left: {
    key: "b",
    left:  { key: "c" },
    right: { key: "d" }
  },
  right: {
    key: "e",
    left:  { key: "f" },
    right: { key: "g" }
  }
};
```

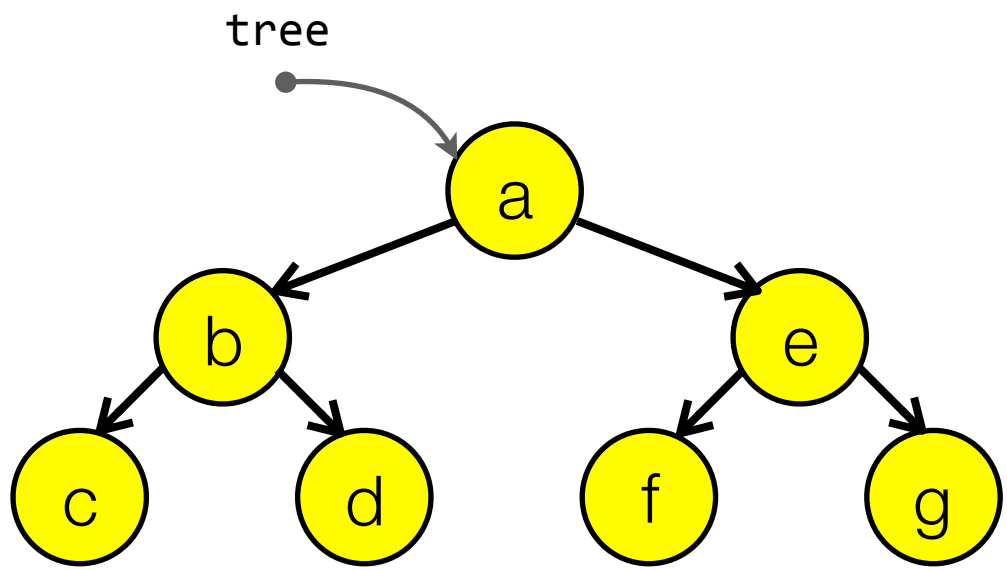


Computer Science 101: pre-order tree walk

- Visit node, then left subtree, then right subtree

```
assert.deepEqual(preOrder(tree), ["a", "b", "c", "d", "e", "f", "g"])
```

```
let tree: Tree<string> = {
  key: "a",
  left: {
    key: "b",
    left:  { key: "c" },
    right: { key: "d" }
  },
  right: {
    key: "e",
    left:  { key: "f" },
    right: { key: "g" }
  }
};
```

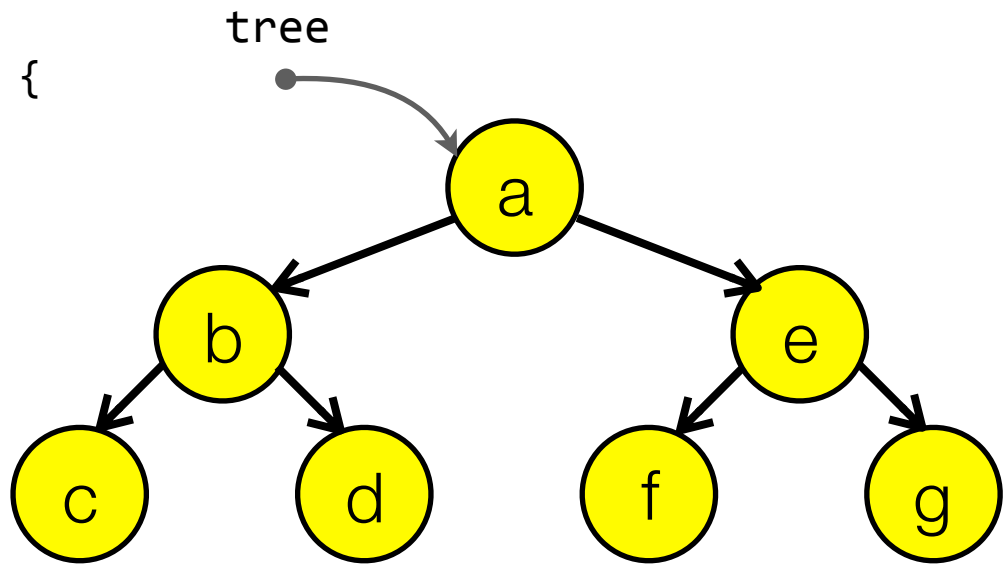


Computer Science 101: pre-order tree walk

- Visit node, then left subtree, then right subtree

```
assert.deepEqual(preOrder(tree), ["a", "b", "c", "d", "e", "f", "g"])
```

```
function preOrder(tree, accum = []) {
  if (tree) {
    accum.push(tree.key);
    preOrder(tree.left, accum);
    preOrder(tree.right, accum);
  }
  return accum;
}
```

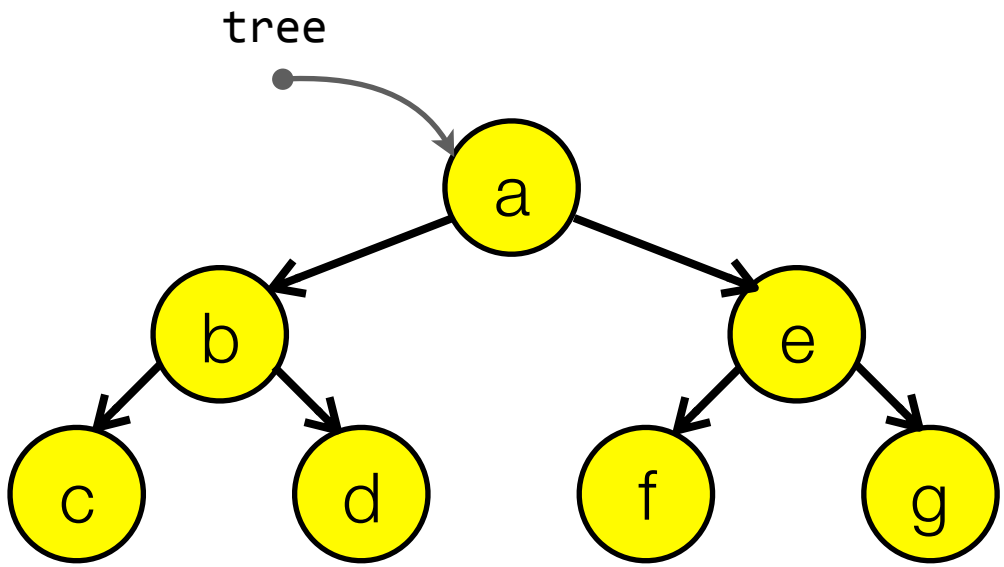


Iterators

- How to support incremental iteration? Change the algorithm so that it returns an **iterator**.

```
function preOrderIter(tree: Tree<T>): Iterator<T>;
```

```
interface Iterator<T> {
  next() : IteratorResult<T>;
}

interface IteratorResult<T> {
  value : T;
  done  : bool;
}
```

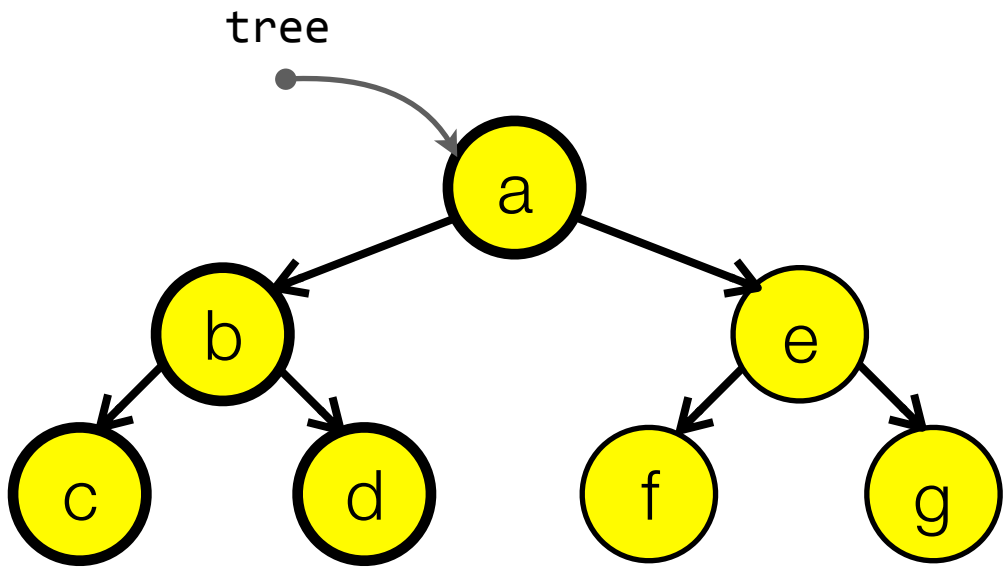


Using Iterators in ECMAScript 5

- Iteration protocol is explicit in the code

```
function preOrderIter(tree: Tree<T>): Iterator<T>;
```

```
let iter = preOrderIter(tree);
let nxt = iter.next();
while (!nxt.done) {
  let k = nxt.value;
  if (k == "d")
    break;
  console.log(k);
  nxt = iter.next();
}
```

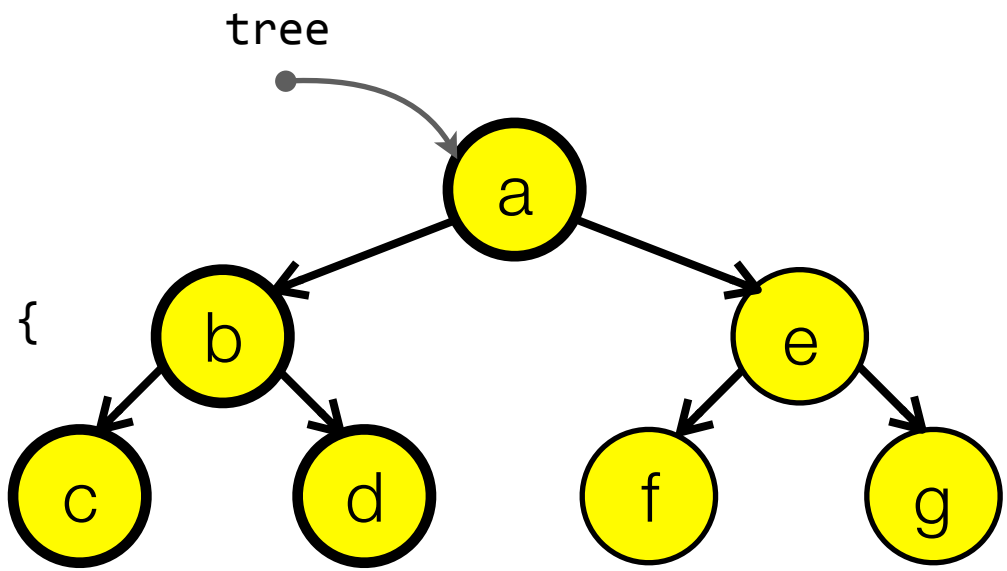


Using Iterators in ECMAScript 6

- New for-of loop enumerates all the elements of an iterator or iterable collection

```
function preOrderIter(tree: Tree<T>): Iterator<T>;
```

```
for (let k of preOrderIter(tree)) {
  if (k == "d")
    break;
  console.log(k);
}
```



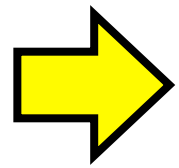
Using Iterators in ECMAScript 6

- The iteration protocol is entirely implicit

```
function preOrderIter(tree: Tree<T>): Iterator<T>;
```

ES5

```
let iter = preOrderIter(tree);
let nxt = iter.next();
while (!nxt.done) {
  let k = nxt.value;
  if (k == "d")
    break;
  console.log(k);
  nxt = iter.next();
}
```



ES6

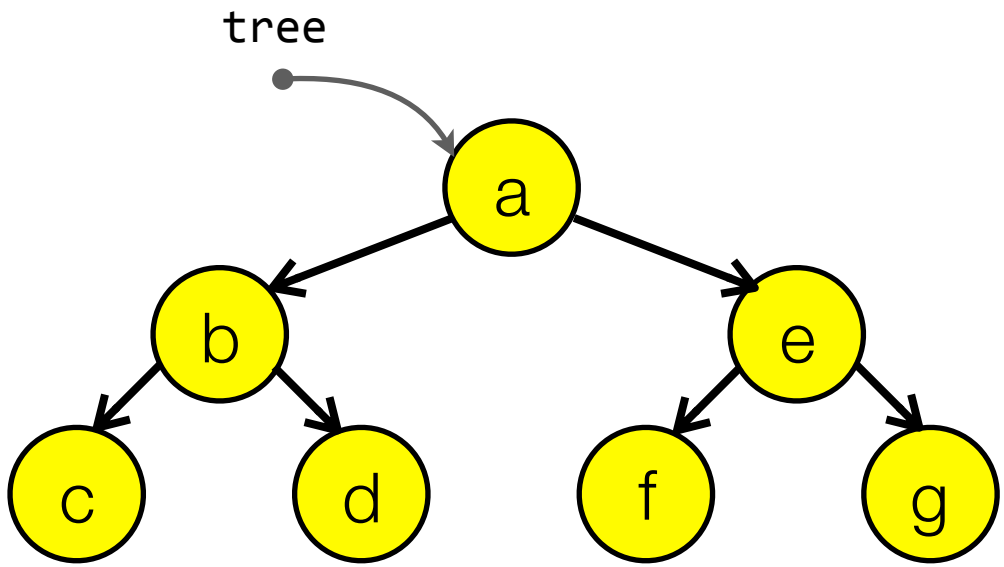
```
for (let k of preOrderIter(tree)) {
  if (k == "d")
    break;
  console.log(k);
}
```

Defining Iterators in ECMAScript 5

- We still need to implement our incremental pre-order tree walk algorithm

```
function preOrderIter(tree: Tree<T>): Iterator<T>;
```

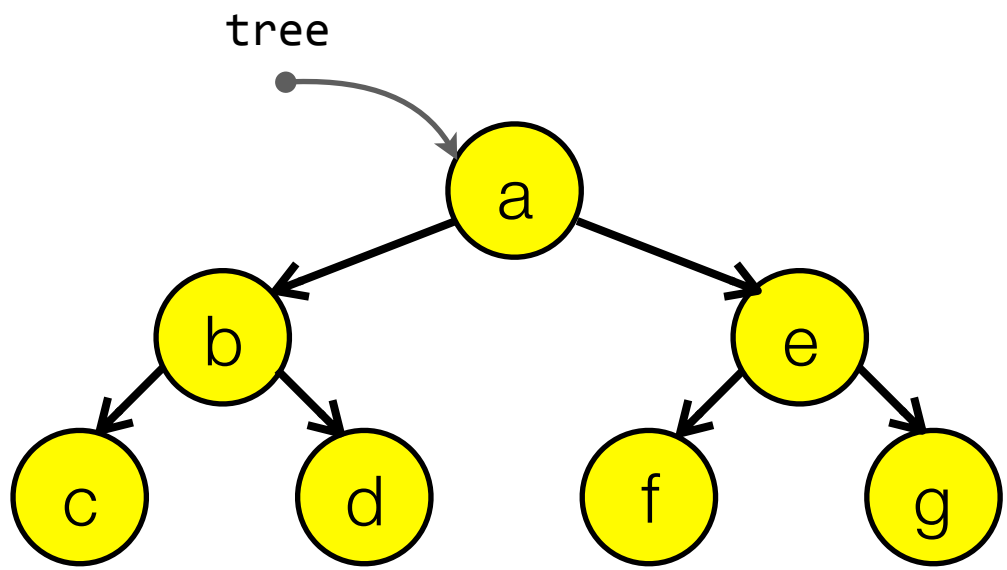
```
interface Iterator<T> {
  next() : IteratorResult<T>;
}

interface IteratorResult<T> {
  value : T;
  done  : bool;
}
```



Defining Iterators in ECMAScript 5

- Iteration protocol is explicit. Execution state (call stack) is explicit. Can't use recursion anymore.

```
function preOrderIter(tree) {
  let todo = [];
  if (tree) {
    todo.push(tree);
  }
  return {
    next() {
      if (todo.length === 0) {
        return {done: true};
      } else {
        let top = todo.pop();
        if (top.right) {
          todo.push(top.right);
        }
        if (top.left) {
          todo.push(top.left);
        }
        return {done: false, value: top.key};
      }
    }
  };
}
```

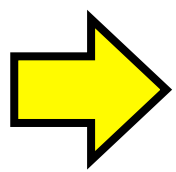


Defining Iterators in ECMAScript 5

- Can we have our cake and eat it too?

Elegant but batch

```
function preOrder(tree, accum = []) {
  if (tree) {
    accum.push(tree.key);
    preOrder(tree.left, accum);
    preOrder(tree.right, accum);
  }
  return accum;
}
```



Hairy but incremental

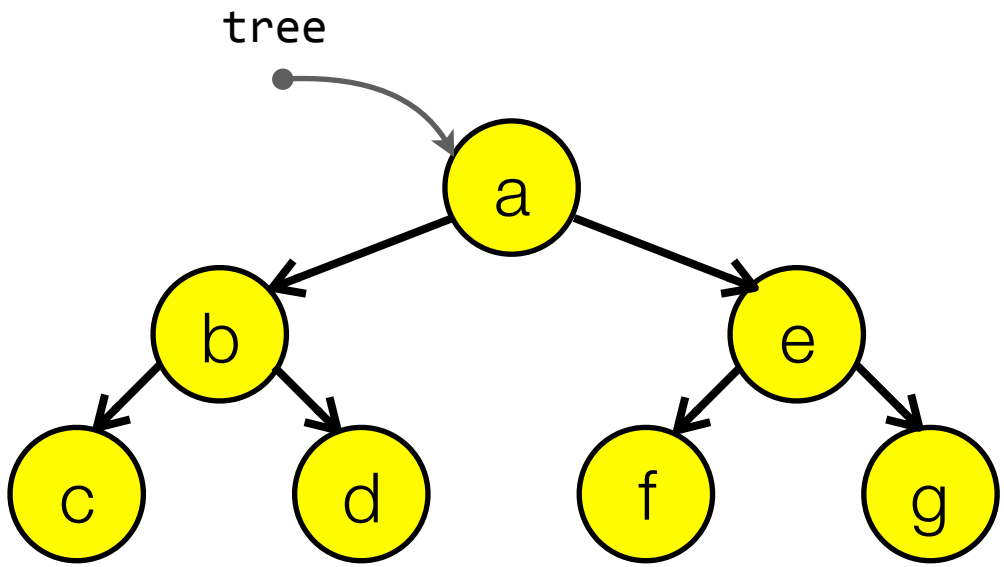
```
function preOrderIter(tree) {
  let todo = [];
  if (tree) {
    todo.push(tree);
  }
  return {
    next() {
      if (todo.length === 0) {
        return {done: true};
      } else {
        let top = todo.pop();
        if (top.right) {
          todo.push(top.right);
        }
        if (top.left) {
          todo.push(top.left);
        }
        return {done: false, value: top.key};
      }
    }
  };
}
```

Generators to the rescue!

- A generator function implicitly creates and returns an iterator

```
function preOrderIter(tree: Tree<T>): Iterator<T>;
```

```
function* preOrderIter(tree) {
  if (tree) {
    yield tree.key;
    yield* preOrderIter(tree.left);
    yield* preOrderIter(tree.right);
  }
}
```



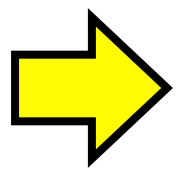
Generators in ECMAScript 6

- Both iteration protocol and execution state become implicit

ES5

Hairy but incremental

```
function preOrderIter(tree) {
  let todo = [];
  if (tree) {
    todo.push(tree);
  }
  return {
    next() {
      if (todo.length === 0) {
        return {done: true};
      } else {
        let top = todo.pop();
        if (top.right) {
          todo.push(top.right);
        }
        if (top.left) {
          todo.push(top.left);
        }
        return {done: false, value: top.key};
      }
    }
  };
}
```



ES6

Elegant *and* incremental

```
function* preOrderIter(tree) {
  if (tree) {
    yield tree.key;
    yield* preOrderIter(tree.left);
    yield* preOrderIter(tree.right);
  }
}
```

New control flow features

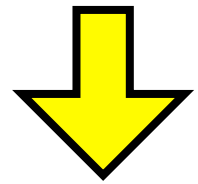
- Iterators
- Generators
- **Promises**

ECMAScript 6 Promises

- A promise is a placeholder for a value that may only be available in the future

ES5

```
readFile("hello.txt", function (err, content) {
  if (err) {
    // handle error
  } else {
    // use content
  }
})
```



ES6

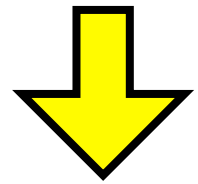
```
var pContent = readFile("hello.txt");
pContent.then(function (content) {
  // use content
}, function (err) {
  // handle error
});
```

ECMAScript 6 Promises

- A promise is a placeholder for a value that may only be available in the future

ES5

```
readFile("hello.txt", function (err, content) {
  if (err) {
    // handle error
  } else {
    // use content
  }
})
```



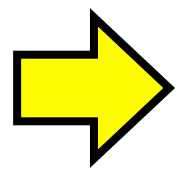
ES6

```
var pContent = readFile("hello.txt");
var p2 = pContent.then(function (content) {
  // use content
}, function (err) {
  // handle error
});
```

ECMAScript 6 Promises

- Promises can be *chained* to avoid callback hell

```
function step1(value, callback): void;

step1(function (e,value1) {
    if (e) { return handleError(e); }
    step2(value1, function(e,value2) {
        if (e) { return handleError(e); }
        step3(value2, function(e,value3) {
            if (e) { return handleError(e); }
            step4(value3, function(e,value4) {
                if (e) { return handleError(e); }
                // do something with value4
            });
        });
    });
});
```



```
function step1(value): Promise;

step1(value)
.then(step2)
.then(step3)
.then(step4)
.then(function (value4) {
    // do something with value4
})
.catch(function (error) {
    // handle any error here
});
```

Example adapted from https://github.com/kriskowal/q

ECMAScript 6 Promises

- Promises already exist as a library in ES5 (e.g. Q, Bluebird)
- Then why standardize?
  - Wide disagreement on a single Promise API. ES6 settled on an API called “Promises/A+”. See promisesaplus.com
  - Standard API allows platform APIs to use Promises as well
  - W3C’s latest DOM APIs already use promises

Part IV
Control flow goodness *beyond* ECMAScript 6

Upcoming control flow features

- Likely in ES2017:
  - Async functions
  - Async iterators

Upcoming control flow features

- Likely in ES2017:
  - **Async functions**
  - Async iterators

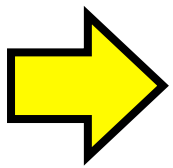
async functions in ECMAScript **2017**

ES2017 proposal

- A C# 5.0 feature that enables asynchronous programming using “direct style” control flow (i.e. no callbacks)

ES6

```
function step1(value): Promise;

step1(value)
.then(step2)
.then(step3)
.then(step4)
.then(function (value4) {
    // do something with value4
})
.catch(function (error) {
    // handle any error here
});
```



ES2017

```
function step1(value): Promise;

(async function() {
  try {
    var value1 = await step1();
    var value2 = await step2(value1);
    var value3 = await step3(value2);
    var value4 = await step4(value3);
    // do something with value4
  } catch (error) {
    // handle any error here
  }
}())
```

async functions in ECMAScript **6**

- Generators can be used as async functions, with some tinkering
- co npm library for node (^4.x or ^0.11.x with `--harmony` flag)

ES2017

```
(async function() {
  try {
    var value1 = await step1();
    var value2 = await step2(value1);
    var value3 = await step3(value2);
    var value4 = await step4(value3);
    // do something with value4
  } catch (error) {
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}())
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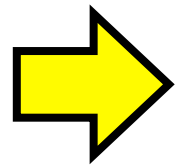

ES6

```
co(function*() {
  try {
    var value1 = yield step1();
    var value2 = yield step2(value1);
    var value3 = yield step3(value2);
    var value4 = yield step4(value3);
    // do something with value4
  } catch (error) {
    // handle any error here
  }
})
```

async functions in ECMAScript **6**

- Generators can be used as async functions, with some tinkering
- co npm library for node (^4.x or ^0.11.x with `--harmony` flag)

ES2017

```
(async function() {
  try {
    var value1 = await step1();
    var value2 = await step2(value1);
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    var value4 = await step4(value3);
    // do something with value4
  } catch (error) {
    // handle any error here
  }
}())
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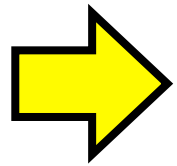

ES6

```
co(function*() {
  try {
    var value1 = yield step1();
    var value2 = yield step2(value1);
    var value3 = yield step3(value2);
    var value4 = yield step4(value3);
    // do something with value4
  } catch (error) {
    // handle any error here
  }
})
```

async functions in ECMAScript **5** (!)

- Babel plug-in based on Facebook Regenerator

facebook.github.io/regenerator

- Also in TypeScript 1.7+

github.com/lukehoban/ecmascript-asyncawait

ES2017

```
(async function() {
  try {
    var value1 = await step1();
    var value2 = await step2(value1);
    var value3 = await step3(value2);
    var value4 = await step4(value3);
    // do something with value4
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  }
}())
```
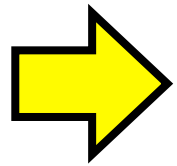



ES5

```
(function callee$0$0() {
  var value1, value2, value3, value4;
  return regeneratorRuntime.async(function callee$0$0$(context$1$0) {
    while (1) switch (context$1$0.prev = context$1$0.next) {
      case 0:
        context$1$0.prev = 0;
        context$1$0.next = 3;
        return regeneratorRuntime.awrap(step1());

      case 3:
        value1 = context$1$0.sent;
        context$1$0.next = 6;
        return regeneratorRuntime.awrap(step2(value1));

      case 6:
        value2 = context$1$0.sent;
        context$1$0.next = 9;
        return regeneratorRuntime.awrap(step3(value2));

      case 9:
        value3 = context$1$0.sent;
        context$1$0.next = 12;
        return regeneratorRuntime.awrap(step4(value3));

      case 12:
        value4 = context$1$0.sent;
        context$1$0.next = 17;
        break;

      case 15:
        context$1$0.prev = 15;
        context$1$0.t0 = context$1$0["catch"](0);

      case 17:
      case "end":
        return context$1$0.stop();
    }
  }, null, this, [[0, 15]]);
})();
```

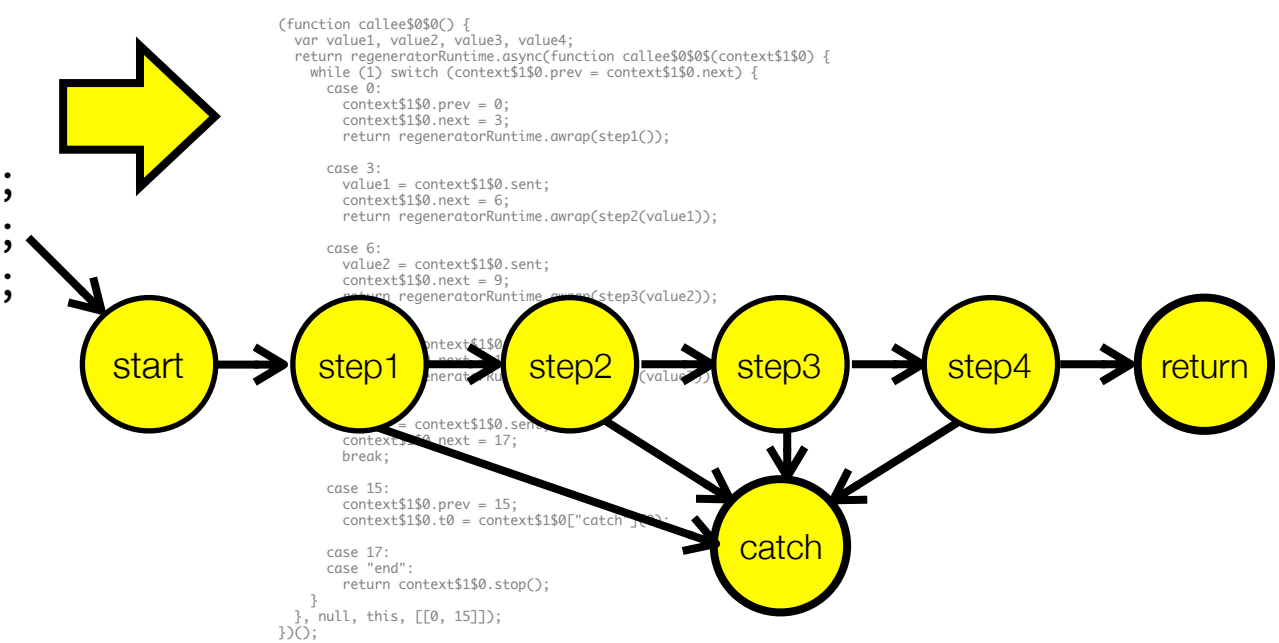
async functions in ECMAScript **5** (!)

- Async functions (and generators) can be compiled into state machines. Each intermediate state represents a “yield point”.

ES2017

```
(async function() {
  try {
    var value1 = await step1();
    var value2 = await step2(value1);
    var value3 = await step3(value2);
    var value4 = await step4(value3);
    // do something with value4
  } catch (error) {
    // handle any error here
  }
}())
```

ES5



Upcoming control flow features

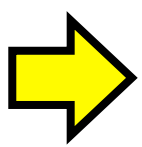
- Likely in ES2017:
  - Async functions
  - **Async iterators**

Async Iterators

ES2017 proposal

- ES6 iterator and generator protocols are synchronous…
- …but many Iterable sources are asynchronous in JS

```
interface Iterator<T> {
  next() : IteratorResult<T>;
}

interface IteratorResult<T> {
  value : T;
  done  : bool;
}
```



```
interface AsyncIterator<T> {
  next() : Promise<IteratorResult<T>>;
}
```

https://github.com/tc39/proposal-async-iteration

Async Iterators

ES2017 proposal

- Async for-of loop can be used in an async function to consume an async iterator

```
function readLines(path: string): AsyncIterator<string>;


async function printLines() {
  for await (let line of readLines(filePath)) {
    print(line);
  }
}
```

Async Generators

ES2017 proposal

- Async generators can await, and yield promises

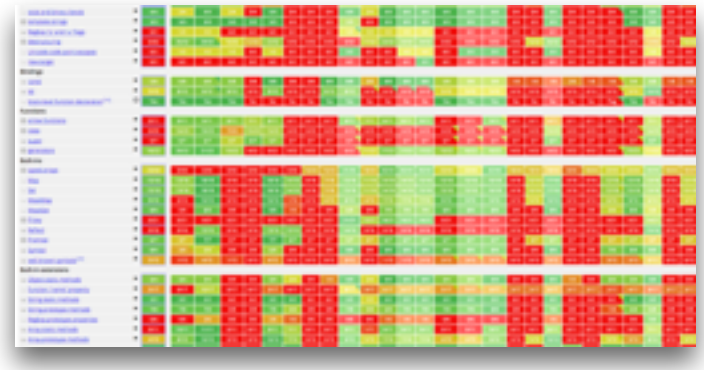
```
function readLines(path: string): AsyncIterator<string>;

async function* readLines(path) {

  let file = await fileOpen(path);

  try {
    while (!file.EOF) {
      yield file.readLine();
    }
  } finally {
    await file.close();
  }
}
```

Polyfill implemented in FB Regenerator

Wrap-up

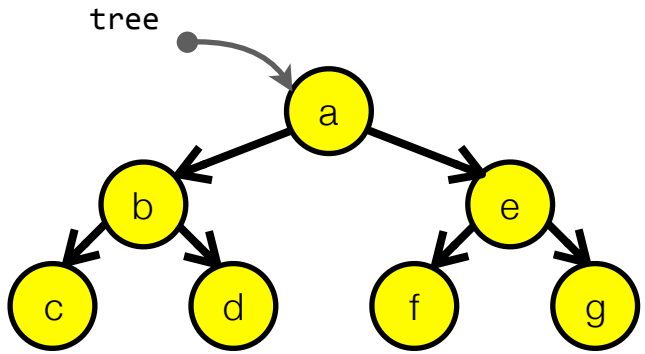
Take-home messages

ES is alive and kicking.
The new yearly release process works!



Server and desktop browser engines have mostly transitioned, mobile is lagging behind.

Take-home messages



Elegant *and* incremental iteration using iterators and generators

Promises help avoid callback hell

Async functions are a game-changer

(Photo credit: https://www.twilio.com/blog/2015/10/asyncawait-the-hero-javascript-deserved.html)

Thanks for listening!

Control Flow Goodness

in ECMAScript 2015 and beyond

Tom Van Cutsem

jsconf.be 2016

@tvcutsem