Intermediate JavaScript

A One Day Learning Spike

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DEVALOT

Contents

Introduction to This Course

Source Code

The source code for this course can be found at the following URL:

https://github.com/devalot/webdev

Overview

This JavaScript course is delivered during a single day.

What's In Store

Before Lunch	After Lunch
Quick Review	Asynchronous Programming
Advanced Functions	Testing w/ Jasmine
Object-Oriented Programming	Browser APIs

Course Requirements

Developer Tools

Please ensure that the following software applications are installed on the computer you'll be using for this course:

- Node.js LTS
- Google Chrome

Text Editor or IDE

You will also need a text editor or IDE installed. If you don't have a preferred text editor you may be interested in one of the following:

- Visual Studio Code
- Atom
- Sublime Text

Websites

Finally, ensure that your network/firewall allows you to access the following web sites:

- Devalot.com

  Handouts, slides, and course source code.

- npmjs.com

  For installing Node.js packages (if necessary).

- GitHub.com

  Class-specific updates to the course source code.

- JSFiddle

  Fast prototyping and experimenting.

- Mozilla Developer Network

  Excellent documentation for HTML, CSS, and JavaScript

Chapter 1

JavaScript Review (Warming Up)

1.1 Variable Hoisting

When using the `var` keyword, only functions can introduce a new variable scope. This leads to something known as hoisting.

1.1.1 Exercise: Hoisting (Part 1 of 2)

What will the output be?

```
function foo() {
  x = 42;
  var x;

  console.log(x); // ?
  return x;
}
```

1.1.2 Answer: Hoisting (Part 1 of 2)

This:

```
function foo() {
  x = 42;
  var x;

  console.log(x); // ?
  return x;
}
```

Turns into:

```
function foo() {
  var x;
  x = 42;
  console.log(x);
  return x;
}
```

1.1.3 Exercise: Hoisting (Part 2 of 2)

And this one?

```
function foo() {
  console.log(x); // ?
  var x = 42;
}
```

1.1.4 Answer: Hoisting (Part 2 of 2)

This:

```
function foo() {
  console.log(x); // ?
  var x = 42;
}
```

Turns into:

```
function foo() {
  var x;
  console.log(x);
  x = 42;
}
```

1.1.5 Explanation of Hoisting

- Hoisting refers to when a variable declaration is lifted and moved to the top of its scope (only the declaration, not the assignment)
- Function statements are hoisted too, so you can use them before actual declaration
- JavaScript essentially breaks a variable declaration into two statements:

  ```
  var x=0, y;

  // Is interpreted as:
  var x=undefined, y=undefined;
  x=0;
  ```

1.1.6 Example: Identify the Scope For Each Variable

```
var a = 5;

function foo(b) {
  var c = 10;
  d = 15;

  if (d === c) {
    var e = "error: wrong number";
    console.log(e);
  }

  var bar = function(f) {
    var c = 2;
    a = 12;
    return a + c + b;
  };
}
```

- Three scopes exists in the above example
- Variables `a` and `d` are global
- There are two independent local variables named `c`
- Variable `bar` is a local variable containing a function
- Variables `b`, `e`, and `f` are local to their respective functions
- Each inner scope has access to the outer, but the outer scopes cannot access the inner ones
- `ReferenceError` indicates that a variable wasn't found in the current scope chain

1.1.7 Loops and Closures

- Be careful with function expressions in loops
- They can have scope issues:

```
// What will this output?
for (var i=0; i<3; i++) {
  setTimeout(function(){
    console.log(i);
  }, 1000*i);
}
console.log("Howdy!");
```

1.2 Equality in JavaScript

1.2.1 Sloppy Equality

- The traditional equality operators in JS are sloppy
- That is, they do implicit type conversion

```
"1" == 1;   // true
[3] == "3"; // true

0 != "0";  // false
0 != "";   // false
```

1.2.2 Strict Equality

More traditional equality checking can be done with the `===` operator:

```
"1" === 1;  // false
0 === "";   // false

"1" !== 1;  // true
[0] !== ""; // true
```

(This operator first appeared in ECMAScript Edition 3, circa 1999.)

1.2.3 Same-Value Equality

Similar to “`===`” with a few small changes:

```
Object.is(NaN, NaN); // true

Object.is(+0, -0);   // false
```

(This function first appeared in ECMAScript Edition 6, 2015.)

1.3 Document Object Model Review

1.3.1 Accessing Individual Elements

Starting on the `document` object or a previously selected element:

`document.getElementById("main");` Returns the element with the given ID (e.g., `<div id="main">`).

`document.querySelector("p span");` Returns the *first* element that matches the given CSS selector.
The search is done using depth-first pre-order traversal.

1.3.2 DOM Living Standard (WHATWG)

Supported in IE >= 9:

`children:` All *element* children of a node (i.e. no text nodes).

`firstElementChild:` First *element* child.

`lastElementChild:` Last *element* child.

`childElementCount:` The number of children that are *elements*.

`previousElementSibling:` The previous sibling that is an *element*.

`nextElementSibling:` The next sibling that is an *element*.

1.3.3 Creating New Nodes

`document.createElement("a");` Creates and returns a new node without inserting it into the DOM.
In this example, a new `<a>` element is created.

`document.createTextNode("hello");` Creates and returns a new text node with the given content.

1.3.4 Adding Nodes to the Tree

```
var parent = document.getElementById("customers"),
    existingChild = parent.firstElementChild,
    newChild = document.createElement("li");
```

`parent.appendChild(newChild);` Appends `newChild` to the end of `parent.childNodes`.

`parent.insertBefore(newChild, existingChild);` Inserts `newChild` in `parent.childNodes` just before the existing
child node `existingChild`.

`parent.replaceChild(newChild, existingChild);` Removes `existingChild` from `parent.childNodes` and inserts
`newChild` in its place.

`parent.removeChild(existingChild);` Removes `existingChild` from `parent.childNodes`.

1.3.5 HTML and Text Content

```
var element = document.getElementById("foo"),
    name    = "bar";
```

`element.innerHTML` Get or set the element's decedents as HTML.

`element.textContent:` Get or set *all* of the text nodes (including decedents) as a single string.

`element.nodeValue` If `element` is a text node, comment, or attribute node, returns the content of the node.

`element.value` If `element` is a form input, returns its value.

1.3.6 Event Handling: A Complete Example

```
node.addEventListener("click", function(event) {
  // `this' === Node the handler was registered on.
  console.log(this);

  // `event.target' === Node that triggered the event.
  console.log(event.target);

  // Add a CSS class:
  event.target.classList.add("was-clicked");

  // You can stop default browser behavior:
  event.preventDefault();
});
```

1.4 Putting It All Together

1.4.1 Exercise: Warming Up with the DOM and Events

1. Open the following files:
   - `src/www/js/warmup/warmup.js`
   - `src/www/js/warmup/index.html` (read only!)
2. Open the `index.html` file in your web browser
3. Follow the instructions in the JavaScript file

Hint: Use MDN as an API reference.

Chapter 2

Advanced Features of JavaScript Functions

2.1 JavaScript Modules

2.1.1 Modules, Namespaces, and Packages

- Organize logical units of functionality
- Prevent namespace clutter and collisions
- Several options for module implementation
  - The module pattern
  - CommonJS modules
  - ECMAScript 6th Edition modules

2.1.2 The Module Pattern

- Allows for private methods and functions
- Useful for creating namespaces
- Uses an anonymous closure to hide private functionality and make a public interface

2.1.3 Immediately-Invoked Function Expressions: Basics

```
(function() {
  var x = 1;
  return x;
})();
```

2.1.4 Immediately-Invoked Function Expressions: Expanded

```
(function() {  // (1) Anonymous function expression.

  var x = 1; // (2) Body of function.
  return x;

})();  // (3) Close function and call function.
```

2.1.5 Example: Module Pattern

```
var Car = (function() {
  // Private variable.
  var speed = 0;

  // Private method.
  var setSpeed = function(x) {
    if (x >= 0 && x < 100) {speed = x;}
  };

  // Return the public interface.
  return {
    stop: function() {setSpeed(0);},
    inc:  function() {setSpeed(speed + 10);},
  };
})();
```

2.1.6 Exercise: Using IIFEs to Make Private Functions

1. Open the following file:

   `src/www/js/hosts/hosts.js`

2. Follow the instructions inside the file

3. Open the `index.html` file for the tests

2.2 Accessing All Function Arguments

2.2.1 The `arguments` Variable

- Array-like interface. But not exactly an array:

  ```
  arguments.length;  // Some number.
  arguments[0];      // First argument.
  arguments.forEach; // undefined :(
  ```

2.2.2 Converting `arguments` into an Array

Converting the `arguments` property into an array isn't as straight forward as it should be. The following code is a common idiom:

```
var args = Array.prototype.slice.call(arguments);
```

or, with ES6:

```
var args = Array.from(arguments);
```

2.2.3 Function Arity

A function's *arity* is the number of arguments it expects. In JavaScript you can access a function's arity with its `length` property:

```
function foo(x, y, z) { /* ... */ }
foo.length; // => 3
```

2.3 Overriding `this` at Invocation

2.3.1 `Function.prototype.call`

Calling a function and explicitly setting `this`:

```
var x = {color: "red"};
var f = function() {console.log(this.color);};

f.call(x);          // this.color === "red"
f.call(x, 1, 2, 3); // `this' + arguments.
```

2.3.2 Function.prototype.apply

The apply method is similar to call except that additional arguments are given with an array:

```
var x = {color: "red"};
var f = function() {console.log(this.color);};

f.apply(x); // this.color === "red"

var args = [1, 2, 3];
f.apply(x, args); // `this' + arguments.
```

2.3.3 Function.prototype.bind

The bind method creates a new function which ensures your original function is always invoked with this set as you desire, as well as any arguments you want to supply:

```
var x = {color: "red"};
var f = function() {console.log(this.color);};

x.f = f;

var g = f.bind(x);
var h = f.bind(x, 1, 2, 3);

g(); // Same as x.f();
h(); // Same as x.f(1, 2, 3);
```

A common use of the bind function is to ensure that this is set correctly when using a function as a callback. For example:

```
// Call `x.f()` in one second:
setTimeout(f.bind(x), 1000);
```

2.4 Partial Function Application

2.4.1 Introduction to Partial Function Application

- What happens when you call a function with fewer arguments than it was defined to take?
- Sometimes it’s useful to provide fewer arguments and get back a function that accepts the remaining functions.

2.4.2 Simple Example Using Haskell

```haskell
-- Add two numbers:
add :: Int -> Int -> Int
add x y = x + y

-- Call a function three times:
tick :: (Int -> Int) -> [Int]
tick f = [f 1, f 2, f 3]

-- Prints "[11,12,13]"
main = print (tick (add 10))
```

2.4.3 Example Using the `bind` Method

```javascript
var add = function(x, y) {
  return x + y;
};

var add10 = add.bind(undefined, 10);

console.log(add10(2));
```

2.4.4 Exercise: Better Partial Functions

Write a `Function.prototype.curry` function that let's the following code work:

```javascript
var obj = {
  magnitude: 10,

  add: function(x, y) {
    return (x + y) * this.magnitude;
  }.curry()
};

var add10 = obj.add(10);
add10(2); // Should return 120
```

- Use the following file: `src/www/js/partial/partial.js`

2.5 Lazy Function Definition

2.5.1 What's Wrong with This Code?

Assuming this function is called millions of times:

```
var digitName = function(n) {
  var names = ["zero", "one", "two", /* more elements */];
  return names[n] || "";
};
```

2.5.2 Lazy Function Definitions to the Rescue

```
var digitName = function(n) {
  var names = ["zero", "one", "two", /* more elements */];

  // No `var' here!
  digitName = function(n) {
    return names[n] || "";
  };

  return digitName(n);
};
```

Chapter 3

Object-Oriented Programming in JavaScript

3.1 The Prototype

3.1.1 Inheritance in JavaScript

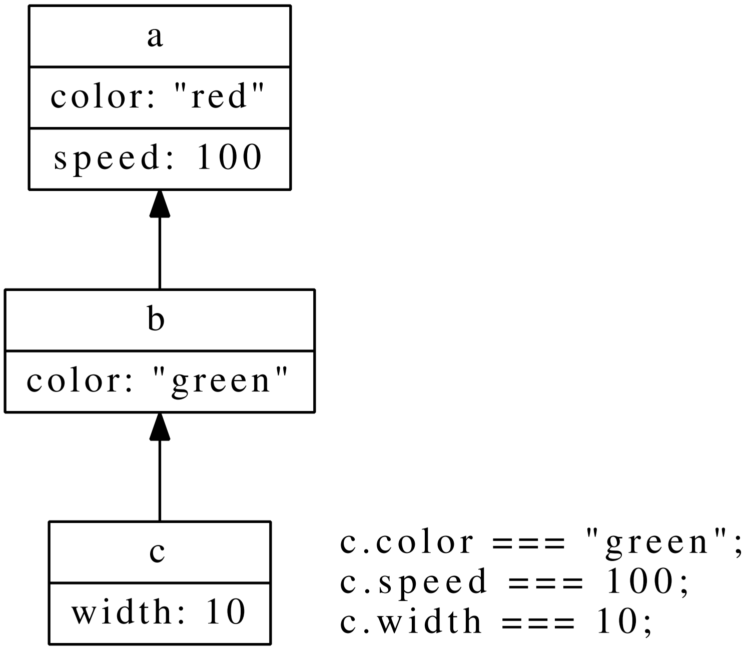
- JavaScript doesn't use classes, it uses prototypes
- There are ways to simulate classes (even ES6 does it!)
- The prototypal model:
  - Tends to be smaller
  - Less redundant
  - Can simulate classical inheritance as needed
  - More powerful

3.1.2 Object Inheritance

3.1.3 Object Inheritance

3.1.4 Prototype Refresher

- All objects have an internal link to another object called its *prototype* (known internally as the `__proto__` property).
- The prototype object also has a prototype, and so on up the *prototype chain* (the final link in the chain is `null`).



```
c.color === "green";
c.speed === 100;
c.width === 10;
```

Figure 3.1: Inheriting Properties

- Objects *delegate* properties to other objects through the prototype chain.
- Only functions have a `prototype` property by default.

3.1.5 Inheritance with `__proto__`

3.1.6 Looking at `Array` Instances

3.1.7 The Prototype Chain

3.1.8 Another Look at `Array` Instances

3.2 Establishing the Prototype Chain

3.2.1 Using `Object.create`

The `Object.create` function creates a new object and sets its `__proto__` property:

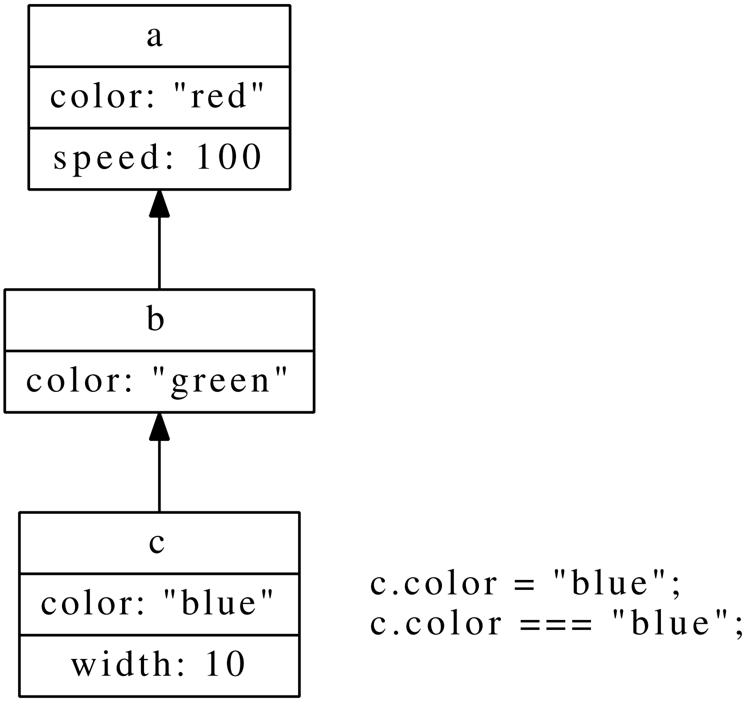


Figure 3.2: Setting a Property

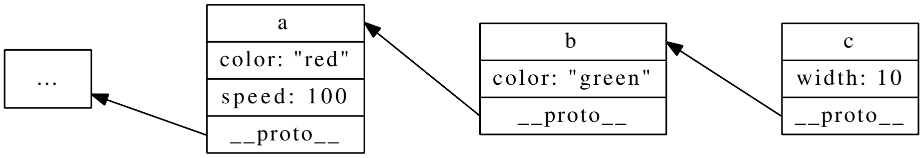


Figure 3.3: Prototypes

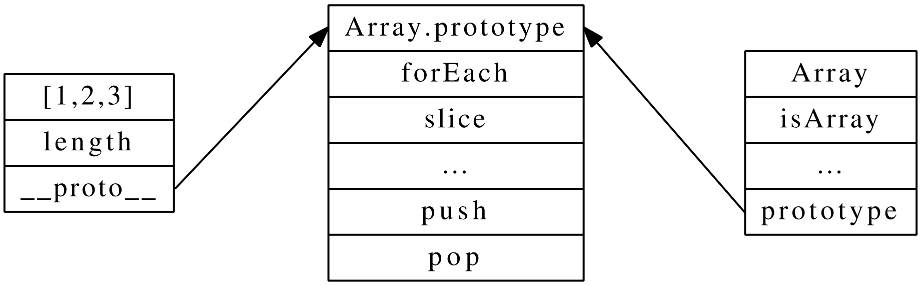


Figure 3.4: Array and Array.prototype

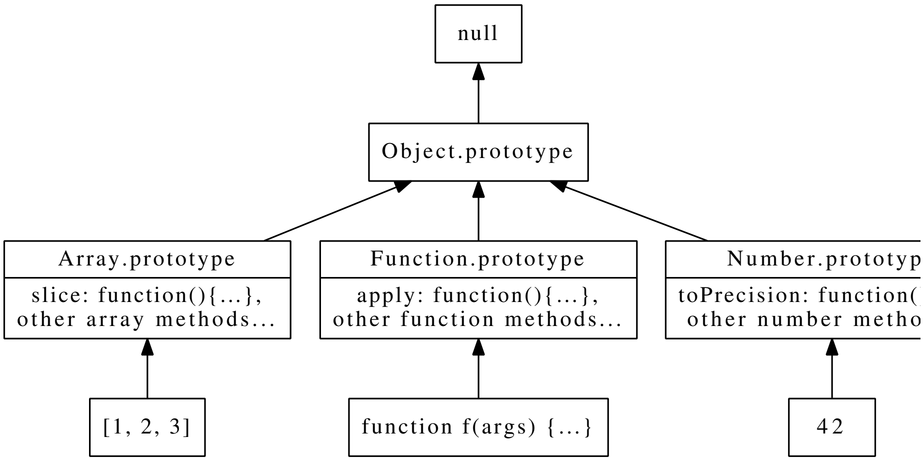


Figure 3.5: Prototypal Inheritance

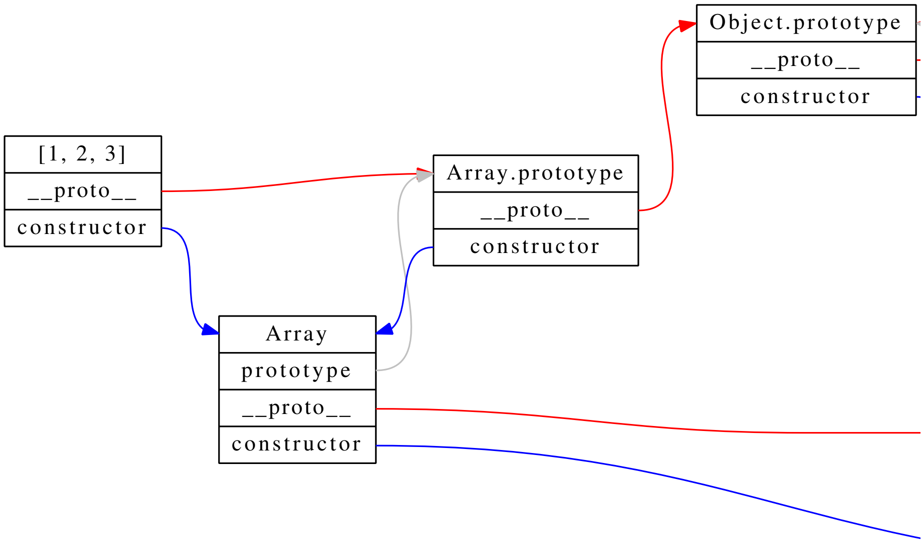


Figure 3.6: Array and Friends

```
var x = Object.create(Array.prototype);
x.push(1);
```

3.2.2 Using the `new` Operator

The `new` operator creates a new object and sets its `__proto__` property. The `new` operator takes a function as its right operand and sets the new object's `__proto__` to the function's `prototype` property.

```
var x = new Array(1, 2, 3);

// Is like:

var y = Object.create(Array.prototype);
y = Array.call(y, 1, 2, 3) || y;
```

3.2.3 Constructor Functions and OOP

```
var Rectangle = function(width, height) {
  this.width  = width;
  this.height = height;
};

Rectangle.prototype.area = function() {
  return this.width * this.height;
};

var rect = new Rectangle(10, 20);
console.log(rect.area());
```

3.2.4 Constructor Functions and Inheritance

```
var Square = function(width) {
  Rectangle.call(this, width, width);
  this.isSquare = true;
};

Square.prototype = Object.create(Rectangle.prototype);
Square.prototype.sideSize = function() {return this.width;};

var sq = new Square(10);
console.log(sq.area());
```

3.2.5 Using `__proto__` in ES6

Starting in ECMAScript Edition 6, the `__proto__` property is standardized as an accessible property.

Warning: Using `__proto__` directly is strongly discouraged due to performance concerns.

3.2.6 Exercise: Class Builder

1. Open the following files:
   - `src/www/js/builder/builder.spec.js` (read only!)
   - `src/www/js/builder/builder.js`
2. Implement the `Builder` function:

   It should generate a constructor function using the `constructor` property given to it. The remaining properties become prototype properties.
3. Use the `index.html` file to run the tests

3.3 Parasitic Inheritance

3.3.1 Constructors that Aren't

Parasitic inheritance is created by:

- Constructor or factory functions
- They don't create their own objects
- After having another function create an object they augment it in some way.

3.3.2 An Example Using the `new` Operator

```
var Rectangle = function(width, height) {
  this.width  = width;
  this.height = height;
};

Rectangle.prototype.area = function() {
  return this.width * this.height;
};

var Square = function(width) {
  var rect = new Rectangle(width, width);
  rect.isSquare = true;
  return rect;
};

var sq = new Square(10);
console.log(sq.area());
```

3.4 Multiple Inheritance via Mixins

3.4.1 What is a Mixin?

- Simulates multiple inheritance
- Properties from interesting objects are copied into the target object, making the target object appear to be made up of the interesting objects.
- All the same problems you get with real multiple inheritance, but without any of the built-in solutions to resolve them.

3.4.2 Using the Mixin Technique

```
var A = function() {};
A.prototype.isA = function() {return true};

var B = function() {};
B.prototype.isB = function() {return true};

var C = function() {};
C.prototype.isC = function() {return true};

C.mixin(A, B);
var obj = new C();

console.log(obj.isA()); // true
console.log(obj.isB()); // true
console.log(obj.isC()); // true
```

3.4.3 Writing the Mixin Machinery

```
Function.prototype.mixin = function() {
  var i, prop;

  for (i=0; i<arguments.length; ++i) {
    for (prop in arguments[i].prototype) {
      this.prototype[prop] =
        arguments[i].prototype[prop];
    }
  }
};
```

3.5 Introspection and Reflection

3.5.1 Simple Introspection Techniques

- The `instanceof` Operator:

  Returns `true` if the left operand was constructed with the function given as the right operand.

  ```
  // Returns `true':
  [1, 2, 3] instanceof Array;
  ```

- The `isPrototypeOf` Function:

  Returns `true` if the receiver is in the prototype (inheritance) chain of the argument. In other words, returns `true` if the receiver is an ancestor of the argument.

  ```
  // Returns `true':
  Array.prototype.isPrototypeOf([1, 2, 3]);
  ```

- The `Object.getPrototypeOf` Function:

  Returns the prototype (i.e. the `__proto__` property) of the argument.

  ```
  // Returns `Array.prototype':
  Object.getPrototypeOf([1, 2, 3]);
  ```

3.6 Object Immutability

3.6.1 `Object.freeze`

```
Object.freeze(obj);
```

```
assert(Object.isFrozen(obj) === true);
```

- Can't add new properties
- Can't change values of existing properties
- Can't delete properties
- Can't change property descriptors

More information

3.6.2 `Object.seal`

```
Object.seal(obj);
```

```
assert(Object.isSealed(obj) === true);
```

- Properties can't be deleted, added, or configured
- Property values can still be changed

More information.

3.6.3 `Object.preventExtensions`

```
Object.preventExtensions(obj);
```

- Prevent any new properties from being added

More information

3.6.4 `Object.defineProperty`

```
Object.defineProperty(obj, propName, definition);
```

- Define (or update) a property and its configuration
- Some things that can be configured:
  - `enumerable`: If the property is enumerated in `for .. in` loops (Boolean)
  - `value`: The property's value

  - `writable`: If the value can change (Boolean)

More information

Chapter 4

Debugging

4.1 Debugging in the Browser

4.1.1 Introduction to Debugging

- All modern browsers have built-in JavaScript debuggers
- We've been using the debugging console the entire time!

4.1.2 Browser Debugging with the Console

- The `console` object:
  - Typically on `window` (doesn't always exist)
  - Methods
    - `log`, `info`, `warn`, and `error`
    - `table(object)`
    - `group(name)` and `groupEnd()`
    - `assert(boolean, message)`

4.1.3 Accessing the Debugger

- In the browser's debugging window, choose **Sources**
- You should be able to see JavaScript files used for the current site

4.1.4 Setting Breakpoints

There are a few ways to create breakpoints:

- Open the source file in the browser and click a line number
- Right-click the line number to create conditional breakpoints
- Use the `debugger;` statement in your code

4.1.5 Stepping Through Code

- After setting breakpoints, you can reload the page (or trigger a function)
- Once the debugger stops on a breakpoint you can step through the code using the buttons in the debugger
  - Step In: Jump into the current function call and debug it
  - Step Over: Jump over the current function call
  - Step Out: Jump out of the current function

4.1.6 Console Tricks

- `$_` the value of the last evaluation
- `$0`—`$4` last inspected elements in historical order
- `$("selector")` returns first matching node (CSS selector)
- `$$("selector")` returns all matching nodes
- `debug(function)` sets a breakpoint in `function`
- `monitor(function)` trace calls to `function`

See the Chrome Command Line Reference for more details.

Chapter 5

Testing in JavaScript

5.1 General Testing Overview

5.1.1 Testing in the Browser

In order to achieve comprehensive testing in JavaScript you need to:

- Test your code in the web browser
- Then test it in every browser you support
- And use a tool that automates this process

5.1.2 The Two Major Flavors of Testing

- Unit tests:

  ```
  assert("empty objects", objects.length > 0);
  ```

- Specification tests:

  ```
  expect(objects.length).toBeGreaterThan(0);
  ```

5.2 Behavior-driven Development with Jasmine

5.2.1 What is Jasmine?

- Specification-based testing
- Expectations instead of assertions

- Provides the testing framework
- Only provides a very simple way to run tests

5.2.2 Example: Writing Jasmine Tests

```
describe("ES6 String Methods", function() {
  it("has a find method", function() {
    expect("foo".find).toBeDefined();
  });
});
```

5.2.3 Basic Expectation Matchers

`toBe(x)`: Compares with `x` using `===`.
`toMatch(/hello/)`: Tests against regular expressions or strings.
`toBeDefined()`: Confirms expectation is not `undefined`.
`toBeUndefined()`: Opposite of `toBeDefined()`.
`toBeNull()`: Confirms expectation is `null`.
`toBeTruthy()`: Should be true `true` when cast to a Boolean.
`toBeFalsy()`: Should be `false` when cast to a Boolean.

5.2.4 Numeric Expectation Matchers

`toBeLessThan(n)`: Should be less than `n`.
`toBeGreaterThan(n)`: Should be greater than `n`.
`toBeCloseTo(e, p)`: `Math.abs(e - actual) < (Math.pow(10, -p) / 2)`

5.2.5 Smart Expectation Matchers

`toEqual(x)`: Can test object and array equality.
`toContain(x)`: Expect an array to contain `x` as an element.

5.2.6 Life Cycle Callbacks

Each of the following functions takes a callback as an argument:

`beforeEach`: Before each `it` is executed.
`beforeAll`: Once before any `it` is executed.
`afterEach`: After each `it` is executed.
`afterAll`: After all `it` specs are executed.

5.2.7 Deferred (Pending) Tests

Tests can be marked as pending either by:

```
it("declared without a body!");
```

or:

```
it("uses the pending function", function() {
  expect(0).toBe(1);
  pending("this isn't working yet!");
});
```

5.2.8 Spying on a Function or Callback (Setup)

```
var foo;

beforeEach(function() {
  foo = {
    plusOne: function(n) { return n + 1; },
  };
});
```

5.2.9 Spying on a Function or Callback (Call Counting)

```
it("should be called", function() {
  spyOn(foo, 'plusOne');
  var x = foo.plusOne(1);

  expect(foo.plusOne).toHaveBeenCalled();
  expect(x).toBeUndefined();
});
```

5.2.10 Spying on a Function or Callback (Call Through)

```
it("should call through and execute", function() {
  spyOn(foo, 'plusOne').and.callThrough();
  var x = foo.plusOne(1);

  expect(foo.plusOne).toHaveBeenCalled();
  expect(x).toBe(2);
});
```

5.2.11 Testing Time-Based Logic (The Setup)

```
var timedFunction;

beforeEach(function() {
  timedFunction = jasmine.createSpy("timedFunction");
  jasmine.clock().install();
});

afterEach(function() {
  jasmine.clock().uninstall();
});
```

5.2.12 Testing Time-Based Logic (setTimeout)

```
it("function that uses setTimeout", function() {
  inFiveSeconds(timedFunction);

  // The callback shouldn't have been called yet:
  expect(timedFunction).not.toHaveBeenCalled();

  // Move the clock forward and trigger timeout:
  jasmine.clock().tick(5001);

  // Now it's been called:
  expect(timedFunction).toHaveBeenCalled();
});
```

5.2.13 Testing Time-Based Logic (setInterval)

```
it("function that uses setInterval", function() {
  everyFiveSeconds(timedFunction);

  // The callback shouldn't have been called yet:
  expect(timedFunction).not.toHaveBeenCalled();

  // Move the clock forward a bunch of times:
  for (var i=0; i<10; ++i) jasmine.clock().tick(5001);

  // It should have been called 10 times:
  expect(timedFunction.calls.count()).toEqual(10);
});
```

5.2.14 Testing Asynchronous Functions

```
describe("asynchronous function testing", function() {
  it("uses an asynchronous function", function(done) {

    // `setTimeout' returns immediately,
    // so this test does too!
    setTimeout(function() {
      done(); // tell Jasmine we were called.
    }, 1000);

  });
});
```

5.2.15 Running Jasmine Tests

- [Standalone][jasmine-standalone] runner:
  - List files in `SpecRunner.html`
  - Opening that file in your browser runs the tests
- [Node.js runner][jasmine-npm]:
  - Provides a `jasmine` tool
  - Runs tests inside Node.js
- [Karma-Jasmine][karma-jasmine] runner:
  - Automatically manages browser farms
  - Runs tests in parallel on all browsers
  - Can use headless browsers (PhantomJS)
  - Support for continuous integration

5.2.16 Best Practices for Testing

- Make sure your tests actually fail

- Separate pure logic from DOM manipulation

- Test with valid *and* invalid input (or use fuzzing)

- Automate your tests so they run all the time

- Avoid mocking/spies if you can (they create “holes”)

5.2.17 Further Information

See the following for more information:

- [Jasmine][] documentation

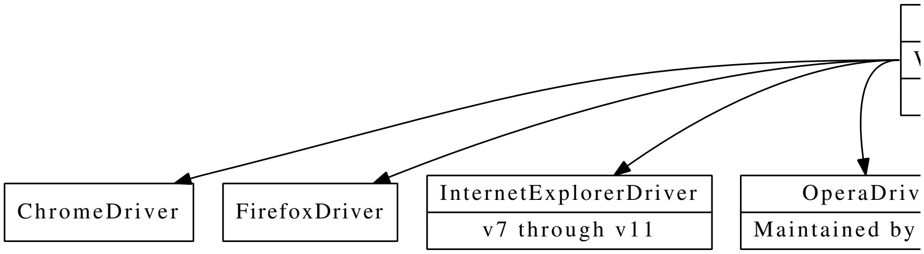
- [Karma][] test runner

Other testing frameworks:

- [JSPec][]: Full-featured behavior testing
- [Sinon][]: Spies, stubs, and mocks
- [Chai][]: Testing assertion library

5.3 Browser Automated Testing

5.3.1 End-to-End Testing Options



Chapter 6

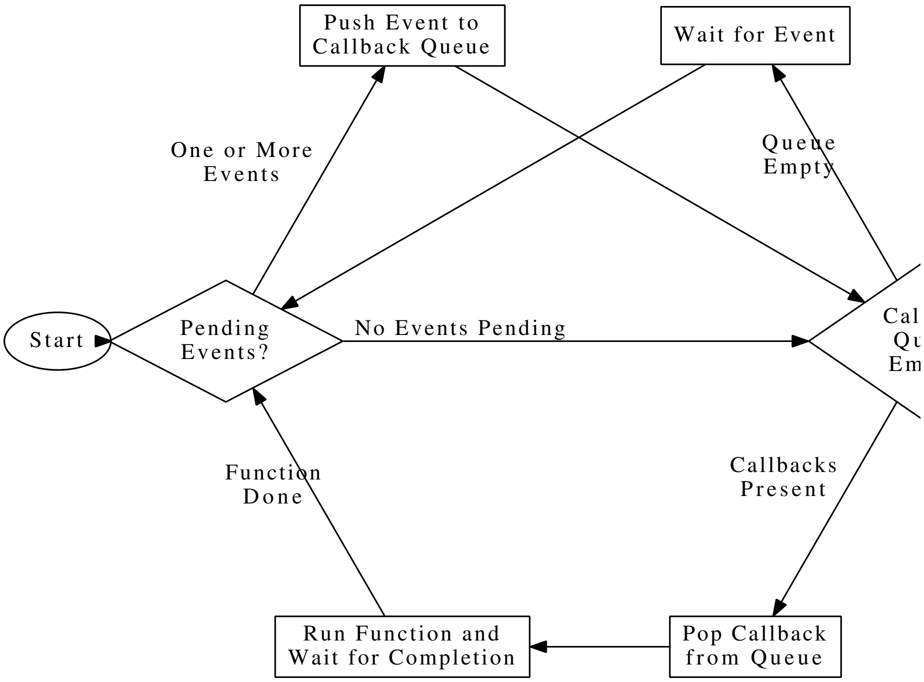
Asynchronous Programming

6.1 The JavaScript Runtime

6.1.1 Introduction to the Runtime

- JavaScript has a single-threaded runtime
- Work is therefore split up into small chucks (functions)
- Callbacks are used to divide work and call the next chunk
- The runtime maintains a work queue where callbacks are kept

6.1.2 Visualizing the Runtime



6.2 Promises

6.2.1 Callbacks without Promises

```
$.get("/a", function(data_a) {
  $.get("/b/" + data_a.id, function(data_b) {
    $.get("/c/" + data_b.id, function(data_c) {
      console.log("Got C: ", data_c);
    }, function() {
      console.error("Call failed");
    });
  }, function() {
    console.error("Call failed");
  });
}, function() {
  console.error("Call failed");
});
```

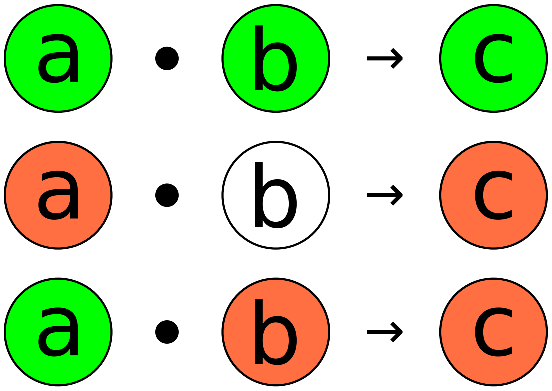
6.2.2 Callbacks Using Promises

```
$.get("/a").
  then(function(data) {
    return $.get("/b/" + data.id);
  }).
  then(function(data) {
    return $.get("/c/" + data.id);
  }).
  then(function(data) {
    console.log("Got C: ", data);
  }).
  catch(function(message) {
    console.error("Something failed:", message);
  });
```

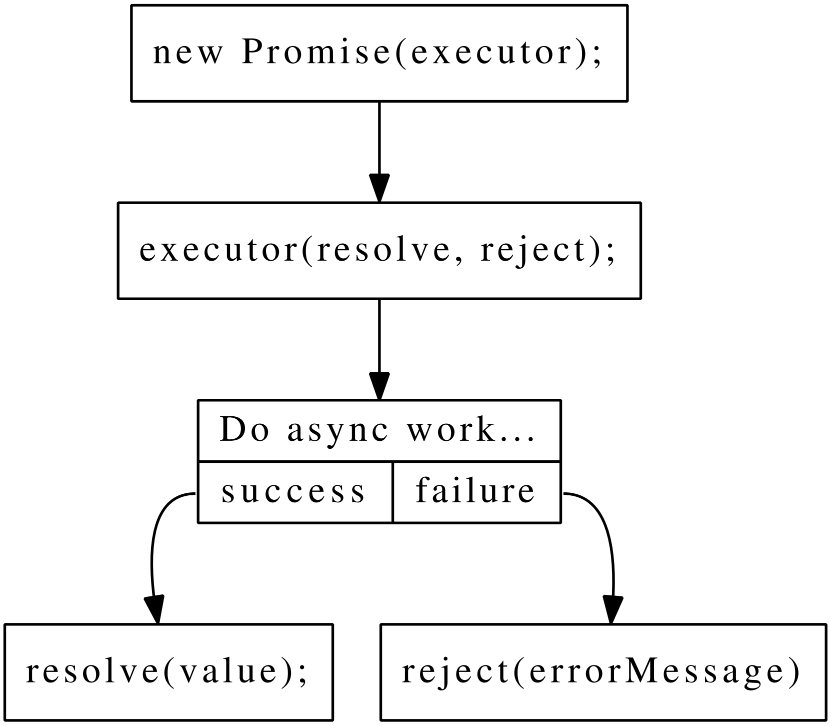
6.2.3 Promise Details

- Guarantee that callbacks are invoked (no race conditions)
- Composable (can be chained together)
- Flatten code that would otherwise be deeply nested

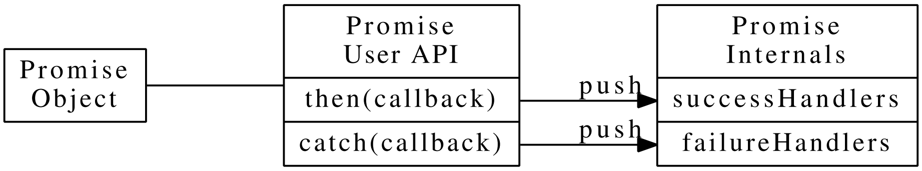
6.2.4 Visualizing Promises (Composition)



6.2.5 Visualizing Promises (Owner)



6.2.6 Visualizing Promises (User)



6.2.7 Composition Example

```
// Taken from the `src/spec/promise.spec.js' file.
var p = new Promise(function(resolve, reject) {
  resolve(1);
});
```

```
p.then(function(val) {
  expect(val).toEqual(1);
  return 2;
}).then(function(val) {
  expect(val).toEqual(2);
  done();
});
```

6.2.8 Ajax Refresher

Making an Ajax request:

```
var req = new XMLHttpRequest();

req.addEventListener("load", function(e) {
  if (req.status == 200) {
    console.log(req.responseText);
  }
});

req.open("GET", "/example/foo.json");
req.send(null);
```

6.2.9 Exercise: A Simple Ajax Library

1. Open `src/www/js/ajax/ajax.js`
2. Fill in the missing pieces
3. Open the `index.html` file in your browser
4. Get the tests in `index.html` to pass

6.2.10 Exercise: Using Your Ajax Library

1. Open `src/www/js/artists/artists.js`
2. Complete the exercise using your Ajax library
3. Open the `index.html` file in your browser
4. Play with your code!

Chapter 7

ECMAScript 6th Edition (ES6/ES2015)

ECMAScript 6 was ratified in June of 2015.

Let’s look at a few of the major changes in ES6. For a more complete list, take a look at the es6features repository on GitHub.

7.1 Lexical (Block-level) Scopes

7.1.1 The New `let` Keyword

- ES6 introduces `let`
- Declare a variable in the scope of containing block:

  ```
  if (expression) {
    var a = 1; // scoped to wrapping function
    let b = 2; // scoped to the block
  } // Woah!
  ```

7.1.2 Hoisting and `let`

It does not hoist!

```
{
  console.log(b); // Error!

  let b = 12;
```

```
  console.log(b); // No problem.
}
```

7.1.3 Looping with `let`

Using let with a for loop is possible in ES6:

```
for (let i=0; i<10; i++) {
  // i is bound to a new scope each iteration
  // getting its value reassigned
  // at the end of the iteration
}
```

7.2 Single Assignment Protection

7.2.1 Preventing Reassignment

The `const` keyword defines a block-level variable that must be initialized when it's declared and can't be reassigned:

```
var f = function() {
  const x = "foo";

  // ...

  x = 1;  // Ignored.
};
```

7.3 Functions

7.3.1 Arrow Functions

```
element.addEventListener("click", function(e) {
  // ...
});

// Becomes:


element.addEventListener("click", e => {
  // ...
});
```

7.3.2 Implicit `return` for Arrow Expressions

If you omit curly braces you can write a single expression that automatically becomes the return value of the function:

```
a.map(function(e) {
  return e + 1;
});

// Becomes:

a.map(e => e + 1);
```

7.3.3 Arrow Warnings

- Arrow function do not have a `this` or an `arguments` variable!
- If you use curly braces you need to use `return`.

7.3.4 Default Parameters

```
let add = function(x, y=1) {
  return x + y;
};
```

```
add(2); // 3
```

- Parameters can have *default* values
- When a parameter isn't bound by an argument it takes on the default value, or `undefined` if no default is set
- Default parameters are evaluated at *call time*
- May refer to any other variables in scope

MDN Docs

7.3.5 Rest Parameters

```
let last = function(x, y, ...args) {
  return args.length;
};
```

```
last(1, 2, 3, 4); // 2
```

- When an argument name is prefixed with "`...`" it will be an array containing all of the arguments that are not bound to names

- Unlike `arguments`, the rest parameter only contains arguments that are not bound to names
- Unlike `arguments`, the rest parameter is a real `Array`

MDN Docs

7.3.6 Spread Syntax

```
let max = function(x, y) {
  return x > y ? x : y;
};

let ns = [42, 99];
```

```
max(...ns); // 99
```

- When the name of an array is prefixed with "`...`" in an expression that expects arguments or elements, the array is expanded
- Works when calling functions and creating array literals
- Can be used to splice arrays together

(Object spreading is part of ES2018.)

MDN Docs

7.3.7 Array Destructuring

```
let firstPrimes = function() {
  return [2, 3, 5, 7];
};

let x, y, rest;
[x, y, ...rest] = firstPrimes();
```

```
console.log(x); // 2
console.log(y); // 3
console.log(rest); // [ 5, 7 ]
```

- Similar to *pattern matching* from functional languages
- The *lvalue* can be an array of names to bind from the *rvalue*

(Object destructuring is part of ES2018.)

MDN Docs

7.4 Object-oriented Programming

7.4.1 Classes

New `class` keyword that provides syntactic sugar over prototypal inheritance:

```
class Square extends Rectangle {
  constructor(width) {
    super(width, width);
  }
  someMethod() {
    return "Interesting";
  }
}
```

7.4.2 Class Features

- Class statements are *not* hoisted.
- Classes can also be defined using an expression syntax:

  ```
  var Person = class {
    // ..
  };
  ```

7.4.3 Same-Value Equality

Similar to "`===`" with a few small changes:

```
Object.is(NaN, NaN); // true

Object.is(+0, -0);   // false
```

(This function first appeared in ECMAScript Edition 6, 2015.)

7.4.4 The `Object.assign` Function

Copies properties from one object to another:

```
var o1 = {a: 1, b: 2, c: 3};
var o2 = { };

Object.assign(o2, o1);
console.log(o2);
```

Produces this output:

```
{ a: 1, b: 2, c: 3 }
```

(This function first appeared in ECMAScript Edition 6, 2015.)

7.4.5 Modules

- Export identifiers from a library:

  ```
  const magicNumber = 42;

  function sayMagicNumber() {
    console.log(magicNumber);
  }

  export { sayMagicNumber };
  ```

- Import those identifiers elsewhere:

  ```
  import sayMagicNumber from './module.js';
  sayMagicNumber();
  ```

7.5 Generators and Iterators

7.5.1 New Generic `for` Loop

The new `for...of` loop can work with any object that supports iteration:

```
var anything = [1, 2, 3];

for (let x of anything) {
  console.log(x);
}
```

7.5.2 Generators

```
let something = {
  [Symbol.iterator]: function*() {
    for (let i=0; i<10; ++i) {
      yield i;
    }
  },
};
```

```
for (let x of something) {
  console.log(x);
}
```

7.5.3 Iterators

```
let something = {
  [Symbol.iterator]: function() {
    let n = 0;

    return {
      next: () => ({value: n, done: n++ >= 10}),
    };
  },
};

for (let x of something) {
  console.log(x);
}
```

7.6 New Data Types

7.6.1 Maps

```
let characters = new Map();

characters.set("Ripley", "Alien");
characters.set("Watney", "The Martian");

characters.has("Ripley"); // true
characters.get("Ripley"); // "Alien"
```

7.6.2 WeakMaps

- Like a `Map`, but *keys* can be garbage collected
- Similar API as a `Map` (missing some functions)
  - `WeakMap.prototype.delete`
  - `WeakMap.prototype.get`
  - `WeakMap.prototype.set`
  - `WeakMap.prototype.has`

7.6.3 Others

- `Set` and `WeekSet`

  Mathematical sets, as well as a weak version.

- `Proxy` and `Reflect`

  Powerful objects for metaprogramming.

- `Symbol`

  Create and use runtime unique entries in the symbol table.

- Template Literals

  String interpolation:

  ```
  `Hello ${name}`
  ```

Chapter 8

ECMAScript 7th Edition (ES7/ES2016)

The 7th edition of ECMAScript contained very few changes and only introduced two major changes to the language.

8.1 Major Changes

8.1.1 Exponentiation Operator

Prior to ES7:

```
Math.pow(4, 2);
```

New in ES7:

```
4 ** 2;
```

8.1.2 `Array.prototype.includes`

A new prototype function to test if a value is in an array.

Prior to ES7:

```
[1, 2, 3].indexOf(3) >= 0;
```

New in ES7:

```
[1, 2, 3].includes(3);
```

Chapter 9

ECMAScript 8th Edition (ES8/ES2017)

ES8 included a small number of important changes to the language.

9.1 Major Changes

9.1.1 Async Functions

Major improvement to asynchronous functions thanks to promises and generators. Asynchronous callbacks are hidden with new syntax.

```
async function getArtist() {
  try {
    var response1 = await fetch("/api/artists/1");
    var artist = await response1.json();

    var response2 = await fetch("/api/artists/1/albums");
    artist.albums = await response2.json();

    return artist;
  } catch(e) {
    // Rejected promises throw exceptions
    // when using `await'.
  }
}
```

9.1.2 Summary of Other Changes

- String padding (ensuring a string is the proper length)
  - `String.prototype.padStart`
  - `String.prototype.padEnd`
- `Object.values` and `Object.entries`
- `Object.getOwnPropertyDescriptors`
- Trailing commas in function parameters and call arguments
- Shared memory (`SharedArrayBuffer`)
- Atomic operations (e.g., `Atomics.store`)

Chapter 10

Popular JavaScript APIs

10.1 The Web Storage API

10.1.1 What is Web Storage?

- Allows you to store key/value pairs
- Two levels of persistence and sharing
- Very simple interface
- Keys and values *must* be strings

10.1.2 Session Storage

- Lifetime: same as the containing window/tab
- Sharing: Only code in the same window/tab
- 5MB user-changeable limit (10MB in IE)
- Basic API:

  ```
  sessionStorage.setItem("key", "value");
  var item = sessionStorage.getItem("key");
  sessionStorage.removeItem("key");
  ```

10.1.3 Local Storage

- Lifetime: unlimited
- Sharing: All code from the same domain

- 5MB user-changeable limit (10MB in IE)
- Basic API:

  ```
  localStorage.setItem("key", "value");
  var item = localStorage.getItem("key");
  localStorage.removeItem("key");
  ```

10.1.4 The `Storage` Object

Properties and methods:

- `length`: The number of items in the store.
- `key(n)`: Returns the name of the key in slot `n`.
- `clear()`: Remove all items in the storage object.
- `getItem(key)`, `setItem(key, value)`, `removeItem(key)`.

More information about the `Storage` object can be found at:

https://developer.mozilla.org/en-US/docs/Web/API/Storage

10.1.5 Browser Support

- IE >= 8
- Firefox >= 2
- Safari >= 4
- Chrome >= 4
- Opera >= 10.50

10.1.6 Documentation

- https://developer.mozilla.org/en-US/docs/Web/API/Window/sessionStorage
- https://developer.mozilla.org/en-US/docs/Web/API/Window/localStorage

10.2 Cache Manifest Files (AppCache)

10.2.1 What is the AppCache?

- A server-side manifest file
- Tells the browser which files to long-term cache
- Allows a web site to work offline

10.2.2 Example Manifest File

Add a `manifest` attribute to your HTML:

```html
<html manifest="/site.appcache">
  <!-- ... -->
</html>
```

Create the manifest file on your server:

```
CACHE MANIFEST

CACHE:
/favicon.ico
index.html
app.js
app.css

NETWORK:
*
```

10.2.3 Server-side Requirements

- The server must transmit the manifest file with the `Content-Type` set to `text/cache-manifest`
- The server should send the correct cache and `E-Tag` headers to the browser to keep the browser from caching the manifest file too long
- The manifest file should be generated server-side with comments in the file containing the `E-Tag` headers for each listed file

10.2.4 Client-side Considerations

- Once you start using application caching the cache becomes the default source for *all* requests
- The browser will use the application cache even if the user is online
- The browser won't allow network traffic back to the site for uncached resources by default
- Make sure your manifest has a `NETWORK:` section with `*`

10.2.5 Updating the Cache in Long-lived Applications

1. Periodically (once a day) call `update`:

   ```
   applicationCache.update();
   ```

2. Listen for update events and notify the user:

   ```
   (function(cache) {
     cache.addEventListener('updateready', function() {
       if (cache.status === cache.UPDATEREADY) {
         // Tell the user to reload the page.
       }
     });
   })(applicationCache);
   ```

10.2.6 Browser Support

- IE >= 10
- Firefox >= 3.5
- Safari >= 4
- Chrome >= 4
- Opera >= 11.5

10.2.7 Further Reading

- A Beginner's Guide to Using the Application Cache
- Offline Web Applications (Spec)

10.3 Canvas

10.3.1 Canvas: Two Drawing APIs

- 2D drawing primitives via paths
- 3D drawing via WebGL
- Both can be hardware accelerated
- Typically 60 FPS (if animating)

10.3.2 Drawing a Circle: The HTML

```
<canvas id="circle"></canvas>
```

10.3.3 Drawing a Circle: JavaScript

```
canvas  = document.getElementById("circle");
context = canvas.getContext("2d");

var path = new Path2D();
path.arc(75, 75, 50, 0, Math.PI * 2, true);
context.stroke(path);
```

10.3.4 Browser Support

- IE >= 9
- Firefox >= 1.5
- Safari >= 2
- Chrome >= 1
- Opera >= 9

10.3.5 Documentation

https://developer.mozilla.org/en-US/docs/Web/API/Canvas_API/Tutorial

10.4 File API

10.4.1 What the File API Is, and Isn't

- It's *not* a general-purpose I/O interface
- It only lets you get basic info about user-selected files:
  - Name
  - Size
  - MIME type
- A user selects a file with an `<input>` or using drag and drop

10.4.2 Example: Chosen File Size

- In the HTML:

  ```
  <input type="file" id="the-input"/>
  ```

- In the JavaScript (after the user picks a file):

```
    var input = document.getElementById("the-input");
    var size = input.files[0].size;
```

10.4.3 Browser Support

- IE >= 10
- Firefox >= 3.0
- Safari >= 6.0
- Chrome >= 13
- Opera >= 11.5

10.4.4 Documentation

https://developer.mozilla.org/en-US/docs/Web/API/File

10.5 Geolocation

10.5.1 Testing If Geolocation is Enabled

```
if ("geolocation" in navigator) {
  // ...
}
```

10.5.2 Getting the Browser’s Location

```
navigator.geolocation.getCurrentPosition(function(pos) {
  // ...
});
```

10.5.3 Browser Support

- IE >= 9
- Firefox >= 3.5
- Safari >= 5
- Chrome >= 5
- Opera >= 16

10.5.4 Documentation

https://developer.mozilla.org/en-US/docs/Web/API/Geolocation/Using_geolocation

10.6 The Fetch API

10.6.1 Using the `fetch` Function

```
fetch("/api/artists", {credentials: "same-origin"})
  .then(function(response) {
    return response.json();
  })
  .then(function(data) {
    updateUI(data);
  })
  .catch(function(error) {
    console.log("Ug, fetch failed", error);
  });
```

10.6.2 Browser Support and Documentation

Browsers:

- IE (no support)
- Edge >= 14
- Firefox >= 34
- Safari >= 10.1
- Chrome >= 42
- Opera >= 29

Docs:

- Living Standard
- MDN

10.7 Web Workers

10.7.1 Web Worker Basics

- Allows you to start a new background “thread”
- Messages can be sent to and from the worker
- Message handling is done through events
- Load scripts with: `importScripts("name.js");`

10.7.2 Browser Support

- IE >= 10
- Firefox >= 3.5
- Safari >= 4
- Chrome >= 4
- Opera >= 10.6

10.7.3 Documentation

https://developer.mozilla.org/en-US/docs/Web/API/Web_Workers_API/Using_web_workers

10.8 WebSockets

10.8.1 WebSockets Basics

- Full duplex connection to a server

- Create your own protocol on top of WebSockets frames

- Not subject to the same origin policy (SOP) or CORS

10.8.2 How It Works

1. The browser requests that a new HTTP connection be *upgraded* to a raw TCP/IP connection

2. The server responds with `HTTP/1.1 101 Switching Protocols`

3. A simple binary protocol is used to support bi-directional communications between the client and server over the upgraded port 80 connection

10.8.3 Security Considerations

- There are no host restrictions on WebSockets connections

- Encrypt traffic and confirm identity when using WebSockets

- Never allow foreign JavaScript to execute in a user's browser

10.8.4 Browser Support

- IE >= 10
- Firefox >= 6
- Safari >= 6
- Chrome >= 14
- Opera >= 12.10

10.8.5 Documentation and Demos

- MDN: WebSockets API
- MDN: WebSockets Example
- socket.io: Popular Library

10.9 Server-Sent Events

10.9.1 A Word About Server-Sent Events

- Pros:
  - Simpler than WebSockets
  - One direction: server to browser
  - Uses HTTP, no need for a custom protocol
- Cons:
  - Not supported in IE (any version)
  - Poor browser support in general (polyfills are available)
- How:
  - Browser: use the `EventSource` global object
  - Server: just write messages to the HTTP connection
- Docs:
  - See MDN

Chapter 11

Alternatives and Extensions to JavaScript

11.1 Overview

11.1.1 Languages that Compile to JavaScript

- PureScript
- Flow
- TypeScript
- Dart

11.1.2 PureScript

- Purely functional programming language that compiles to JS
- Strong, static type system (similar to Haskell)
- Clean, human-readable JavaScript output
- Lots of open source modules for PureScript

11.1.3 Flow

- Language extension to JavaScript
- Standalone static type checking system

- Runs as part of your build process
- Uses Babel to transpile to standard JavaScript
- Sponsored by Facebook

11.1.4 Flow Features

- Type inference (no type annotations required)
- Syntax for type annotations so you can be explicit
- Automatic `null` checking
- Enabled per-file or per-function

11.1.5 What Does it Look Like?

Adding types to a function:

```
// Explicit type annotations:
var add = function(x: number, y: number): number {
  return x + y;
};

// This will fail type checking:
add("1", 2);

// Also fails type checking:
var sum = add(1, 2);
console.log(sum.length);
```

11.1.6 Using Flow

1. Allow Flow to process a file by adding a comment flag:

   ```
   // @flow
   ```

2. Type check the code by running `flow check`
3. Use Babel to remove the type annotations

11.1.7 Flow Demo Application

1. http://localhost:3000/alternatives/flow/
2. `www/alternatives/flow`
3. Before it will work you need to:

```
$ npm install -g gulp-cli
$ npm install
$ gulp
```

11.1.8 TypeScript

- A language based on ES6 (classes, arrow functions, etc.)
- All features compile to ES5
- Same basic type-annotation syntax as Flow
- Type inference and null-checking are weaker than Flow
- Sponsored by Microsoft

11.1.9 Dart

- OOP Language standardized as ECMA-408
- Optional type system
- Requires a runtime system in JavaScript
- Sponsored by Google

11.1.10 Popular ES6 to ES5 Transpilers

- Babel
- Traceur

11.1.11 Looking to the Future

- WebAssembly

JavaScript Resources

JavaScript Documentation

- Mozilla Developer Network

Books on JavaScript

- JavaScript: The Good Parts
  - By: Douglas Crockford
  - Great (re-)introduction to the language and common pitfalls
- "You Don't Know JS" (book series)
  - By: Kyle Simpson
  - Look at JavaScript in a new light
  - https://github.com/getify/You-Dont-Know-JS
- Learning JavaScript Design Patterns
  - By: Addy Osmani
  - Through book about design patters in JavaScript
  - Exercises and Answers

Training Videos from Pluralsight

Beginner to Intermediate

- Basics of Programming with JavaScript
- JavaScript Fundamentals
- Building a JavaScript Development Environment
- JavaScript: From Fundamentals to Functional JS

Intermediate to Advanced

- Object-oriented Programming in JavaScript
- Reasoning About Asynchronous JavaScript
- Advanced JavaScript
- TypeScript Fundamentals
- Angular 2: Getting Started

Libraries

- Testing: [Jasmine][], [JSPec][], [Sinon][], and [Chai][]

Compatibility Tables

- ES6 Status By kangax