ECMAScript 2015 (ES6)

Building Modern Web Applications - VSP2019

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What is ES6?

1. **What is ES6?**
2. Object-oriented Programming
3. Functional Programming

What is ES6?

- JavaScript specifications are maintained by an international organization - ECMA International
  - ECMA-262 & ISO/IEC-22275
  - ECMAScript is a **living and evolving standard**
  - Goal is to **standardize JS**, as different browser vendors implement different versions: JavaScript, JScript, ActionScript, etc.
  - Current latest edition (as of 2019) is ES10
  - ES5 has been the longest serving standard and still the most prevalent
  - ES6 has gained a lot of momentum and becoming mainstream

ES5 vs ES6

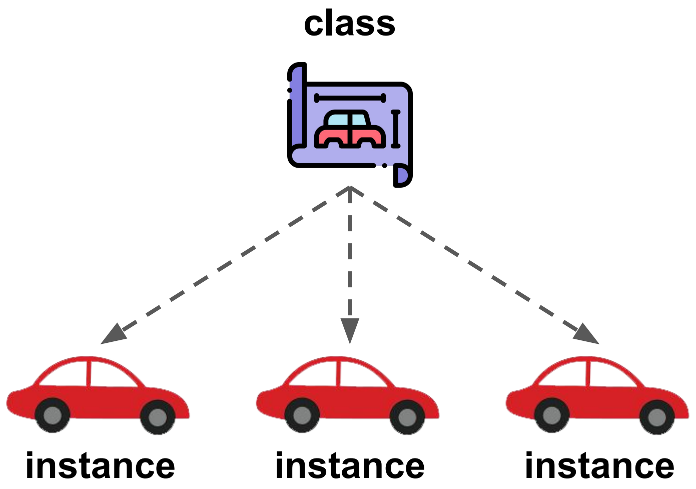
- ES5 still has quirks that create confusion among users
  - Prototypal inheritance
  - Semantics of keywords like: `var`, `this`
- ES6 introduces many useful features
  - Syntactic sugar for commonly used code patterns
  - Better support for object-oriented programming
  - Better support for functional programming
- Good coverage of ES6 features can be found at:
  - http://es6-features.org
  - https://github.com/lukehoban/es6features
- In this class we will focus on a subset of the ES6 features

Object-oriented Programming

1. What is ES6?
2. **Object-oriented Programming**
3. Functional Programming

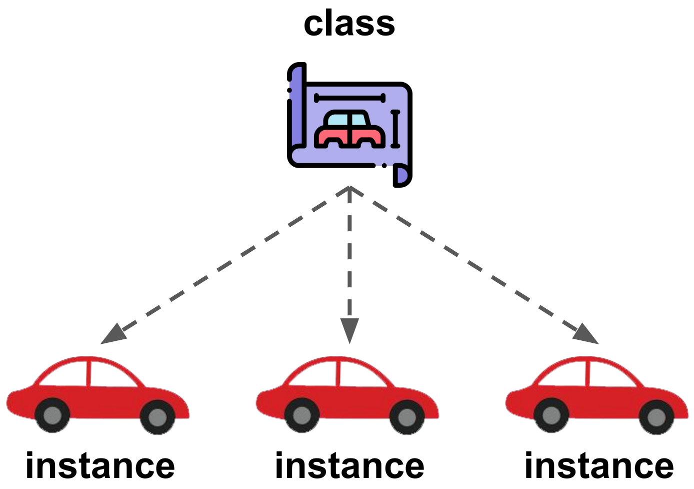
Object-oriented Programming

Object-oriented

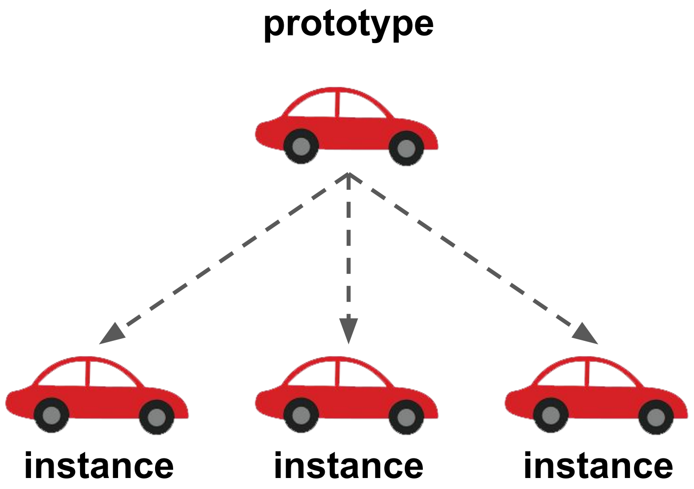


Object-oriented Programming

Object-oriented



Prototypal



Object-oriented Programming

- JavaScript is still prototypal at its core
- Prototypes can emulate OOP patterns
  - However, it is syntactically and semantically different
- ES6 introduces the `class` keyword to support OOP

Object-oriented Programming

New keywords introduced in this chapter

- `new` : for creating an instance of an Object
- `this` : for referencing the function invocation context
- `instanceof` : for checking whether A is an instance of B
- `class` : ES6 keyword for declaring a Class
- `constructor` : for defining the constructor function for a class
- `extends` : ES6 keyword for extending/inheriting from a Class
- `super` : ES6 keyword for referencing the superclass

Object-oriented Programming

this keyword

- this refers to the object on which the function is called

```
var myCar = {
  name: "Smart",
  power: 1,
  velocity: 0,
  accelerate: function (fuel){
    this.velocity += fuel * this.power;
  }
}

myCar.accelerate(10);
```

Object-oriented Programming

`this` keyword

- `this` refers to the object on which the function is called

```
function accelerate (fuel){
  this.velocity += fuel * this.power;
}
var myCar = {
  name: "Smart",
  power: 1,
  velocity: 0,
  accelerate: accelerate
}
myCar.accelerate(10);

```

Object-oriented Programming

`this` keyword

- `this` refers to the object on which the function is called

```
function accelerate (fuel){
  this.velocity += fuel * this.power;
}
var myCar = {
  name: "Smart",
  power: 1,
  velocity: 0,
  accelerate: accelerate
}
myCar.accelerate(10);
accelerate(12);        // What is "this"?
```

Object-oriented Programming

`this` keyword

- Function objects have a method called `bind`, which can be used to "lock" what `this` refers to

```
function accelerate (fuel){
  this.velocity += fuel * this.power;
}
var myCar = {
  name: "Smart",
  power: 1,
  velocity: 0,
  accelerate: accelerate
}
myCar.accelerate(10);
accelerate.bind(myCar)(12);        // What is "this"?
```

Object-oriented Programming

new keyword

```
function Car (){


};
Car.prototype = {
  name: "Smart",
  power: 1,
  velocity: 0
};
```

Object-oriented Programming

new keyword

```javascript
function Car (name, power=1){
    this.name = name;
    this.power = power;
    this.velocity = 0;
};
Car.prototype = {
  name: "Smart",
  power: 1,
  velocity: 0
};
```

Object-oriented Programming

new keyword

```
function Car (name, power=1){
   this.name = name;
   this.power = power;
   this.velocity = 0;
};
Car.prototype = {};
```

Object-oriented Programming

new keyword

```
function Car (name, power=1){
    this.name = name;
    this.power = power;
    this.velocity = 0;
};
Car.prototype = {};
Car.prototype.accelerate = function(fuel){
    this.velocity += fuel * this.power;
};
```

Object-oriented Programming

new keyword

```
function Car (name, power=1){
   this.name = name;
   this.power = power;
   this.velocity = 0;
};
Car.prototype = {};
Car.prototype.accelerate = function(fuel){
   this.velocity += fuel * this.power;
};

var myCar = new Car("Smart");
myCar.accelerate(10);
```

Object-oriented Programming

`new` keyword

- Invoking `new Foo(arg1, arg2)` will perform the following:
    - Create a new object by shallow-copying `Foo.prototype`; we will refer to this new object as `newFoo` in this slide
        - Since this is a “shallow copy”, functions and objects bound to `newFoo`’s properties will all point to the corresponding objects on `Foo.prototype`. (e.g., `myCar.accelerate === Car.prototype.accelerate`)
    - Invoke the `Foo` function in the context of the newly created object `newFoo` (i.e., `Foo.bind(newFoo)(arg1, arg2)`); we thus refer to the `Foo` function as “a constructor”

Object-oriented Programming

Object-oriented

```
class Car {
  constructor (name, power=1){
    this.name = name;
    this.power = power;
    this.velocity = 0;
  }
  accelerate (fuel){
    this.velocity
      += fuel * this.power;
  }
}
var myCar = new Car("Smart");
myCar.accelerate(10);

```

Prototypal

Object-oriented Programming

Object-oriented

```
class Car {
  constructor (name, power=1){
    this.name = name;
    this.power = power;
    this.velocity = 0;
  }
  accelerate (fuel){
    this.velocity
      += fuel * this.power;
  }
}
var myCar = new Car("Smart");
myCar.accelerate(10);
```

Prototypal

```
function Car (name, power=1){
  this.name = name;
  this.power = power;
  this.velocity = 0;
};
Car.prototype.accelerate
  = function(fuel){
      this.velocity
        += fuel * this.power;
  };

var myCar = new Car("Smart");
myCar.accelerate(10);
```

Object-oriented Programming

`class` and `constructor` keyword

```
class Car {
  constructor (name, power=1){
    this.name = name;
    this.power = power;
    this.velocity = 0;
  }
  accelerate (fuel){
    this.velocity
      += fuel * this.power;
  }
}

var myCar = new Car("Smart");
myCar.accelerate(10);
```

Class Activity: Defining a Class

lectures/lecture-6/activity1.js

- Define a class named “Thing” and implement the following:
  - The constructor accepts a single argument `id`, and initializes 2 instance properties `id` and `live`. The property `id` is set to the argument `id` and `live` is set to `false`
  - `printStatus` method, printing in the format “{id} [on|off]” using `console.log`
  - `powerOn` method, setting `live` property to `true`
  - `powerOff` method, setting `live` property to `false`

```
class Thing {
    // To implement
}

var thing = new Thing("thing-0");
thing.printStatus();     // prints: thing-0 (off)
thing.powerOn();
thing.printStatus();     // prints: thing-0 (on)
```

Object-oriented Programming

`extends` and `super` keyword

```
class RacingCar extends Car {
  constructor (name){
    super(name, 3.5);
  }

  turbo (fuel){
    this.velocity += fuel * this.power * 1.5;
  }

}
```

Object-oriented Programming

`extends` and `super` keyword

```
class RacingCar extends Car {
  constructor (name){
    super(name, 3.5);
  }

  turbo (fuel){
    this.velocity += fuel * this.power * 1.5;
  }

}

var superCar = new RacingCar("F1");
superCar.accelerate(10);
superCar.turbo(5);
```

Class Activity: Inheritance

lectures/lecture-6/activity2.js

- Implement the classes `Sensor` and `Actuator`, which inherits from the `Thing` class from the previous activity
  - `Sensor` and `Actuator` should, in addition to calling the superclass constructor, initialize a property `value` to `null`
  - `Sensor` should have its own method `readValue`. If `live` is `true`, it should set the `value` property to a random value and return it. Else, it should return `null`
  - `Actuator` should have its own method `writeValue`, taking in a single argument `val`. If `live` is `true`, it should set the `value` property to `val`. Else, it should do nothing
  - Override the `printStatus` method as below:
    - For `Sensor`s, it should print in the format “{id} [on|off] -> {value}”
    - For `Actuator`s, it should print in the format “{id} [on|off] <- {value}”

Functional Programming

1. What is ES6?
2. Object-oriented Programming
3. **Functional Programming**

Functional Programming

- JavaScript supports functional programming
- When used appropriately, `function`s can implement pure functions
  - Except it is not actually a pure function
  - Keywords like `this`, `arguments` make JavaScript functions impure
- ES6 introduces **arrow functions** to support real functional programming

Functional Programming

- Arrow functions are **not replacements** for ES5 functions
- Arrow functions are **anonymous functions**
- `this` and `arguments` inside arrow functions are lexically bound

Functional Programming

- Arrow functions are **not replacements** for ES5 functions
- Arrow functions are **anonymous functions**
- `this` and `arguments` inside arrow functions are lexically bound

Syntax Example:

```
(radius, height) => {
   return radius * radius * Math.PI * height;
}

(radius, height) => (radius * radius * Math.PI * height);
```

Functional Programming

- Pure functions
  - Always returns the same value given the same arguments
  - Have no side effects like mutating an external object (e.g., I/O, network resource, variables outside of its scope)
  - Examples:
    - area of circle, distance between 2 points in 3-dimensional space
- Impure functions
  - Might depend on an external context
  - Might change an external object
  - Examples:
    - `Date.now()`
    - `console.log()`

Functional Programming

Arrow function syntax

```
// Regular function
function(arg1, arg2){
   // do some stuff here
   return arg1 + arg2;
}

// Imperative usage
(arg1, arg2) => {
   // do some stuff here
   return arg1 + arg2;
}

// Pure function
(arg1, arg2) => (arg1 + arg2);
```

Functional Programming

Regular ES5 Function

```javascript
var f = function (g, x, y){
  var gx = g(x);
  var gy = g(y);
  var result = gx + gy;
  return result;
}
```

ES6 Arrow Function

```javascript
var f = (g, x, y)=> {
  var gx = g(x);
  var gy = g(y);
  var result = gx + gy;
  return result;
};
```

Functional Programming

Regular ES5 Function

```
var f = function (g, x, y){
  return g(x) + g(y);
}
```

ES6 Arrow Function

```
var f = (g, x, y)=>(g(x)+g(y));
```

Functional Programming

Regular ES5 Function

```
var u = function(f){
  return function(x){
    return f(x, u(f));
  }
}
```

ES6 Arrow Function

```
var u = f=> x=> f(x, u(f));
```

Functional Programming

Regular ES5 Function

```
var Y = function(f){
  return (function(x){
        return x(x);
    })(function(y){
        return f(function(x){
            return y(y)(x);
          });
    });
}
```

ES6 Arrow Function

```
var Y = f=>
(x=> x(x))(y=> f(x=> y(y)(x)));
```

Class Activity: Rewriting Code with Arrow Functions

lectures/lecture-6/activity3.js

```
var fib = function(n){
   if (n > 1) return fib(n-1) + fib(n-2);
   else return 1;
}
```

Class Activity: Rewriting Code with Arrow Functions

Solution

lectures/lecture-6/activity3.js

```
var fib = function(n){
   if (n > 1) return fib(n-1) + fib(n-2);
   else return 1;
}

var fib = n=> (n > 1 ? fib(n-1) + fib(n-2) : 1);
```

Class Activity: Rewriting Code with Arrow Functions

lectures/lecture-6/activity3.js

```
var fib = function(n){
   if (n > 1) return fib(n-1) + fib(n-2);
   else return 1;
}

var fib = n=> (n > 1 ? fib(n-1) + fib(n-2) : 1);

var factorial ?
```

Class Activity: Rewriting Code with Arrow Functions

lectures/lecture-6/activity3.js

```
var fib = function(n){
   if (n > 1) return fib(n-1) + fib(n-2);
   else return 1;
}

var fib = n=> (n > 1 ? fib(n-1) + fib(n-2) : 1);

var factorial = n=> (n > 1 ? n * factorial(n-1) : 1);
```

Functional Programming

- Arrow Function usage scenario

```
class Timer {
  constructor (){
    this.seconds = 0;
    this.reference = null;
  }
  start (){
    this.reference = setInterval(function(){
      this.seconds += 0;
    }, 1000);
  }
  stop (){
    clearInterval(this.reference);
  }
}
```

Functional Programming

- Arrow Function usage scenario

```
class Timer {
  constructor (){
    this.seconds = 0;
    this.reference = null;
  }
  start (){
    var self = this;
    this.reference = setInterval(function(){
      self.seconds += 0;
    }, 1000);
  }
  stop (){
    clearInterval(this.reference);
  }
}
```

Functional Programming

- Arrow Function usage scenario

```
class Timer {
  constructor (){
    this.seconds = 0;
    this.reference = null;
  }
  start (){
    this.reference = setInterval(()=> {
      this.seconds += 0;
    }, 1000);
  }
  stop (){
    clearInterval(this.reference);
  }
}
```

Class Activity: Rewriting Code with Arrow Functions

Find the problem in the following code and fix it lectures/lecture-6/activity4.js

```javascript
class User {
  constructor (username){
    this.id = username;
  }

  readAllSensors (things){
    var mine = things.filter(function(thing){
      return (thing.owner === this.id && thing instanceof Sensor);
    });
    // ... more code
  }
}
```

Class Activity: Rewriting Code with Arrow Functions

Solution

```
class User {
  constructor (username){
    this.id = username;
  }

  readAllSensors (things){
    var mine = things.filter(thing =>
             (thing.owner === this.id && thing instanceof Sensor));
    // ... more code
  }
}
```