30th November 2019

Native prototypes

The "prototype" property is widely used by the core of JavaScript itself. All built-in constructor functions use it.

First we'll see at the details, and then how to use it for adding new capabilities to built-in objects.

Object.prototype

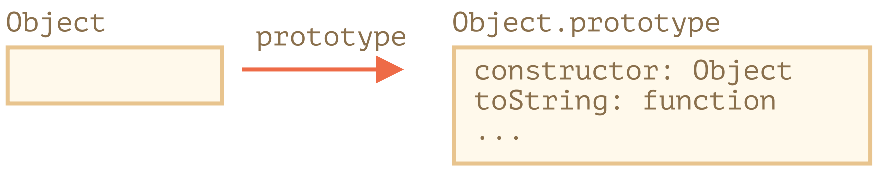
Let's say we output an empty object:

```
let obj = {};
alert( obj ); // "[object Object]" ?
```

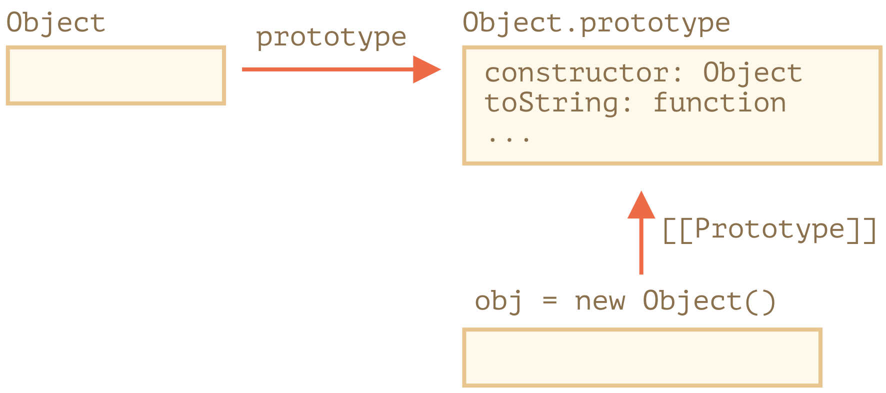
Where's the code that generates the string "[object Object]" ? That's a built-in toString method, but where is it? The obj is empty!

…But the short notation obj = {} is the same as obj = new Object() , where Object is a built-in object constructor function, with its own prototype referencing a huge object with toString and other methods.

Here's what's going on:



When new Object() is called (or a literal object {...} is created), the [[Prototype]] of it is set to Object.prototype according to the rule that we discussed in the previous chapter:



So then when `obj.toString()` is called the method is taken from `Object.prototype`.

We can check it like this:

```
let obj = {};

alert(obj.__proto__ === Object.prototype); // true
// obj.toString === obj.__proto__.toString == Object.prototype.toString
```

Please note that there is no more `[[Prototype]]` in the chain above `Object.prototype`:

```
alert(Object.prototype.__proto__); // null
```

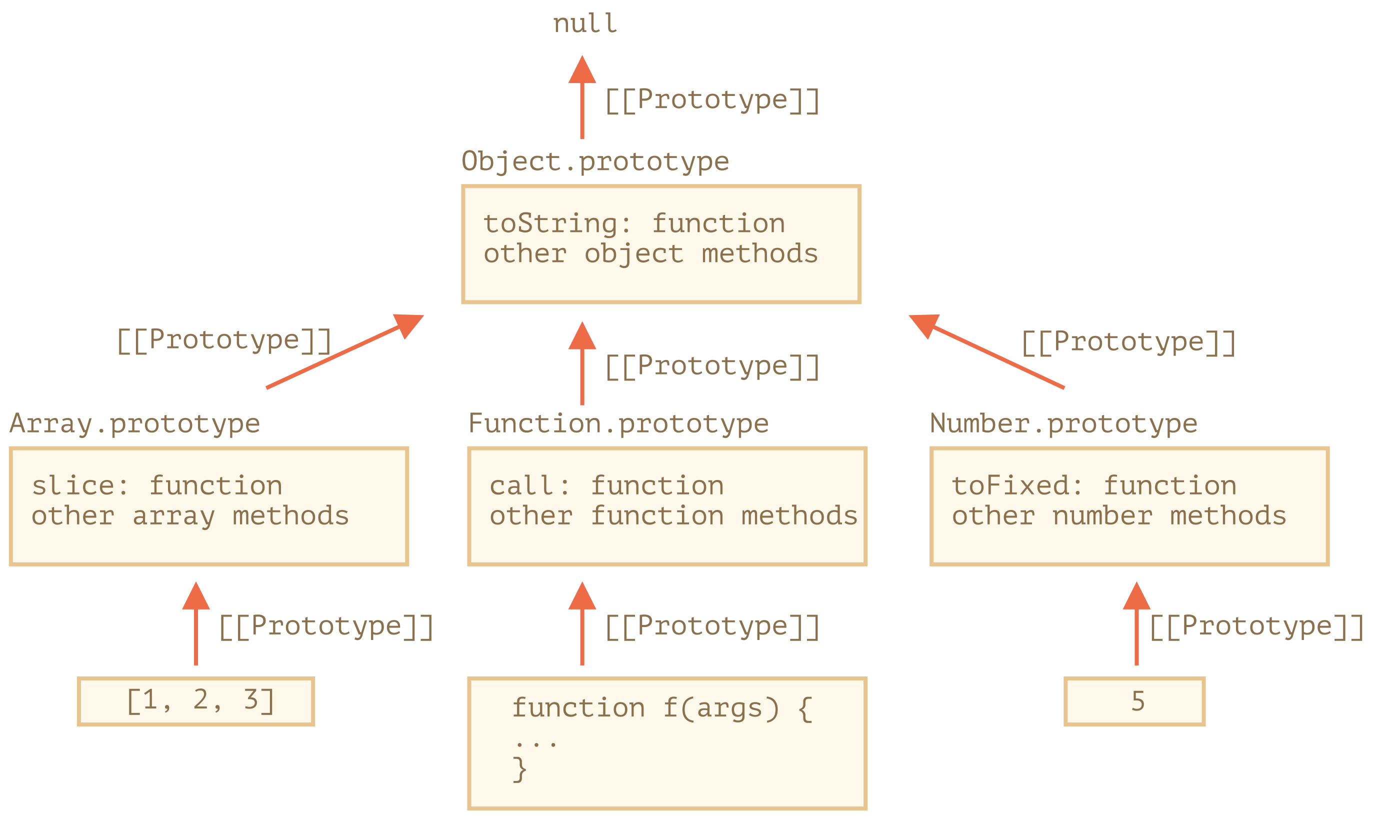
Other built-in prototypes

Other built-in objects such as `Array`, `Date`, `Function` and others also keep methods in prototypes.

For instance, when we create an array `[1, 2, 3]`, the default `new Array()` constructor is used internally. So `Array.prototype` becomes its prototype and provides methods. That's very memory-efficient.

By specification, all of the built-in prototypes have `Object.prototype` on the top. That's why some people say that "everything inherits from objects".

Here's the overall picture (for 3 built-ins to fit):



Let's check the prototypes manually:

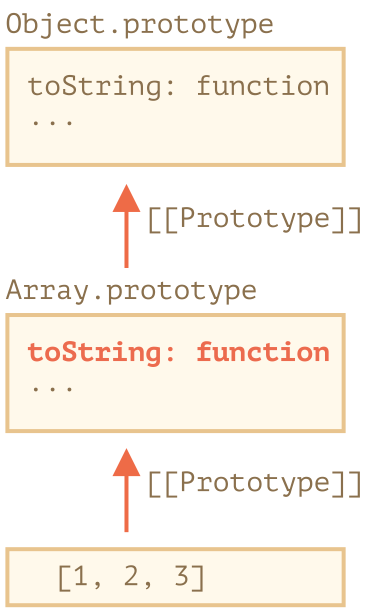
```
let arr = [1, 2, 3];

```

```
// it inherits from Array.prototype?
alert( arr.__proto__ === Array.prototype ); // true

// then from Object.prototype?
alert( arr.__proto__.__proto__ === Object.prototype ); // true

// and null on the top.
alert( arr.__proto__.__proto__.__proto__ ); // null
```

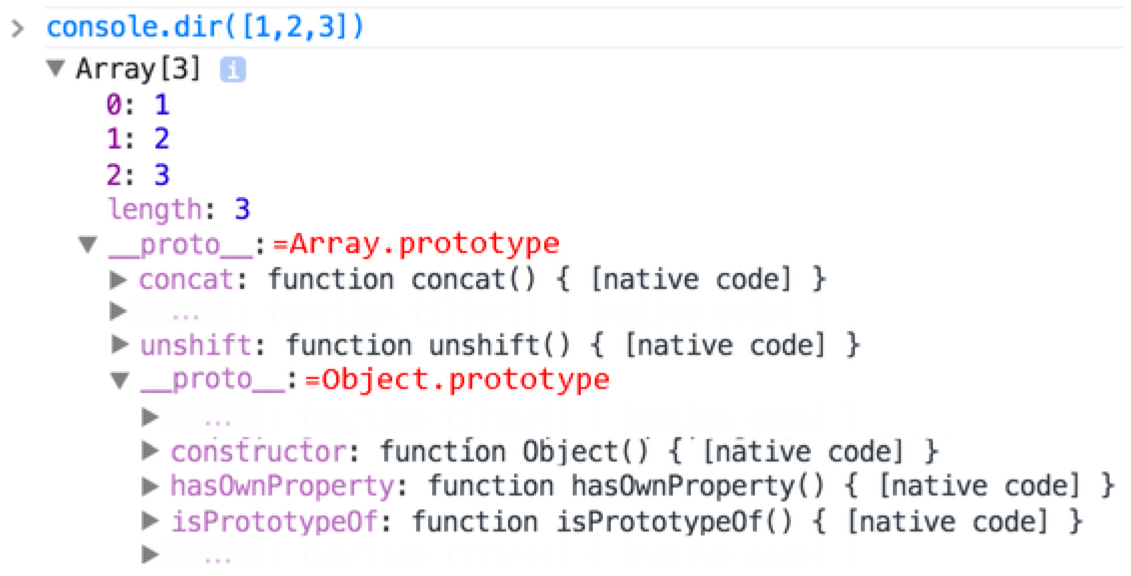
Some methods in prototypes may overlap, for instance, `Array.prototype` has its own `toString` that lists comma-delimited elements:

```
let arr = [1, 2, 3]
alert(arr); // 1,2,3 <-- the result of Array.prototype.toString
```

As we've seen before, `Object.prototype` has `toString` as well, but `Array.prototype` is closer in the chain, so the array variant is used.



In-browser tools like Chrome developer console also show inheritance (`console.dir` may need to be used for built-in objects):



```
> console.dir([1,2,3])
  ▼ Array[3]
      0: 1
      1: 2
      2: 3
      length: 3
    ▼ __proto__: =Array.prototype
      ▶ concat: function concat() { [native code] }
      ▶   ...
      ▶ unshift: function unshift() { [native code] }
      ▼ __proto__: =Object.prototype
        ▶   ...
        ▶ constructor: function Object() { [native code] }
        ▶ hasOwnProperty: function hasOwnProperty() { [native code] }
        ▶ isPrototypeOf: function isPrototypeOf() { [native code] }
        ▶   ...
```

Other built-in objects also work the same way. Even functions – they are objects of a built-in `Function` constructor, and their methods (`call` / `apply` and others) are taken from `Function.prototype` . Functions have their own `toString` too.

```
function f() {}

alert(f.__proto__ == Function.prototype); // true
alert(f.__proto__.__proto__ == Object.prototype); // true, inherit from objec
```

Primitives

The most intricate thing happens with strings, numbers and booleans.

As we remember, they are not objects. But if we try to access their properties, temporary wrapper objects are created using built-in constructors `String` , `Number` and `Boolean` . They provide the methods and disappear.

These objects are created invisibly to us and most engines optimize them out, but the specification describes it exactly this way. Methods of these objects also reside in prototypes, available as `String.prototype` , `Number.prototype` and `Boolean.prototype` .

Values `null` and `undefined` have no object wrappers

Special values `null` and `undefined` stand apart. They have no object wrappers, so methods and properties are not available for them. And there are no corresponding prototypes either.

Changing native prototypes

Native prototypes can be modified. For instance, if we add a method to `String.prototype` , it becomes available to all strings:

```
String.prototype.show = function() {
  alert(this);
};

"BOOM!".show(); // BOOM!
```

During the process of development, we may have ideas for new built-in methods we'd like to have, and we may be tempted to add them to native prototypes. But that is generally a bad idea.

Important:

Prototypes are global, so it's easy to get a conflict. If two libraries add a method `String.prototype.show` , then one of them will be overwriting the method of the other.

So, generally, modifying a native prototype is considered a bad idea.

In modern programming, there is only one case where modifying native prototypes is approved. That's polyfilling.

Polyfilling is a term for making a substitute for a method that exists in the JavaScript specification, but is not yet supported by a particular JavaScript engine.

We may then implement it manually and populate the built-in prototype with it.

For instance:

```
if (!String.prototype.repeat) { // if there's no such method
  // add it to the prototype

  String.prototype.repeat = function(n) {
    // repeat the string n times

    // actually, the code should be a little bit more complex than that
    // (the full algorithm is in the specification)
    // but even an imperfect polyfill is often considered good enough
    return new Array(n + 1).join(this);
  };
}

alert( "La".repeat(3) ); // LaLaLa
```

Borrowing from prototypes

In the chapter Decorators and forwarding, call/apply we talked about method borrowing.

That's when we take a method from one object and copy it into another.

Some methods of native prototypes are often borrowed.

For instance, if we're making an array-like object, we may want to copy some `Array` methods to it.

E.g.

```
let obj = {
  0: "Hello",
  1: "world!",
  length: 2,
};

obj.join = Array.prototype.join;

alert( obj.join(',') ); // Hello,world!
```

It works because the internal algorithm of the built-in `join` method only cares about the correct indexes and the `length` property. It doesn't check if the object is indeed an array. Many built-in methods are like that.

Another possibility is to inherit by setting `obj.__proto__` to `Array.prototype`, so all `Array` methods are automatically available in `obj`.

But that's impossible if `obj` already inherits from another object. Remember, we only can inherit from one object at a time.

Borrowing methods is flexible, it allows to mix functionalities from different objects if needed.

Summary

- All built-in objects follow the same pattern:
  - The methods are stored in the prototype (`Array.prototype` , `Object.prototype` , `Date.prototype` , etc.)
  - The object itself stores only the data (array items, object properties, the date)
- Primitives also store methods in prototypes of wrapper objects: `Number.prototype` , `String.prototype` and `Boolean.prototype` . Only `undefined` and `null` do not have wrapper objects
- Built-in prototypes can be modified or populated with new methods. But it's not recommended to change them. The only allowable case is probably when we add-in a new standard, but it's not yet supported by the JavaScript engine

✓ Tasks

Add method "f.defer(ms)" to functions

importance: 5

Add to the prototype of all functions the method `defer(ms)` , that runs the function after `ms` milliseconds.

After you do it, such code should work:

```
function f() {
  alert("Hello!");
}

f.defer(1000); // shows "Hello!" after 1 second
```

solution

Add the decorating "defer()" to functions

importance: 4

Add to the prototype of all functions the method `defer(ms)` , that returns a wrapper, delaying the call by `ms` milliseconds.

Here's an example of how it should work:

```
function f(a, b) {
  alert( a + b );
}

f.defer(1000)(1, 2); // shows 3 after 1 second
```

Please note that the arguments should be passed to the original function.

solution

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