Web Programming Step by Step

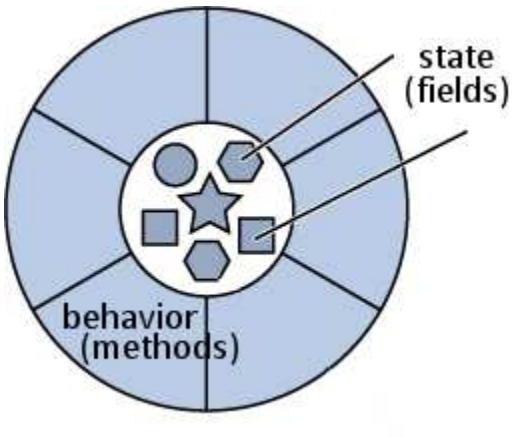
Lecture 27
Object-Oriented JavaScript

Lecture Outline

- Motivation for objects
- Creating custom objects
- Object prototypes and "classes"
- Pseudo-inheritance using prototypes
- The Prototype framework's features for classes and inheritance

Why use classes and objects?

- small programs are easily written without objects
- JavaScript treats functions as *first-class citizens*
- larger programs become cluttered with disorganized functions
- objects group *related data and behavior*
  - helps manage size and complexity, promotes code reuse
- You have already *used* many types of JavaScript objects
  - Strings, arrays, HTML / XML DOM nodes
  - Prototype `Ajax.Request`, Scriptaculous `Effect` / `Sortable` / `Draggable`



Creating a new anonymous object

```
var name = {
  fieldName: value,
  ...
  fieldName: value
};
```
JS

```
var pt = {
  x: 4,
  y: 3
};
alert(pt.x + ", " + pt.y);
```
JS

- in JavaScript, you can create a new object without creating a class
- the above is like a `Point` object; it has fields named `x` and `y`
- the object does not belong to any class; it is the only one of its kind
  - `typeof(pt) === "object"`

You've already done this...

```
new Ajax.Request("http://example.com/app.php",
  {
    method: "get",             // an object with a field named method (String)
    onSuccess: ajaxSuccess     // and a method named onSuccess
  }
);

$("my_element".fade(
  {
    duration: 2.0,             // an object with 3 fields named:
    from: 1.0,                 // duration, from, and to (Number)
    to: 0.5
  }
);
```
JS

- the parameters in { } passed to Prototype/Scriptaculous were actually anonymous objects

Objects that have behavior (functions/methods)

```
var name = {
  ...
  methodName: function(parameters) {
    statements;
  }
};
```
JS

```
var pt = {
  x: 4,  y: 3,
  distanceFromOrigin: function() {
    return Math.sqrt(this.x * this.x + this.y * this.y);
  }
};

alert(pt.distanceFromOrigin());   // 5
```
JS

- like in Java, objects' methods run "inside" that object
  - inside an object's method, the object refers to itself as `this`
  - unlike in Java, the `this` keyword is mandatory in JS

A poor attempt at a "constructor"

What if we want to create an entire new class, not just one object?

- JavaScript, unlike Java, *does NOT have classes*
- we could emulate the functionality of a constructor with a function:

```
// Creates and returns a new Point object. (This is bad code.)
function constructPoint(xValue, yValue) {
  var pt = {
    x: xValue,  y: yValue,
    distanceFromOrigin: function() {
      return Math.sqrt(this.x * this.x + this.y * this.y;
    }
  };
  return pt;
}
```
JS

```
var p = constructPoint(4, -3);
```
JS

- the above code is ugly and doesn't match the `new` syntax we're used to

Constructor functions

```
// Constructs and returns a new Point object.
function Point(xValue, yValue) {
  this.x = xValue;
  this.y = yValue;
  this.distanceFromOrigin = function() {
    return Math.sqrt(this.x * this.x + this.y * this.y);
  };
}
```
JS

```
var p = new Point(4, -3);
```
JS

- a constructor is just a normal function
- when any function called with `new`, JavaScript does the following:
  - creates a new empty anonymous object and uses it as `this` within the function
  - implicitly returns the new object at the end of the function
- what happens if our "constructor" is called as a normal function, without `new`?

```
var p = Point(4, -3);
```

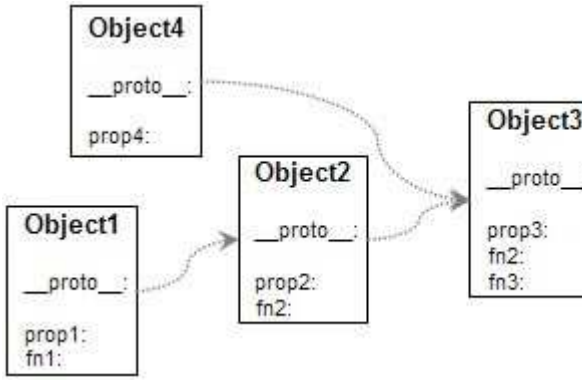
Problems with our constructor

```
// Constructs and returns a new Point object.
function Point(xValue, yValue) {
  this.x = xValue;
  this.y = yValue;
  this.distanceFromOrigin = function() {
    return Math.sqrt(this.x * this.x + this.y * this.y);
  };
}
```
JS

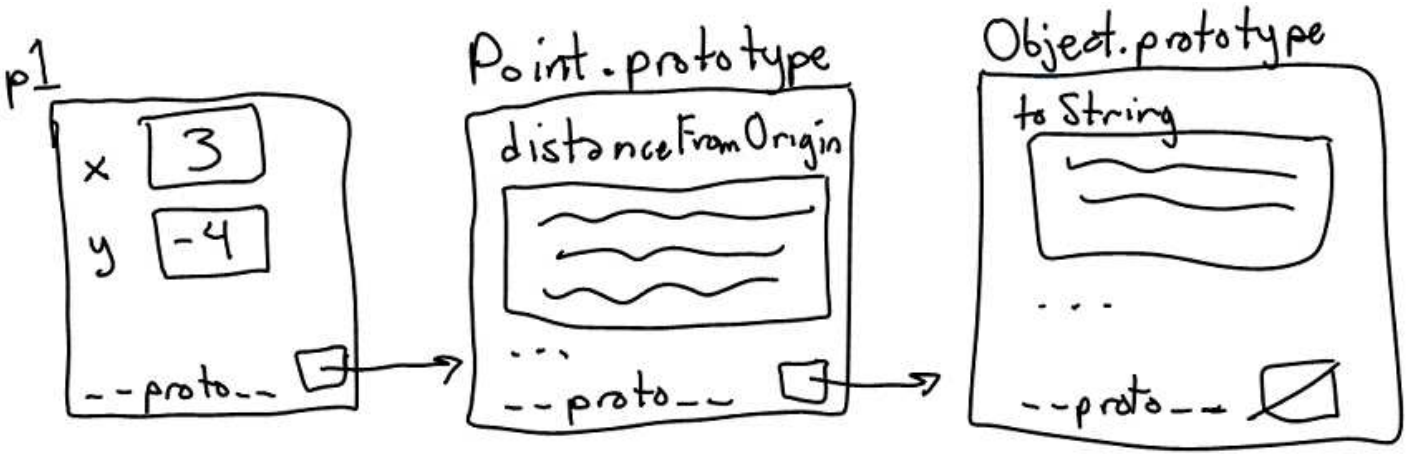
- ugly syntax; every method must be declared inside the constructor
- (subtle) replicates the methods in every object (wasteful)
  - every `Point` object has its own entire copy of the `distanceFromOrigin` code

A paradigm shift: prototypes

- **prototype**: an ancestor of a JavaScript object
  - like a "super-object" instead of a superclass
  - a parent at the object level rather than at the class level
  - not to be confused with Prototype framework
- every object contains a reference to its prototype
  - the default is `Object.prototype`
  - strings use `String.prototype`, etc.
  - a prototype can have a prototype, and so on
- an object "inherits" all methods/data from its prototype(s)
  - it doesn't have to make a copy of them, which saves memory
- prototypes allow JavaScript to mimic classes and inheritance



An object's prototype chain



- when you try to look up a property or method in an object, JavaScript:
  1. Sees if the object itself contains that property/method.
  2. If not, recursively checks the object's prototype to see if it has the property/method.
  3. Continues up the "prototype chain" until it finds the property/method or gives up with `undefined`.

Constructors and prototypes

```
// also causes Point.prototype to become defined
function Point(xValue, yValue) {
  ...
}
```
JS

- every constructor also has an associated prototype object
  - example: when we define our `Point` constructor, that creates a `Point.prototype`
  - initially this object has nothing in it
- every object you construct will use the constructor's prototype object as its prototype
  - example: every constructed `Point` object will use `Point.prototype`
- *(revised)* when any function called with `new`, JavaScript does the following:
  - creates a new empty anonymous object
  - **attaches the function's prototype object to the new object as its prototype**
  - runs the constructor's code, using the new object as `this`
  - implicitly returns the new object at the end of the function

Modifying a prototype

```
// adding a method to the prototype
className.prototype.methodName = function(parameters) {
  statements;
}
```
JS

```
Point.prototype.distanceFromOrigin = function() {
  return Math.sqrt(this.x * this.x + this.y * this.y);
};
```
JS

- adding a method/field to a prototype will give it to all objects using that prototype
  - better than manually adding each method to each object (copying the method N times)
- we generally put only methods and constant data (not fields!) in a prototype object
  - what would happen if we put the `x` and `y` fields in `Point.prototype`?
- *Exercise*: Add `distance` and `toString` methods.

`Point` prototype methods

```
// Computes the distance between this point and the given point p.
Point.prototype.distance = function(p) {
  var dx = this.x - p.x;
  var dy = this.y - p.y;
  return Math.sqrt(dx * dx + dy * dy);
};

// Returns a text representation of this object, such as "(3, -4)".
Point.prototype.toString = function() {
  return "(" + this.x + ", " + this.y + ")";
};
```
JS

- our `Point` code could be saved into a file `Point.js`
- the `toString` method works similarly as in Java

Modifying built-in prototypes

```
// add a 'contains' method to all String objects
String.prototype.contains = function(text) {
  return this.indexOf(text) >= 0;
};

// add a 'lightUp' method to all HTML DOM element objects
HTMLElement.prototype.lightUp = function() {
  this.style.backgroundColor = "yellow";
  this.style.fontWeight = "bold";
};
```
JS

- ANY prototype can be modified, including those of existing types
  - Prototype and other libraries do this
  - not quite the same as adding something to a single object
- *Exercise*: Add a `reverse` method to strings.
- *Exercise*: Add a `shuffle` method to arrays.

Pseudo-inheritance with prototypes

```
function SuperClassName(parameters) {    // "superclass" constructor
  ...
};
```
JS

```
function SubClassName(parameters) {      // "subclass" constructor
  ...
};
```
JS

```
SubClassName.prototype = new SuperClassName(parameters);    // connect them
```
JS

- to make a "subclass", tell its constructor to use a "superclass" object as its prototype
- why not just write it this way?

```
SubClassName.prototype = SuperClassName.prototype;    // connect them
```
JS

Pseudo-inheritance example

```
// Constructor for Point3D "class"
function Point3D(x, y, z) {
  this.x = x;
  this.y = y;
  this.z = z;
};

Point3D.prototype = new Point(0, 0);   // set as "subclass" of Point

// override distanceFromOrigin method
Point3D.prototype.distanceFromOrigin = function() {
  return Math.sqrt(this.x * this.x + this.y * this.y + this.z * this.z);
};
```
JS

- mostly works fine, but there no equivalent of the `super` keyword
- no built-in way to call an overridden method
- no easy way to call the superclass's constructor

Classes and prototypes

- limitations of prototype-based code:
  - unfamiliar / confusing to many programmers
  - somewhat unpleasant syntax
  - difficult to get inheritance-like semantics (subclassing, overriding methods)

- Prototype library's `Class.create` method makes a new class of objects
  - essentially the same as using prototypes, but uses a more familiar style and allows for richer inheritance semantics

Creating a class

```
className = Class.create({
  // constructor
  initialize : function(parameters) {
    this.fieldName = value;
    ...
  },

  methodName : function(parameters) {
    statements;
  },
  ...
});
```
JS

- constructor is written as a special `initialize` function

`Class.create` example

```
Point = Class.create({
  // Constructs a new Point object at the given initial coordinates.
  initialize: function(initialX, initialY) {
    this.x = initialX;
    this.y = initialY;
  },

  // Computes the distance between this Point and the given Point p.
  distance: function(p) {
    var dx = this.x - p.x;
    var dy = this.y - p.y;
    return Math.sqrt(dx * dx + dy * dy);
  },

  // Returns a text representation of this Point object.
  toString: function() {
    return "(" + this.x + ", " + this.y + ")";
  }
});
```
JS

Inheritance

```
className = Class.create(superclass, {
  ...
});
```
JS

```
// Points that use "Manhattan" (non-diagonal) distances.
ManhattanPoint = Class.create(Point, {
  // Computes the Manhattan distance between this Point and p.
  // Overrides the distance method from Point.
  distance: function(p) {
    var dx = Math.abs(this.x - p.x);
    var dy = Math.abs(this.y - p.y);
    return dx + dy;
  },

  // Computes this point's Manhattan Distance from the origin.
  distanceFromOrigin: function() {
    return this.x + this.y;
  }
});
```
JS

Referring to superclass: `$super`

```
name: function($super, parameters) {
  statements;
}
```
JS

```
ManhattanPoint3D = Class.create(ManhattanPoint, {
  initialize: function($super, initialX, initialY, initialZ) {
    $super(initialX, initialY);   // call Point constructor
    this.z = initialZ;
  },

  // Returns 3D "Manhattan Distance" from p.
  distance: function($super, p) {
    var dz = Math.abs(this.z - p.z);
    return $super(p) + dz;
  },
});
```
JS

- can refer to superclass's overridden method as `$super` in code