Software Construction and User Interfaces (SE/ComS 319)

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JAVASCRIPT SPOTLIGHTS

How to add js to html file

// how to include in html file

<**script**> your javascript code goes in here </script>

// can also include from a separate file

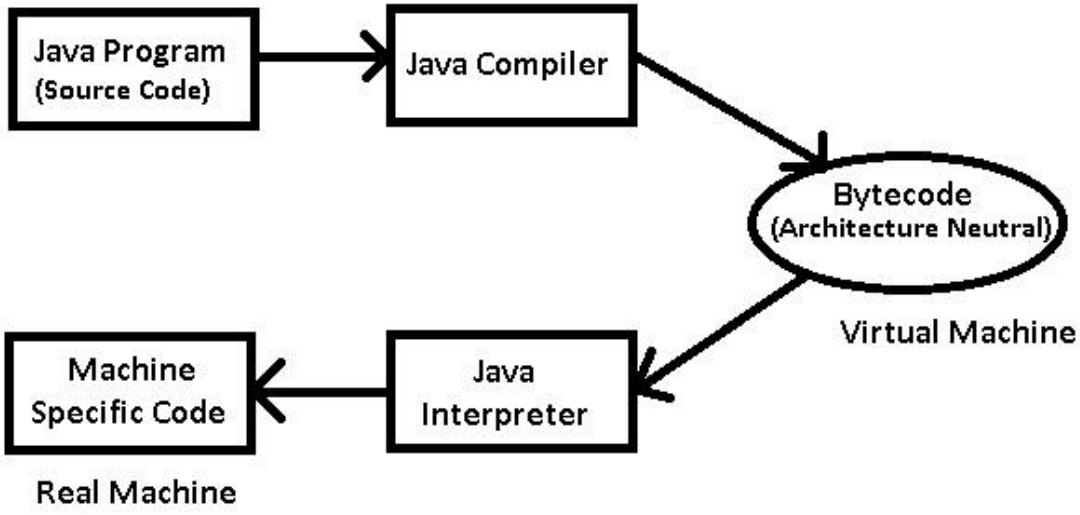
<script src="./01_example.js"></script>

// can include from a remote site

<script src="http://…./a.js"></script>

JavaScript – Interpreter

- JavaScript is **interpreted** at runtime by the client browser
  - Similar to Java Virtual Machine (JVM) that interprets **byte code**
- Java compiler
  - Provides abstract machine that is programmed in Java
  - Is based on another abstract machine, i.e. the Java VM
  - Machine commands, bytecode are hidden
  - The masking is checked by the compiler
- **Interpreter vs. compiler?**



Interpreter vs. Compiler

- **Interpreter:** (example: **JavaScript**, Python, Ruby).
  - Translates program one statement at a time ➔ less amount of time to analyze the source code but the overall execution time is slower.
  - No intermediate object code is generated ➔ memory efficient.
  - Continues translating the program until the first error is met, in which case it stops ➔ debugging is easy.
- **Compiler:** (example: C/C++)
  - Scans the entire program and translates it into machine code ➔ large amount of time to analyze the source code but the overall execution time is comparatively faster.
  - Generates intermediate object code and requires linking ➔ more memory
  - Error message after scanning the whole program ➔ Debugging hard

JavaScript syntax

The JavaScript syntax is similar to C# and Java

- Operators (+, *, =, !=, &&, ++, …)
- Variables (**typeless**) ➔ JavaScript is typeless
- Conditional statements (if, else)
- Loops (for, while)
- Arrays (my_array[])
- Associative arrays (my_array['abc'])
- Functions

Data types

JavaScript data types:

- Numbers (integer, floating-point)
- Boolean (true / false)

String type – string of characters

```
var myName = "You can use both single or double
quotes for strings";
```

Arrays

```
var my_array = [1, 5.3, "aaa"];
```

Associative arrays (hash tables)

```
var my_hash = {a:2, b:3, c:"text"};
```

Data types (2)

- Every variable can be considered as object
  - Arrays are objects
- Objects use **names** to access its "members"
- Example
  - **person.firstName** returns John:

```
var person = {firstName:"John", lastName:"Doe", age:46};
```

String operations

The + operator joins strings

```
string1 = "fat ";
string2 = "cats";
alert(string1 + string2);  // fat cats
```

What is "9" + 9?

```
alert("9" + 9);  // 99
```

Converting string to number:

```
alert(parseInt("9") + 9);  // 18
```

Arrays operations and properties

Declaring new empty array:

```
var arr = new Array();
```

Declaring an array holding few elements:

```
var arr = [1, 2, 3, 4, 5];
```

Appending an element / getting the last element:

```
arr.push(3);
var element = arr.pop();
```

Reading the number of elements (array length):

```
arr.length;
```

Everything is object!

Every variable can be considered as object

- For example strings and arrays have member functions:

```
var test = "some string";
alert(test.charAt(5)); // shows letter 's'
alert("test".charAt(1)); //shows letter 'e'
alert("test".substring(1,3)); //shows 'es'
```

```
var arr = [1,3,4];
alert (arr.length); // shows 3
arr.push(7); // appends 7 to end of array
alert (arr[3]); // shows 7
```

Sum of numbers – Example

sum-of-numbers.html

```
<html>

<head>
  <title>JavaScript Demo</title>
  <script type="text/javascript">
    function calcSum() {
      value1 =
        parseInt(document.mainForm.textBox1.value);
      value2 =
        parseInt(document.mainForm.textBox2.value);
      sum = value1 + value2;
      document.mainForm.textBoxSum.value = sum;
    }
  </script>
</head>
```

Switch statement

The `switch` statement works like in C# / Java:

```
switch (variable) {
  case 1:
    // do something
    break;
  case 'a':
    // do something else
    break;
  case 3.14:
    // another code
    break;
  default:
    // something completely different
}
```

Loops

Like in C# / Java / C++

- for loop
- while loop
- do … while loop

```
var counter;
for (counter=0; counter<4; counter++) {
  alert(counter);
}
while (counter < 5) {
  alert(++counter);
}
```

Functions

```
function average(a, b, c)
{
    var total;
    total = a+b+c;
    return total/3;
}
```

Parameters come in here.

Declaring variables is optional. Type is never declared.

Value returned here.

Function arguments and return value

- Functions are not required to return a value
- When calling function it is not obligatory to specify all of its arguments
  - The function has access to all the arguments passed via arguments array

```
function sum() {
  var sum = 0;
  for (var i = 0; i < arguments.length; i ++)
    sum += parseInt(arguments[i]);
  return sum;
}
alert(sum(1, 2, 4));
```

Standard popup boxes

- Alert box with text and [OK] button
  - Just a message shown in a dialog box:

```
alert("Some text here");
```

- Confirmation box
  - Contains text, [OK] button and [Cancel] button:

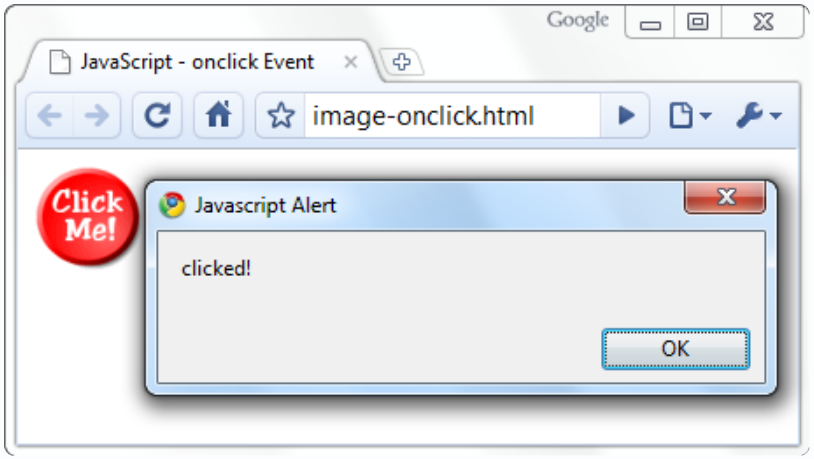
```
confirm("Are you sure?");
```

- Prompt box
  - Contains text, input field with default value:

```
prompt ("enter amount", 10);
```

Calling a JavaScript function from Event Handler – Example

```
<html>
<head>
<script type="text/javascript">
  function test (message) {
    alert(message);
  }
</script>
</head>

<body>
  <img src="logo.gif"
    onclick="test('clicked!')" />
</body>
</html>
```



While loops

```
while( expression )
   statement;
```

Executes a statement until expression becomes false

Evaluates expression before first iteration

```
do
   statement;
while( expression );
```

Evaluates expression after first iteration

Executes statement at least once

While loops – “while” vs “do… while”

While-loop example

Print the numbers 0 to 99 to the screen

```
int i = 0;
while( i < 100 )
{
  alert(i);
  i++;
}
```

For loops (1)

General format:

```
for( expr1; expr2; expr3 )
   statement;
```

`expr1` is executed at the beginning of the loop

`expr2` is executed at the beginning of every iteration

- If it is false, the loop ends

`expr3` is executed at the end of every iteration

For loops (2)

General format:

```
for( expr1; expr2; expr3 )
   statement;
```

It is possible to omit any of the expressions

- The semicolon must stay

If `expr2` is omitted, the condition is always true

- it becomes an infinite loop

```
for( ;; ) //infinite loop
```

For loops (3)

Usual use case:

```
int i;
for( i=0; i < 100; i++ )
  alert(i);
```

Break statement

```
break;
```

Terminates the innermost loop or switch statement

Execution resumes after the loop or switch statement

```
while( 1 )
{
  n++;
  if ( n > 5 ) break;
}
```

Continue statement

```
continue;
```

Terminates the current iteration of the innermost loop

Execution resumes at the beginning of the next iteration

```
for (i=0; i<100; i++)
{
  if ( i == 57 ) continue;
  alert( i );
}
```

Print the numbers 0 to 99, but not 57

Accessing DOM

- GET the DOM element by ID or CLASS attributes

document.getElementById("xyz")

document.getElementByClassName("abc")

someDOMelement.value // this is value of the element

Accessing DOM – Example

```
<html>
<body>
<h2>JavaScript Arrays</h2>

<p>JavaScript array elements are accessed using
numeric indexes (starting from 0).</p>

<p id="demo"></p>

<script>
var cars = ["Saab", "Volvo", "BMW"];
document.getElementById("demo").innerHTML =
cars[0];
</script> </body> </html>
```

How to print

```
document.write()          // write to DOM
document.write("test")

console.log()             // write to console

alert()                   // popup

<p id="xyz" class="abc"> </p>
document.getElementById("xyz").innerHTML= "hi"
```

Demonstration

- Demonstration
  - JavaScript example in Browser
- Good resource for JavaScript:
  - https://www.w3schools.com/

JAVASCRIPT MEMORY MANAGEMENT

Memory management in JavaScript

- Memory life cycle
  - Allocate the memory you need
  - Use the allocated memory (read, write)
  - Release the allocated memory when it is not needed anymore

- **Automatic garbage collection in JavaScript**
  - Opposite to low-level memory management primitives like malloc() and free() (e.g. in C/C++ language)

Static memory allocation vs. dynamic memory allocation

- Static (28 bytes):

```
int n; // 4 bytes
int x[4]; // array of 4 elements, each 4 bytes
double m; // 8 bytes
```

- Dynamic (runtime):

```
int n = readInput(); // reads input from the user
...
// create an array with "n" elements
```

Static allocation	Dynamic allocation
• Size must be known at compile time • Performed at compile time • Assigned to the stack • FILO (first-in, last-out)	• Size may be unknown at compile time • Performed at run time • Assigned to the heap • No particular order of assignment

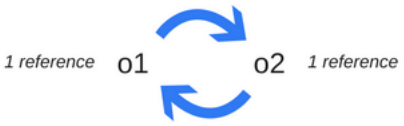
Reference-counting garbage collection (1)

- Reference-counting garbage collection algorithm
  - An object has no other objects referencing it
  - It is considered garbage collectible if there are zero references pointing at this object.
- Problem
  - **Memory leak:**
    - Memory that is not needed by an application anymore that for some reason is not returned to OS or the pool of free memory.

Reference-counting garbage collection (2)

- **Limitation** of Reference-counting garbage collection
  - Cycles (causing memory leak)
  - Example:

```
function f()
{
        var o1 = {};
        var o2 = {};
        o1.a = o2; // o1 references o2
        o2.a = o1; // o2 references o1
        return 'azerty';
}

f();
```



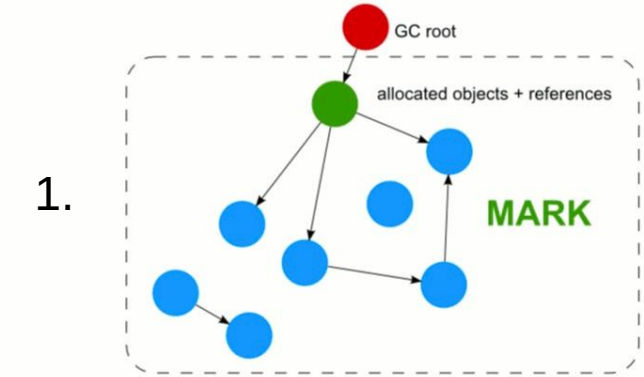
  - Internet Explorer 6 and 7 are known to have reference-counting garbage collectors

Mark-and-sweep algorithm (1)

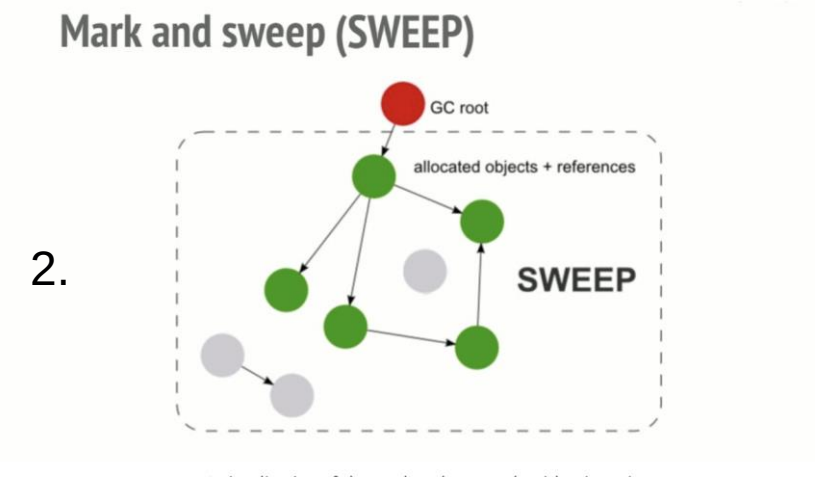
- Mark-and-sweep algorithm
  - an object is unreachable ➔ Garbage
  - knowledge of a set of objects called roots
    - (In JavaScript, the root is the global object).
  - Periodically, the garbage-collector will start from these roots
    - Finds all objects that are referenced from these roots
    - The garbage collector will find all reachable objects and collect all non-reachable objects.
- This algorithm is **better** than Reference-counting garbage collection
  - Cycles are not a problem
  - In our example, after the function call returns, the 2 objects are not referenced anymore (not reachable from the global object)

Mark-and-sweep algorithm (2)

1.

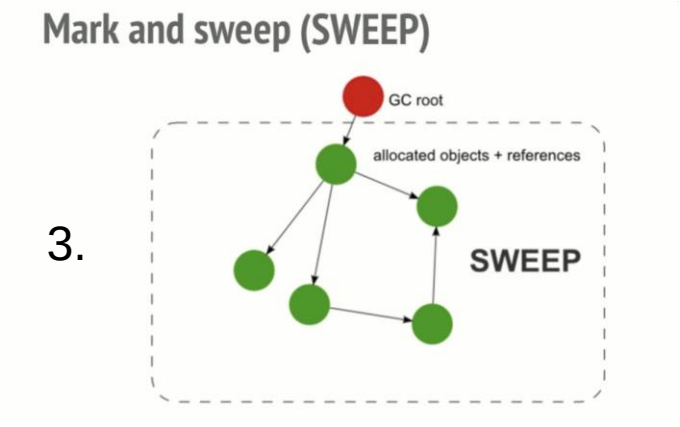


2.



- All modern browsers ship a mark-and-sweep garbage-collector

3.



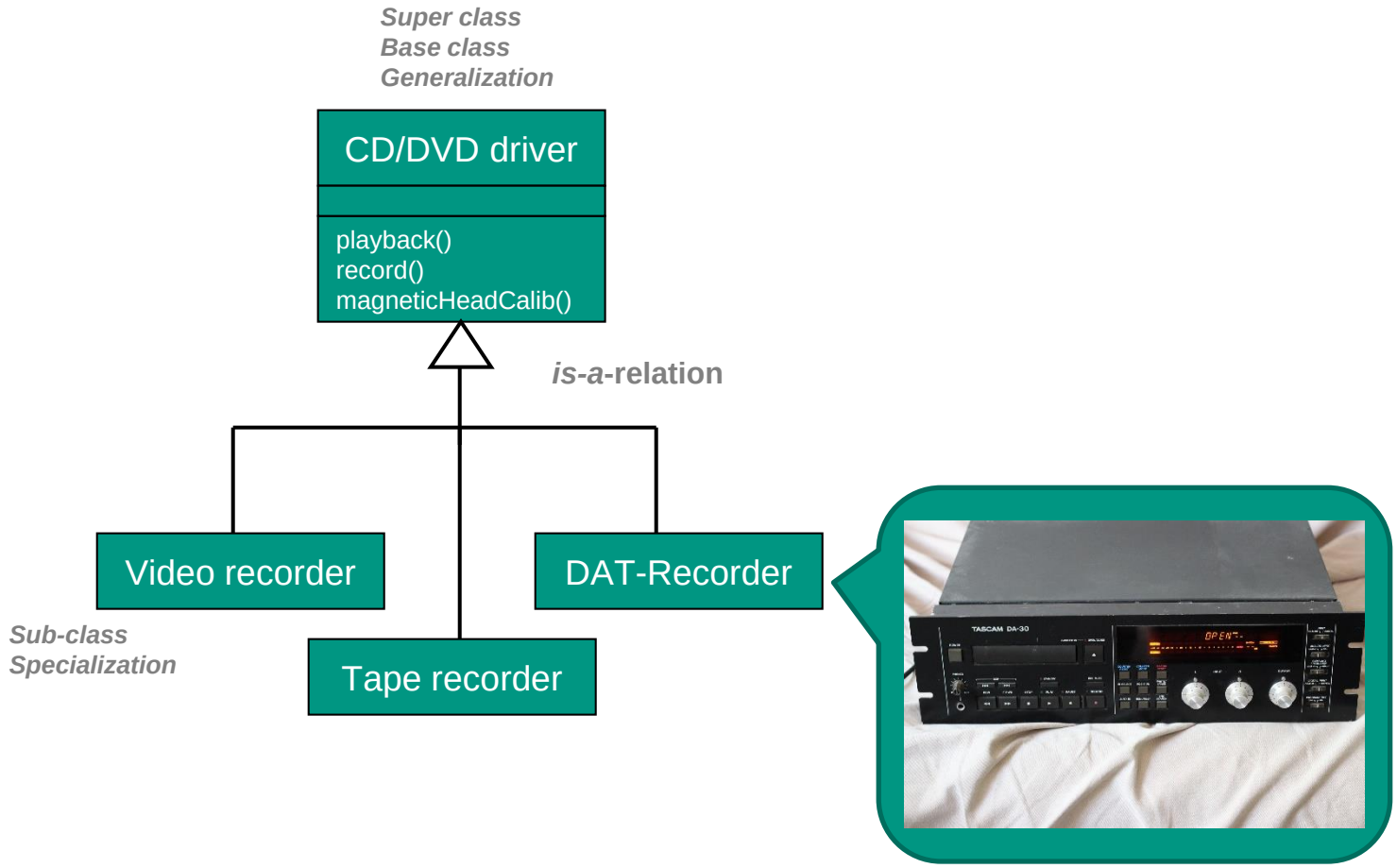
Source: https://blog.sessionstack.com/

Garbage collection…

- Managed code (e.g. Java code) benefits from automatic garbage collection
  - Comfortable for programmers!
- But with overhead!
  - Compared to C/C++ with manual garbage collection by programmer – no automatic garbage collection!

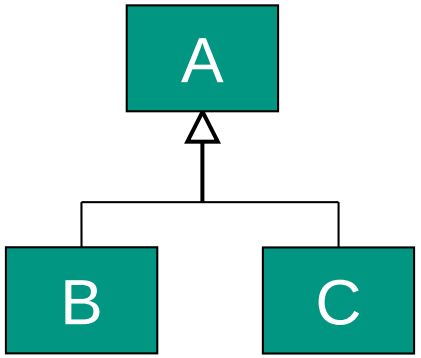
JAVASCRIPT PROTOTYPE-BASED INHERITANCE

Inheritance



Inheritance

- Let A and B be classes, and ΩA and ΩB the set of objects that make up classes A and B.
  - Then B is a subclass / specialization of A (or A is a superclass / generalization of B) if: ΩB ⊆ ΩA.
- It is also said that B inherits from A.
- Since each instance of B is also an instance of A, the relationship between A and B is called the "**is-a**" relationship.
- If A has several subclasses, these subclasses should usually be disjoint.



Prototype-based inheritance (1)

- Javascript is different from traditional object-oriented languages in that it uses prototype inheritance.
- In a nutshell, prototype inheritance in Javascript works like this:

1. An object has a number of properties. This includes any attributes or functions (methods).
2. An object has a special parent property, this is also called the prototype of the object (__proto__). An object inherits all the properties of its parent.

Prototype-based inheritance (2)

3. An object can override a property of its parent by setting the property on itself.
4. A constructor creates objects. Each constructor has an associated prototype object, which is simply another object.
5. When an object is created, it's parent is set to the prototype object associated with the constructor that created it.
6. The prototype objects are used to implement *inheritance* with the mechanism of *dynamic dispatch (delegation)*.

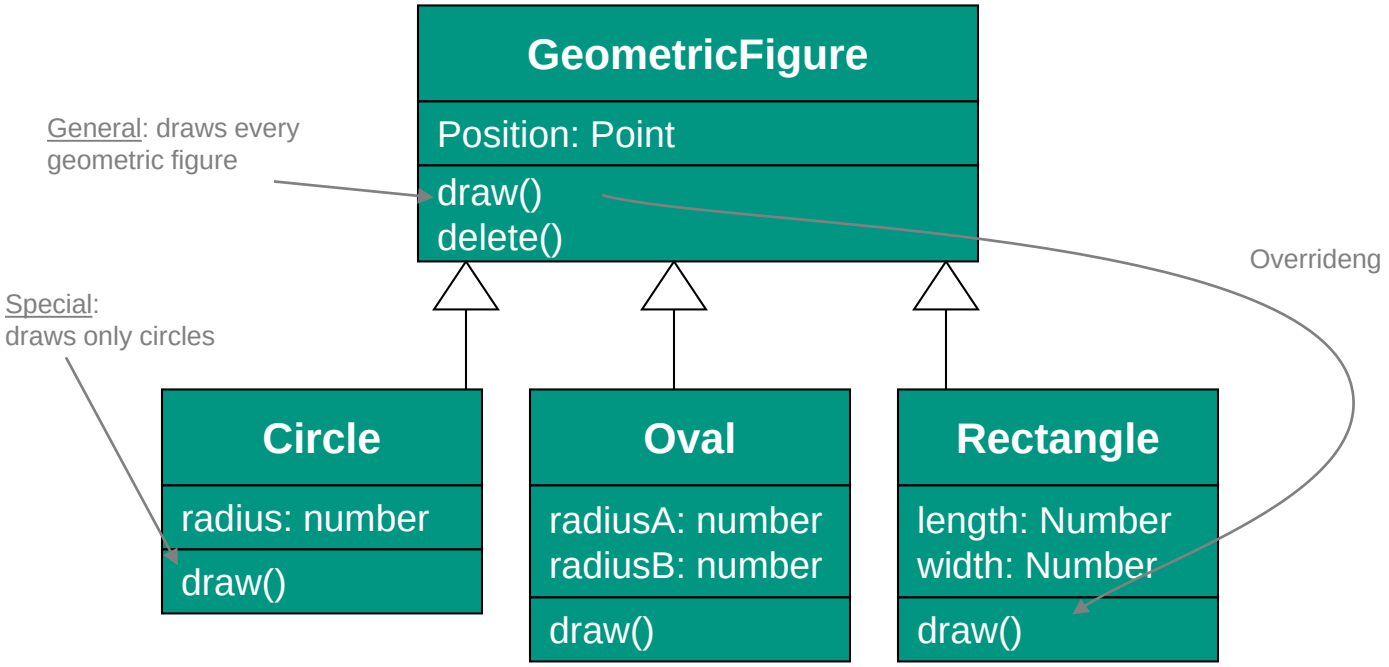
Static vs. dynamic dispatch

- Static dispatch: references are resolved at compile time
- Dynamic dispatch: resolves the references at runtime.
- Static dispatch in Java:
  - A class may have multiple methods with the same name but different parameter types
  - Method calls are dispatched to the method with the right number of parameters that has the most specific types that the actual parameters could match.
- Dynamic (virtual method) dispatch in Java:
  - A subclass can override a method declared in a superclass. So at run-time, the JVM has to dispatch the method call to the version of the method that is appropriate to the run-time type of this.

Overloading – Example

```
public class Sum {

    // Overloaded sum(). This sum takes two int parameters
    public int sum(int x, int y)
    { … }

    // Overloaded sum(). This sum takes three int parameters
    public int sum(int x, int y, int z)
    { … }

    // Overloaded sum(). This sum takes two double parameters
    public double sum(double x, double y)
    { … }


}
```

Overriding – Example

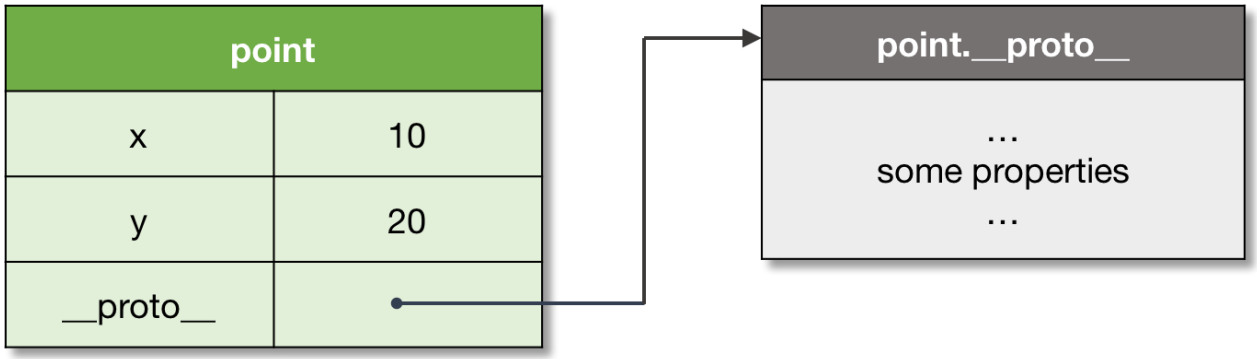


- Each of the three specializations must implement their own drawing method

Prototype inheritance (3)

- Object: An object is a collection of properties, and has a single prototype object.
- A prototype of an object is referenced by the internal [[Prototype]] property, which to user-level code is exposed via the __proto__ property.

```
1var point = {
2  x: 10,
3  y: 20,
4};
```



Source: http://dmitrysoshnikov.com/ecmascript/javascript-the-core-2nd-edition/

- By default objects receive Object.prototype as their inheritance object.

Prototype chain

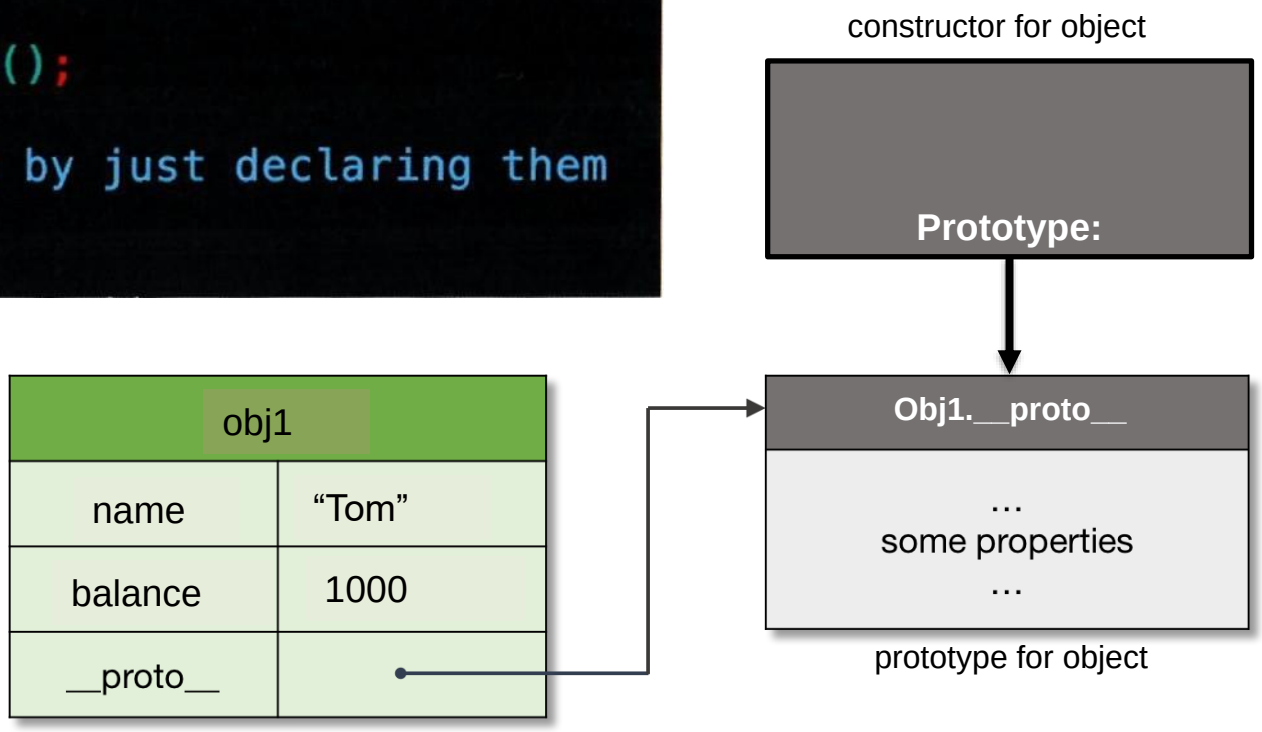
- Any object can be used as a prototype of another object
- If a property is not found in the object itself, there is an attempt to *resolve* it in the prototype; in the prototype of the prototype, etc.
- The prototype can be set *explicitly* via either the __proto__ property, or Object.create method

➔ *Dynamic dispatch* or *delegation!*

```
1// Base object.
2let point = {
3  x: 10,
4  y: 20,
5};
6
7// Inherit from `point` object.
8let point3D = {
9  z: 30,
10  __proto__: point,
11};
12
13console.log(
14  point3D.x, // 10, inherited
15  point3D.y, // 20, inherited
16  point3D.z  // 30, own
17);
```

Prototype inheritance – Example (1)

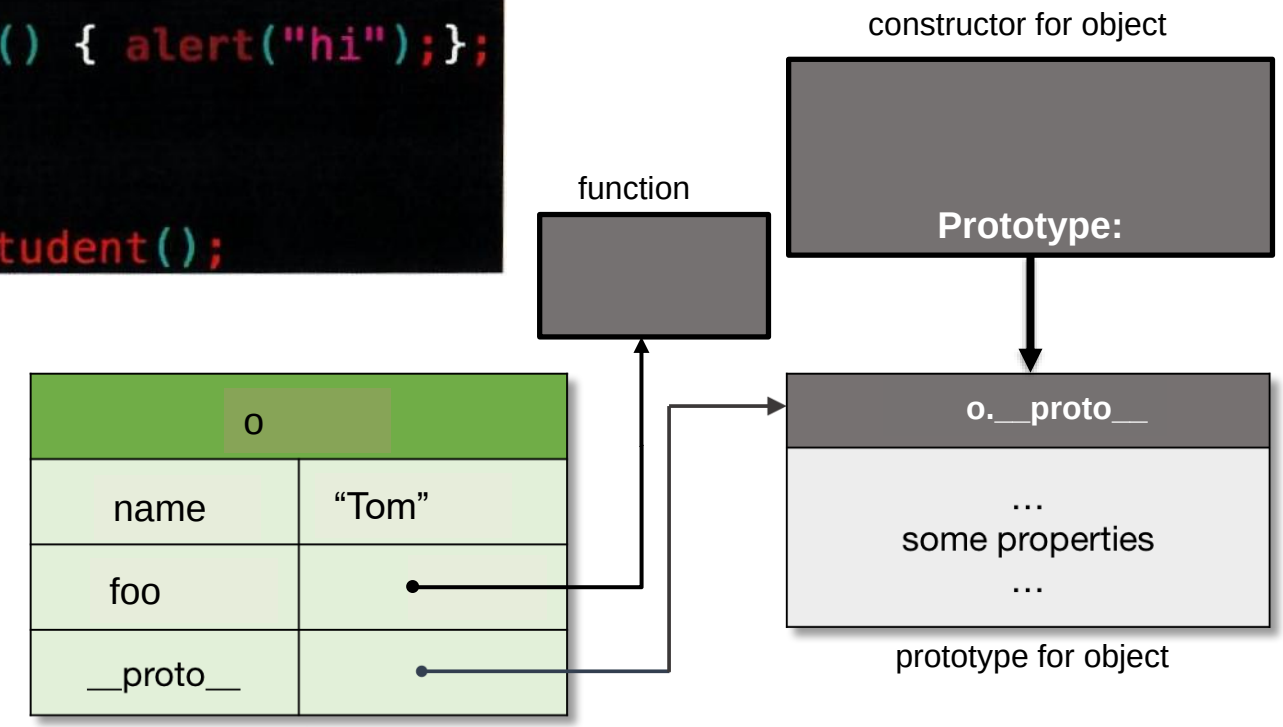
```
// way one
var obj1 = new Object();

// can add attributes by just declaring them
obj1.name = "Tom";
obj1.balance = 1000;
```



- Every object, when is created, receives its *prototype*.
- If the prototype is not set *explicitly*, objects receive *default prototype* as their *inheritance object*.

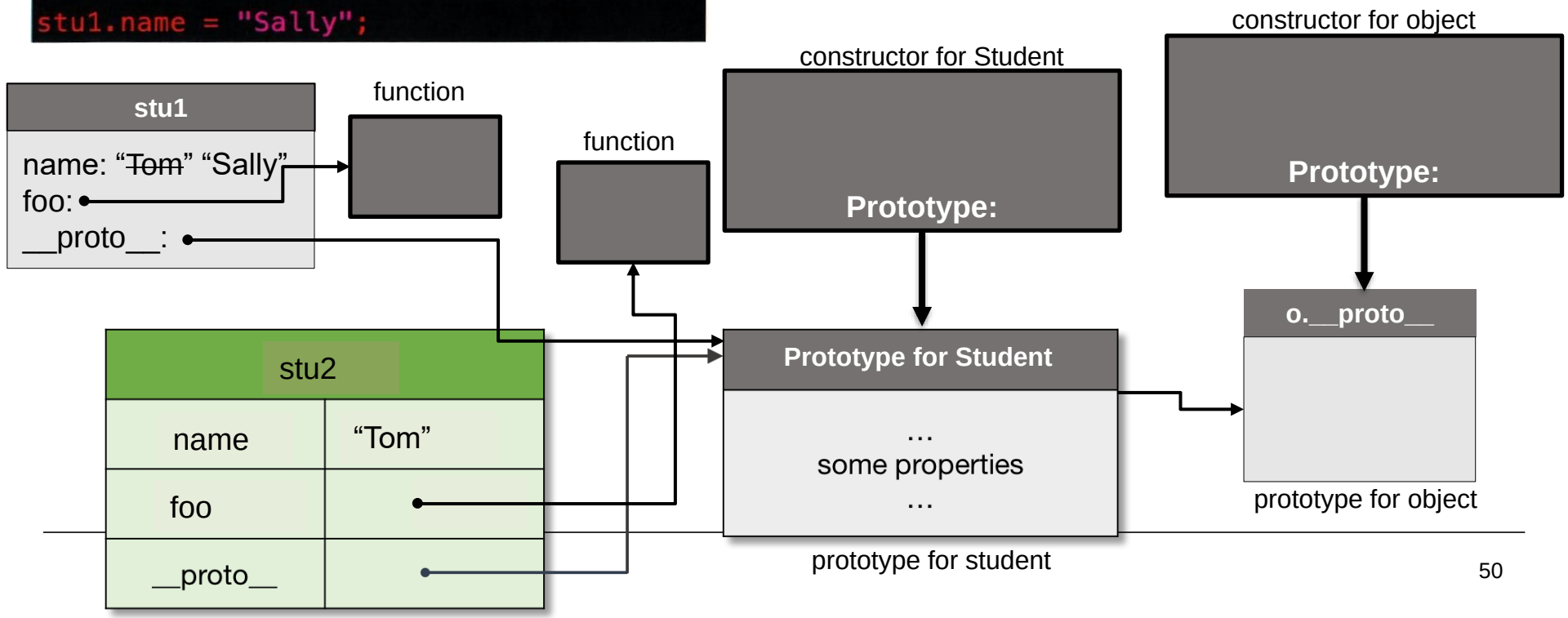
Prototype inheritance – Example (2)

```
// -----------------
// Factory pattern
// -----------------
function createStudent() {
  var o = new Object();
  o.name = "Tom";
  o.foo = function() { alert("hi");};
  return o;
}

var obj3 = createStudent();
```



Prototype inheritance – Example (3)

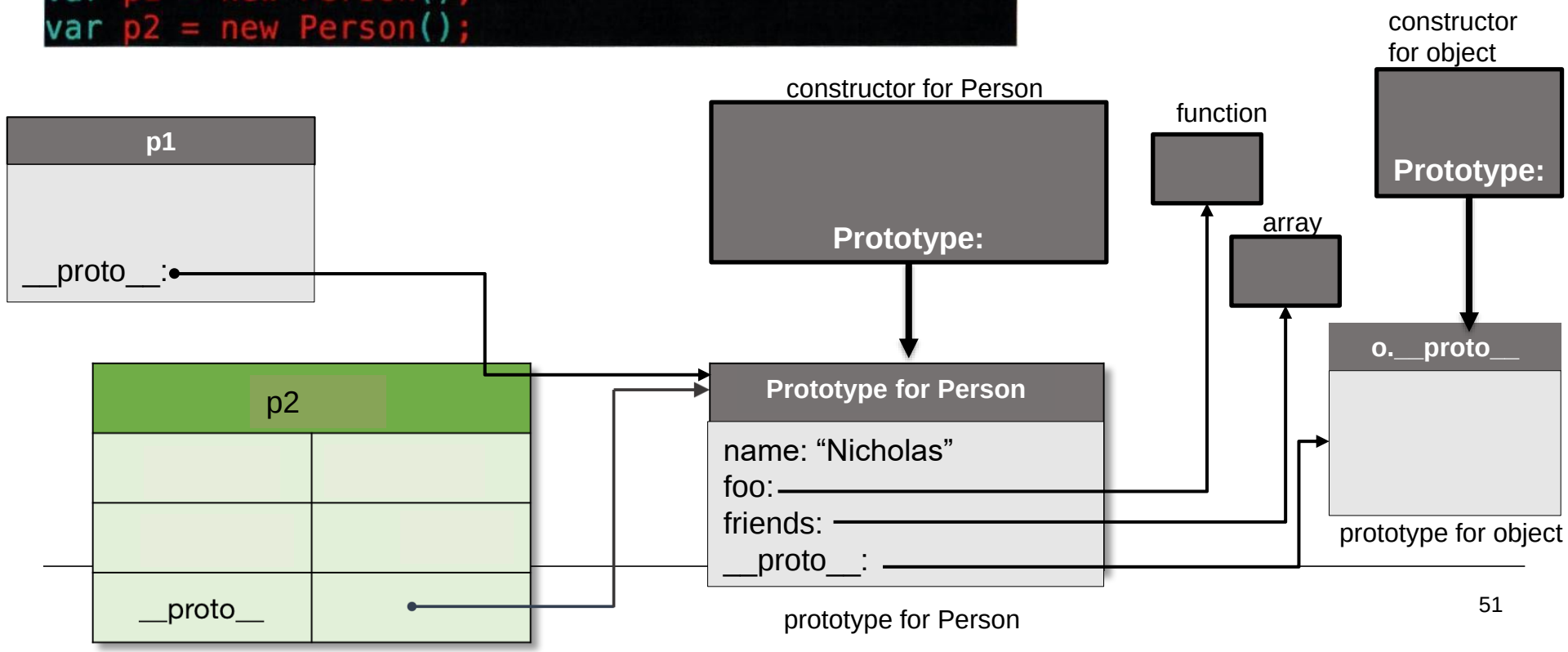
```
// -----------------
// Constructor pattern
// -----------------

function Student () { // called a constr
  this.name = "Tom";
  this.foo = function() {alert("hi"); };
};

var stu1 = new Student(); // create a ne
var stu2 = new Student();

stu1.name = "Sally";
```



Prototype inheritance – Example (4)

```
// ----------------
// Prototype pattern
// ----------------
function Person() {};
Person.prototype.name = "Nicholas";
Person.prototype.foo = function() {alert("hi");};
Person.prototype.friends = ["Tom","Sally"];

var p1 = new Person();
var p2 = new Person();
```

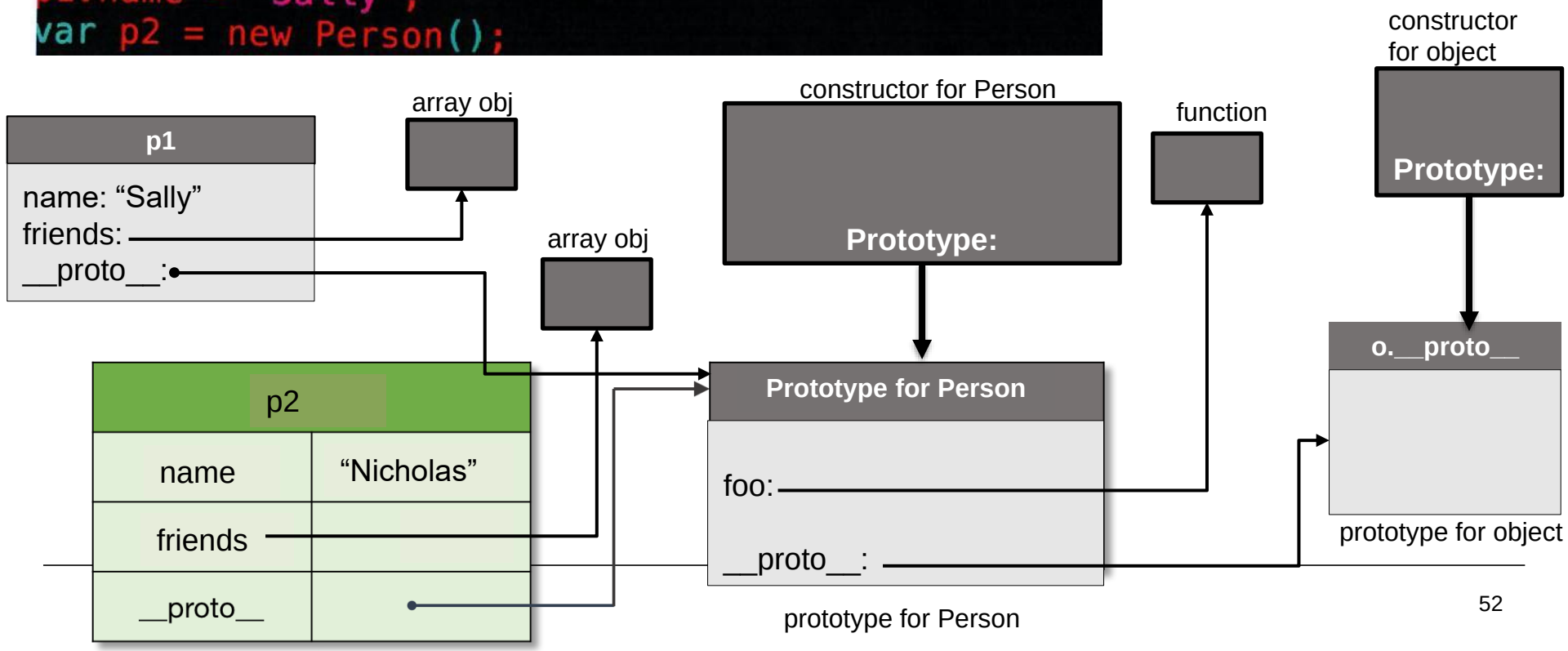
prototype property allows you to add new properties/methods to object constructors (to all existing objects of a given type)



Prototype inheritance – Example (5)

```
function Person() {
  this.name = "Nicholas";
  this.friends = ["Sam","Molly"];
}
Person.prototype.foo = function() {alert("hi");};
var p1 = new Person();
p1.name = "Sally";
var p2 = new Person();
```

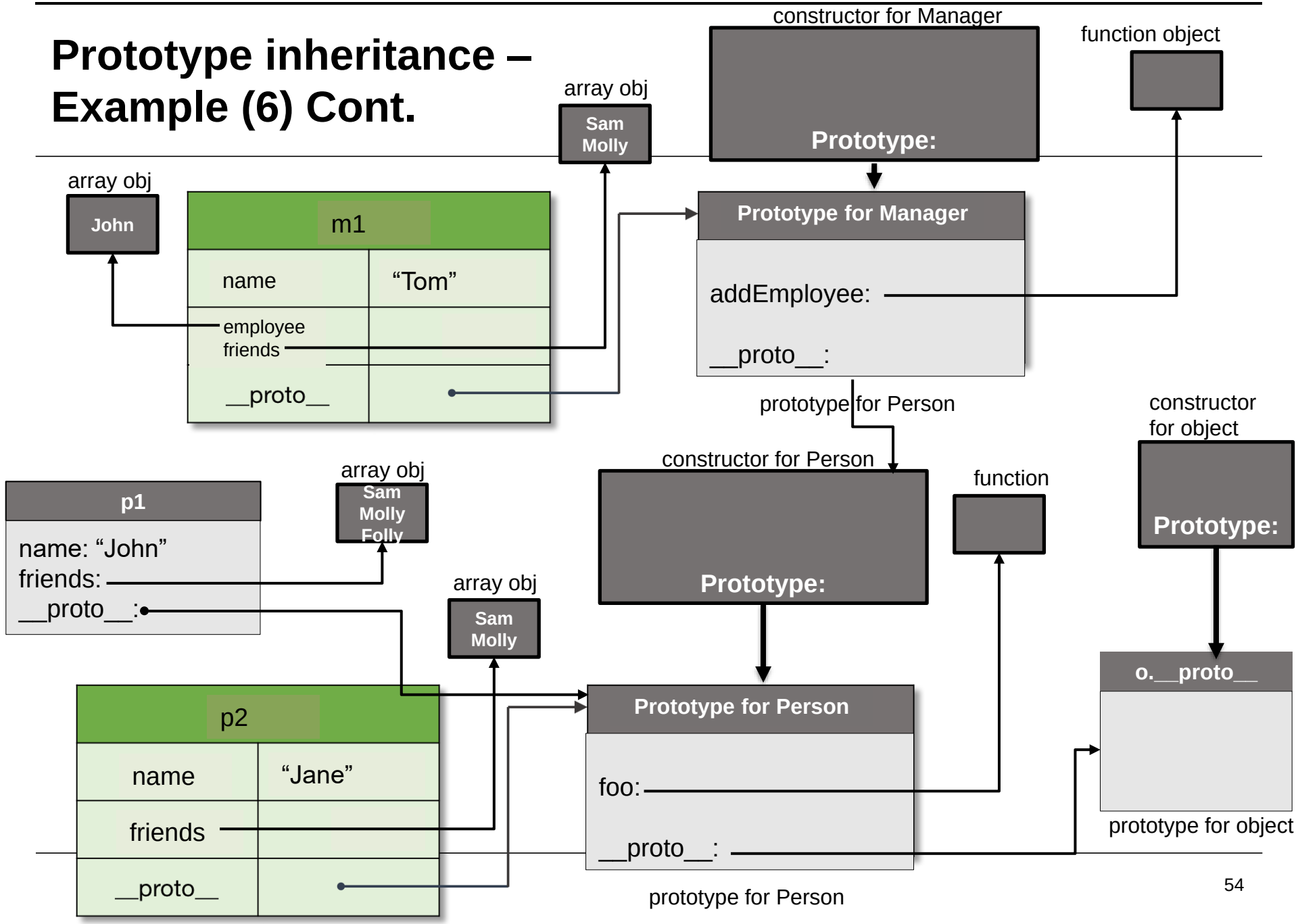
Only modify your **own** prototypes. Never modify the prototypes of standard JavaScript objects!



Prototype inheritance – Example (6)

```
class Person {
  constructor(s) {
    this._name = s;
    this._friends = ["Sam", "Molly"];
  }

  foo() {
    console.log("hi " + this._name);
    console.log(this._friends);
  }

}

let p1 = new Person("John");
let p2 = new Person("Jane");

p1._friends.push("Folly");

class Manager extends Person {

  constructor(s) {
    super(s);
    this._employee = [];
  }

  addEmployee(s) {
    this._employee.push(s);
  }


}

p1.foo();
p2.foo();

m1 = new Manager("Tom");
m1.addEmployee("John");
```

Prototype inheritance – Example (6) Cont.



Literature – JavaScript

- https://www.w3schools.com/
- JavaScript. The Core: 1st and 2nd Edition
  - http://dmitrysoshnikov.com/ecmascript/javascript-the-core-2nd-edition/
  - http://dmitrysoshnikov.com/ecmascript/javascript-the-core/