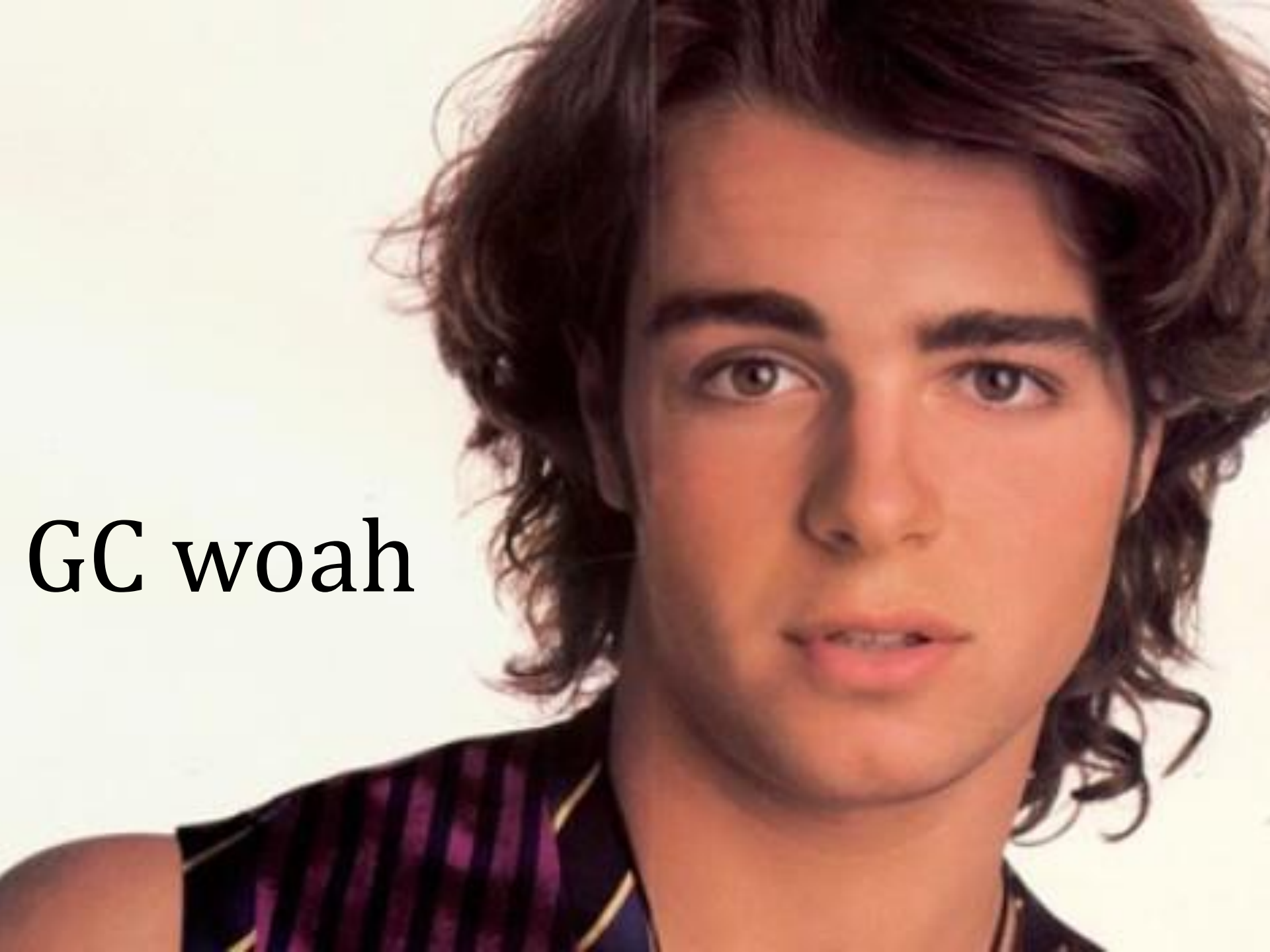

GC woah

What?

Figuring out the heap address of a script object.

What?

Figuring out the heap address of a script object.
(without a traditional memory read bug)

Dion Blazakis Center for Bugs Who Can’t Read Good

Why?

Knowing is half the battle.

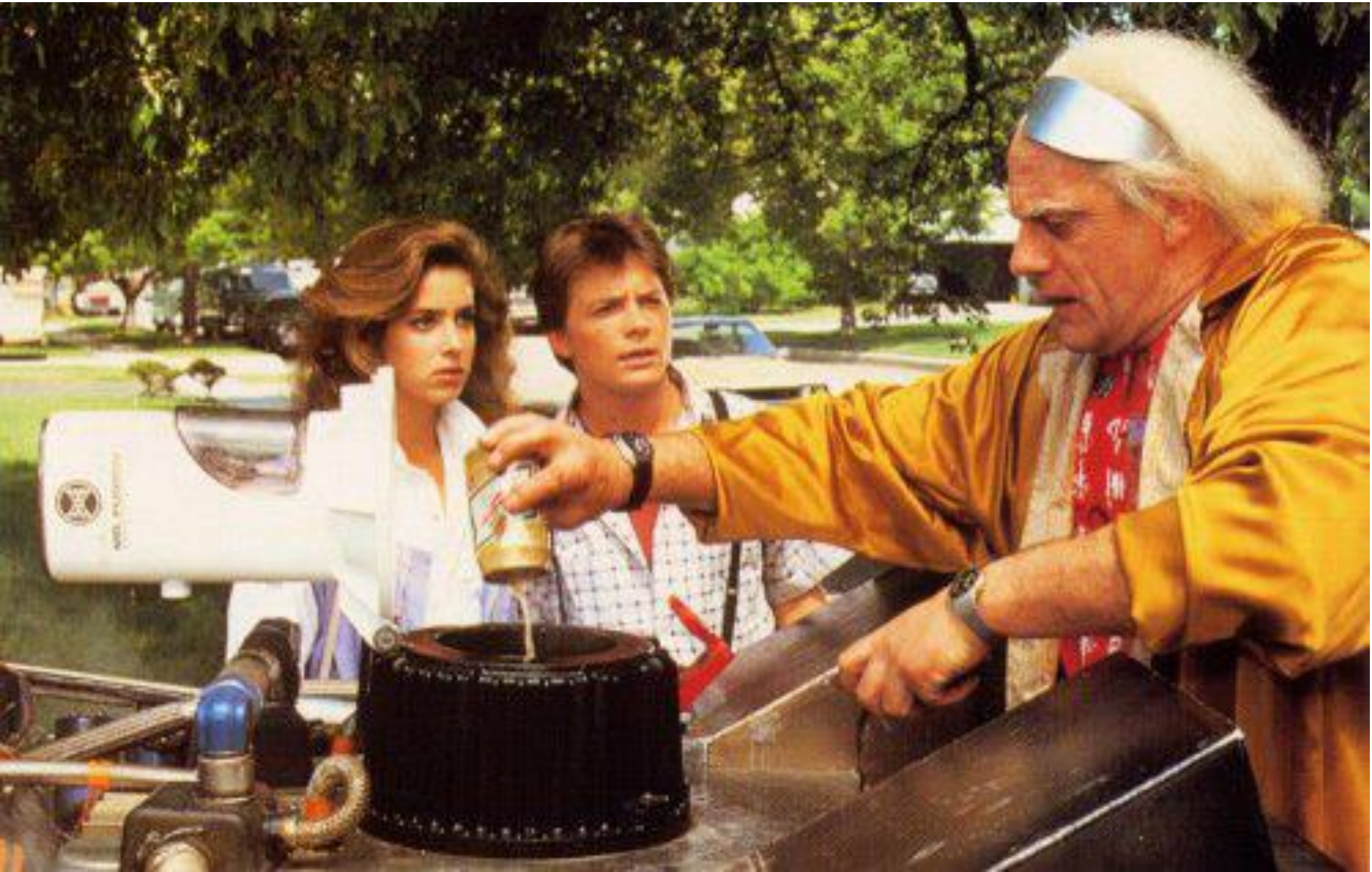
‘Cause
we can.

Disclaimer:

Probably least practical thing you'll see all Summerc0n.

Contact redpantz about refund. (just be sure to speak his language)

How?



How?

How?

Turn a conservative garbage collector into a heap address oracle

Garbage collection

Memory management is handled by the GC:

```
var obj = new Object();
obj.drink = “at Summerc0n.”;
obj = null;
```

Garbage collection

Memory management is handled by the GC:

```
var obj = new Object();
obj.drink = “at Summerc0n.”;
obj = null;

o1 = new ScriptObject(OBJECT);
```

Garbage collection

Memory management is handled by the GC:

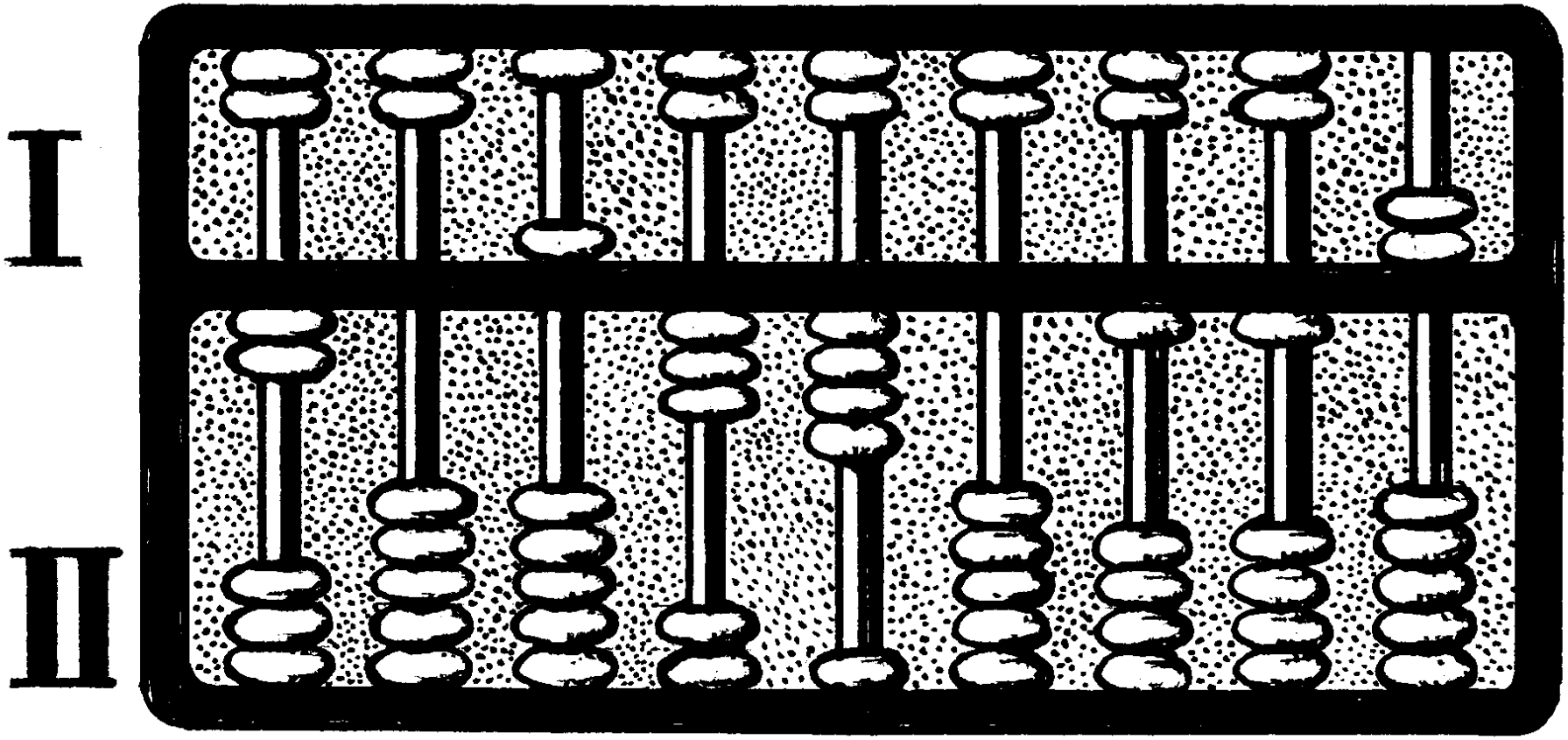
```
var obj = new Object();
obj.drink = “at Summerc0n.”;
obj = null;

o1 = new ScriptObject(OBJECT);
o2 = new ScriptObject(STRING);
```

Garbage collection

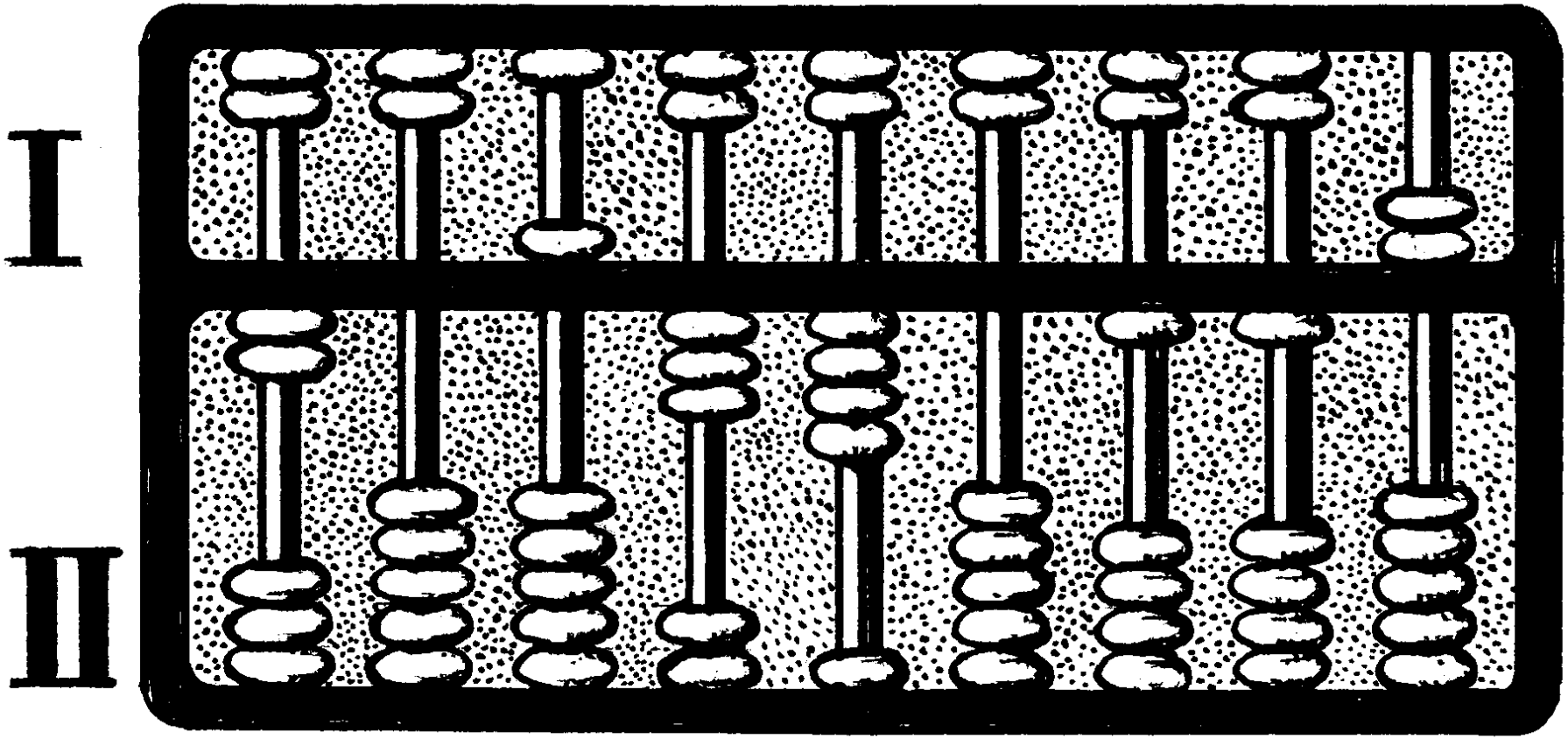
Memory management is handled by the GC:

```
var obj = new Object();
obj.drink = “at Summerc0n.”;
obj = null;

o1 = new ScriptObject(OBJECT);
o2 = new ScriptObject(STRING);
delete o1;
delete o2;
```

Reference Counting

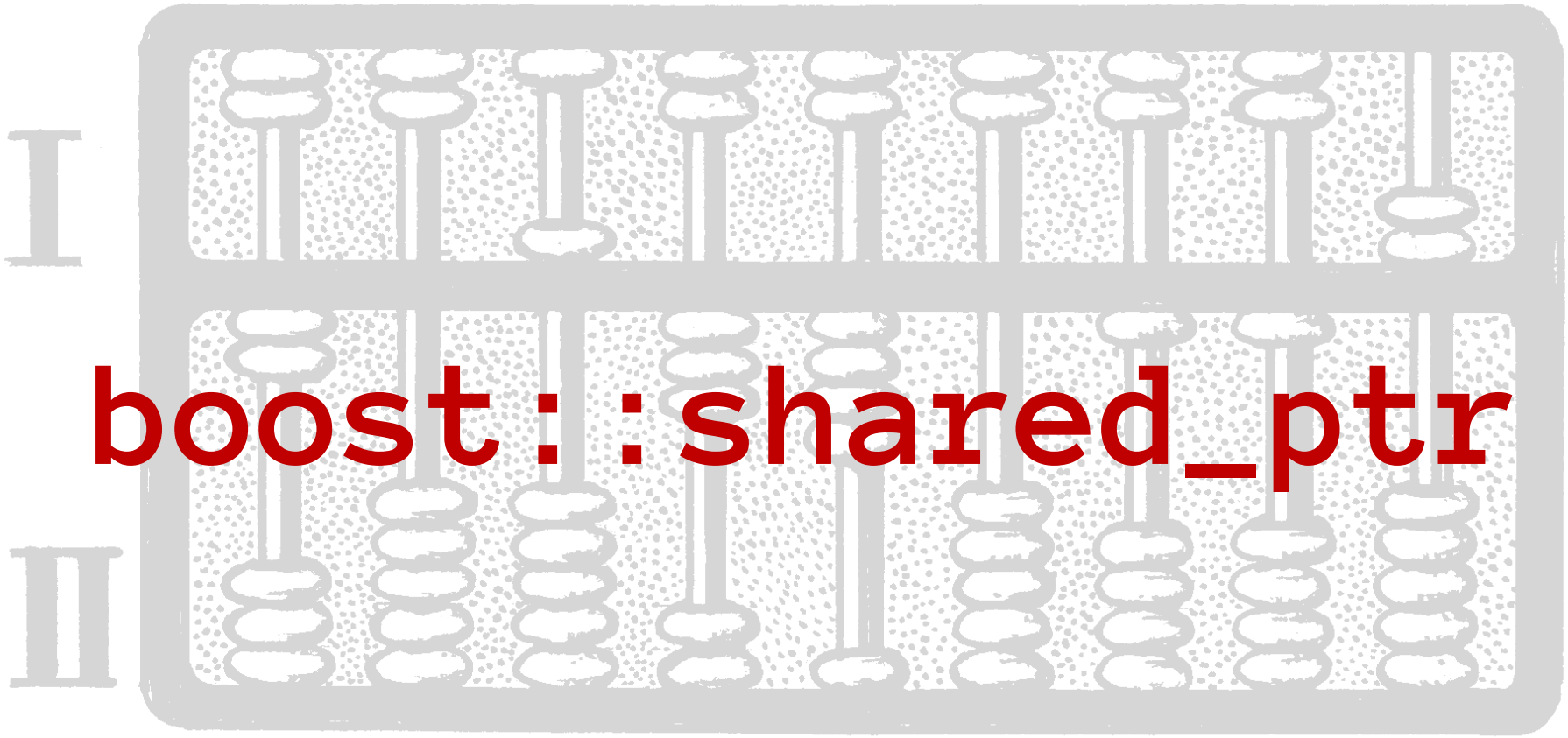


Reference Counting



Keep track of number of references and free when 0

Reference Counting



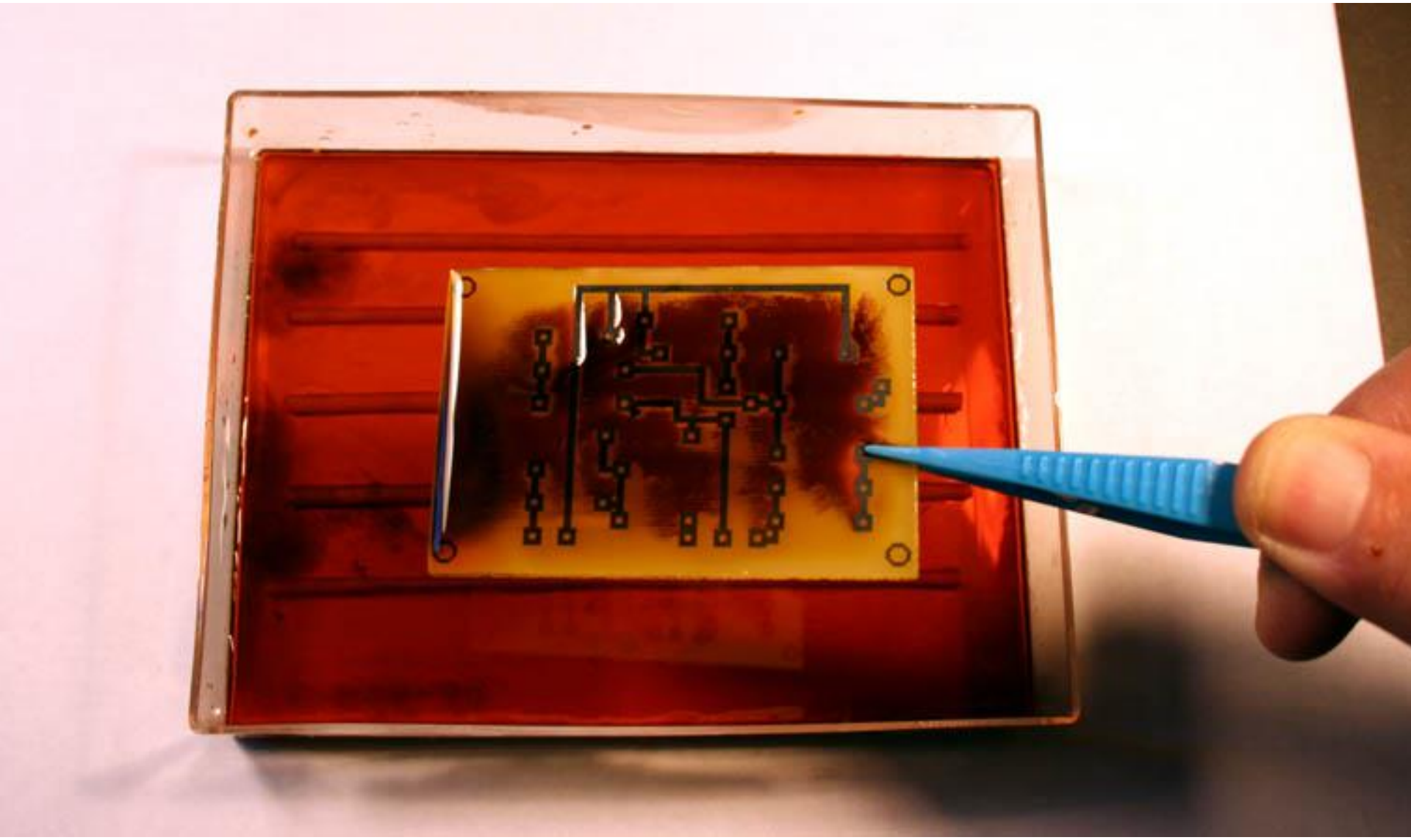
`boost::shared_ptr`

Keep track of number of references and free when 0

Example: Reference Cycles

```
var x = new Object(); // obj 1: 1 refs
var y = new Object(); // obj 2: 1 refs
x.wizard_hat = y;     // obj 2: 2 refs
y.wizard_robe = x;    // obj 1: 2 refs
x = null;             // obj 1: 1 refs
y = null;             // obj 2: 1 refs
forceGC();            // uh oh ☹
```

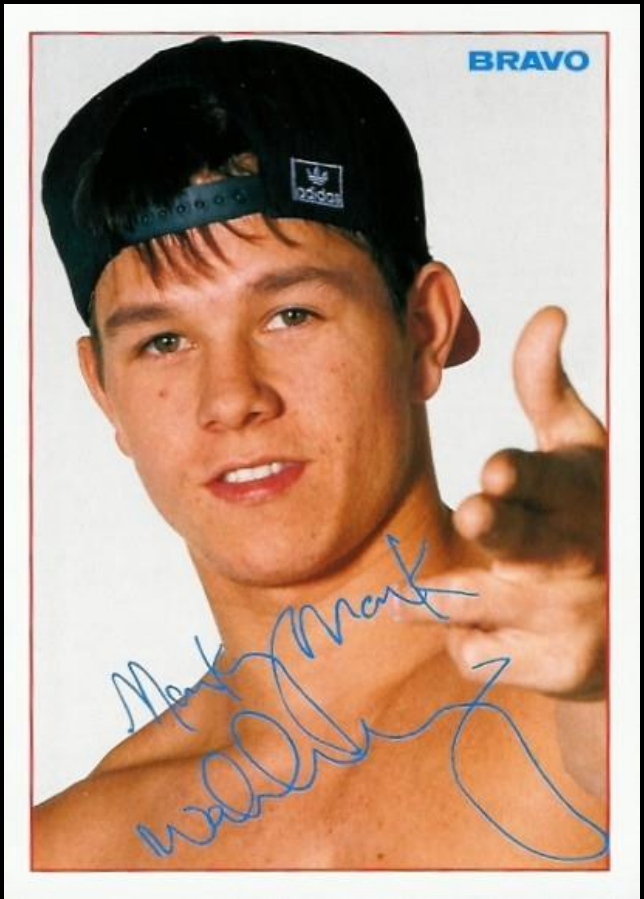
GC: Mark and Sweep



GC: Mark and Sweep

1. Find all live objects.
2. Mark them as used.
3. Ask the allocator to walk all allocations and free those that aren’t marked. (SWEEEEEEEP)

GC: Marking




```
worklist = gc_roots
while (!worklist.isEmpty()) {
      gc_obj = worklist.dequeue();
      if (!gc_obj.isMarked()) {
            gc_obj.mark();
            worklist.queue(gc_obj.getRefs());
      }
}
```

```
worklist = gc_roots;
while (!worklist.isEmpty()) {
      gc_obj = worklist.dequeue();
      if (!gc_obj.isMarked()) {
            gc_obj.mark();
            worklist.queue(gc_obj.getRefs());
      }
}
```

Roots

Ensuring all roots are accounted for isn't trivial.

Especially with JIT and native structures holding refs to script objects.

Some engines make the effort to do this precisely (see V8).

Most punt.

Conservative GC

If you can't prove otherwise, assume a value in memory (only some regions are – like the stack) is a GC-able object.

Conservative GC

If you can't prove otherwise, assume a value in memory (only some regions are – like the stack) is a GC-able object.

OVERMARKING!

```
var f = function(x) {
     do_something_that_causes_gc();
     };

var y = 0x24242424;

f(y);
```

```
var f = function(x) {
     do_something_that_causes_gc();
     };

var y = 0x24242424;

f(y);
```

“Hey, allocator, does 0x24242424 look like it could be a pointer to a heap object? Should I mark it?”

```
var f = function(x) {
     do_somethin[illegible]t_causes_g[illegible]
     };

var y = 0x2424242[illegible]

f(y);
```

TYPE CONFUSION!!!1 (SORTA)

Hey, allocator, does 0x24242424 look like it could be a pointer to a heap object? Should I mark it?”

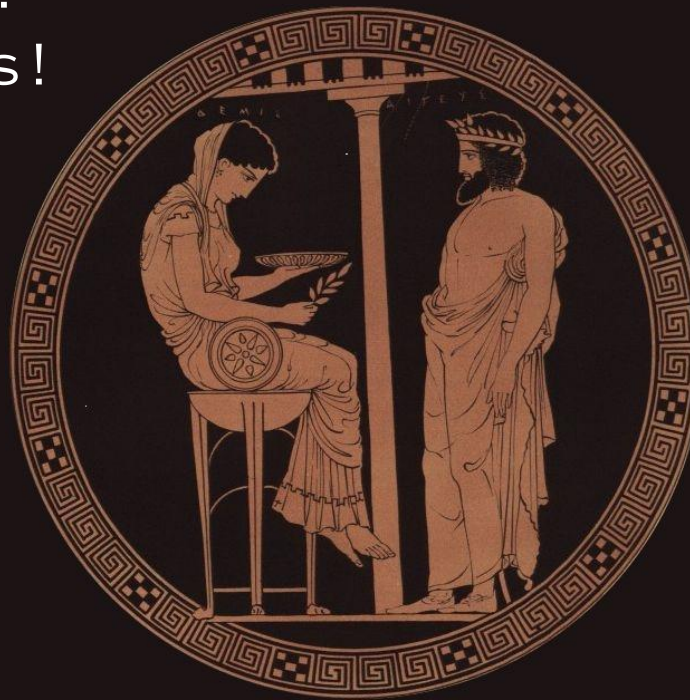
```
var f = function(x) {
    do_something_that_[illegible]e_gc();
    };

var y = 0x[illegible]2424;

f(y[illegible]
```

“[illegible] allocator do[illegible]s 0[illegible]424242 [illegible]k [illegible]ike it cou[illegible] be a [illegible] to a hea[illegible] [illegible]ject? Should I [illegible]ark it?”

DEMOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOOO!!!!!!!!!!!!

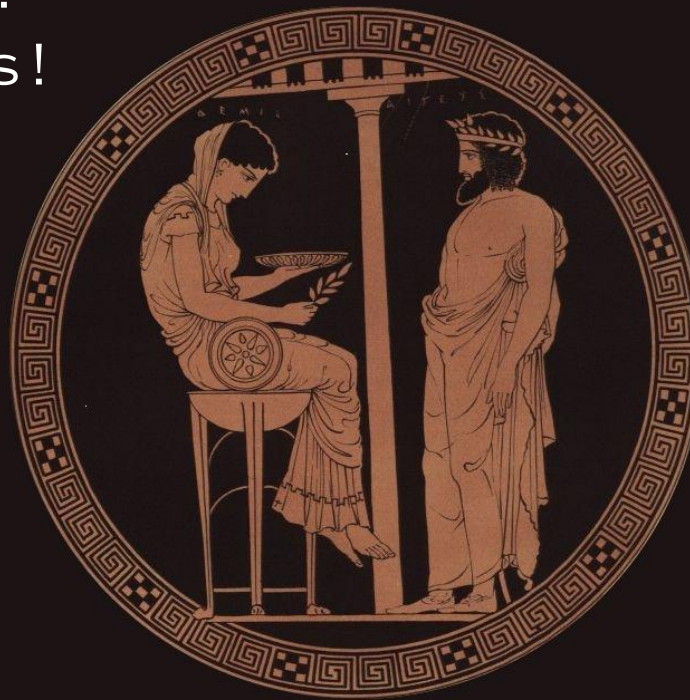
The Plan

1. Make a bunch of objects
2. Put some address guesses on the stack
3. Remove all refs to objects and force GC
4. Are they all gone?
   - If not we found the address!
   - If so, guess another address!



The Plan

1. Make a bunch of objects
2. Put some address guesses on the stack
3. Remove all refs to objects and force GC
4. Are they all gone?
   - If not we found the address!
   - If so, guess another address!



Steps: 1. Bunch o’ Objects

```
count = a_whole_bunch;
strongs = new Array();

while (count > 0) {
    var obj: Object = createSprayObject(count);
    strongs.push(obj);
    count -= 1;
}
```

Steps 2: Put guesses on stack

```
sprayStackArguments(
  pageToDouble(baseAddress + scanDelta * 0),
  pageToDouble(baseAddress + scanDelta * 1),
  pageToDouble(baseAddress + scanDelta * 2),
  pageToDouble(baseAddress + scanDelta * 3),
  pageToDouble(baseAddress + scanDelta * 4),
  pageToDouble(baseAddress + scanDelta * 5),
  pageToDouble(baseAddress + scanDelta * 6),
  pageToDouble(baseAddress + scanDelta * 7),
  recurseDepth);
```

Step 3: Remove refs and GC

```
strongs = new Array();
forceGC();
```

Steps 4: Any pinned objs?

Shit.

Interlude: Chicken and egg

How do we ask if something has been collected if we have no references left to it?

Interlude: Chicken and egg

How do we ask if something has been collected if we have no references left to it?

For ActionScript:
Use a weak Dictionary

Dictionary() Constructor

```
public function Dictionary(weakKeys:Boolean = false)
```

Language Version: ActionScript 3.0
Runtime Versions: AIR 1.0, Flash Player 9, Flash Lite 4

Creates a new Dictionary object. To remove a key from a Dictionary object, use the `delete` operator.

Parameters

`weakKeys:Boolean` (default = `false`) — Instructs the Dictionary object to use "weak" references on object keys. If the only reference to an object is in the specified Dictionary object, the key is eligible for garbage collection and is removed from the table when the object is collected. Note that the Dictionary never removes weak `String` keys

Steps: 1. Bunch o' Objects (v2)

```
count = a_whole_bunch;
weaks = new Dictionary(true);
strongs = new Array();

while (count > 0) {
    var obj: Object = createSprayObject(count);
     weaks[obj] = count;
    strongs.push(obj);
    count -= 1;
}
```

Step 4. Any pinned objs? (v2)

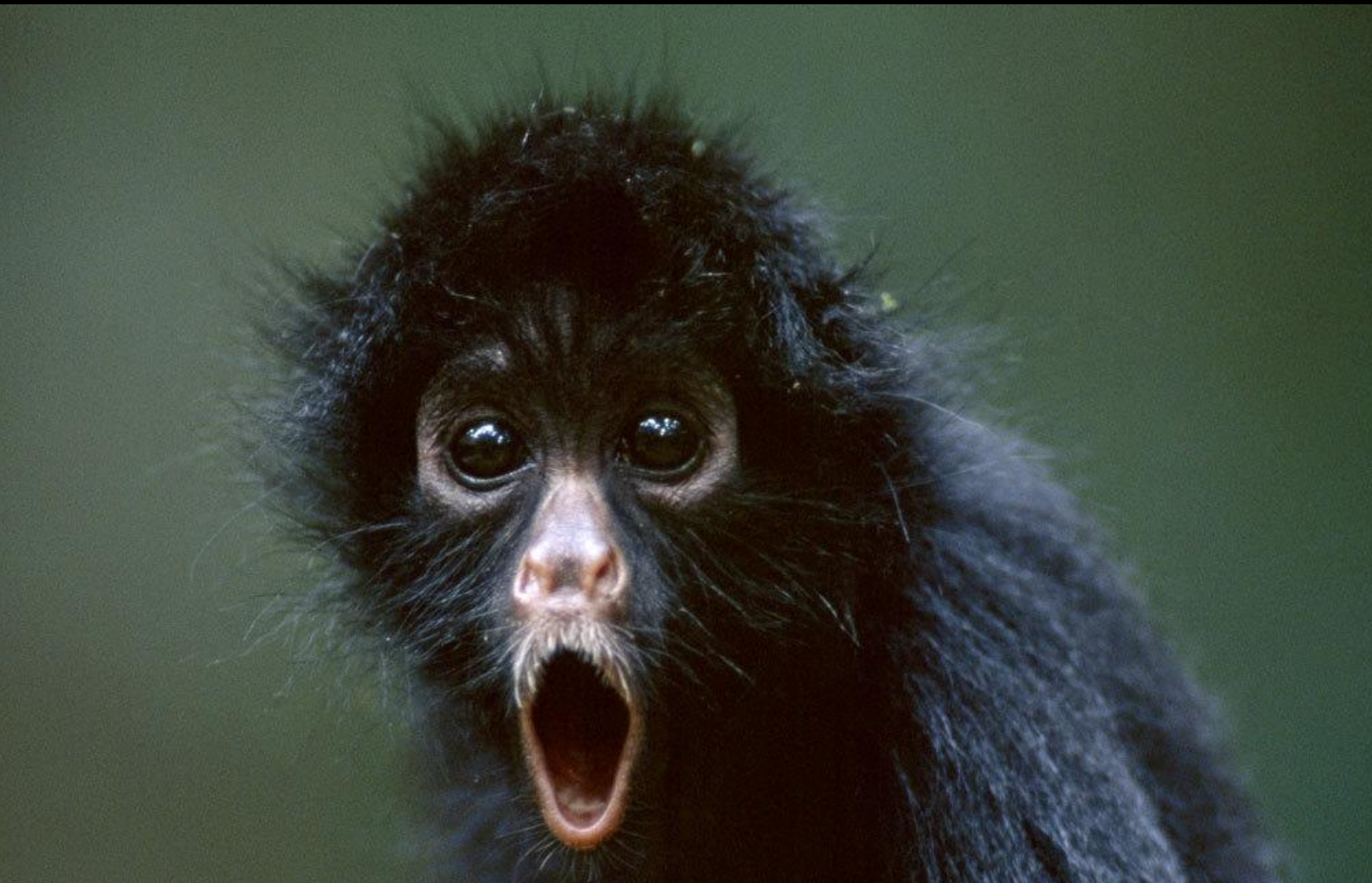
```
public function countKeys(d:Dictionary) {
    var count = 0;
    for (var key : Object in d) {
        count += 1;
    }
    return count;
}
```

Step 4. Any pinned objs? (v2)

```
public function anyLeft() {
    for (var key : Object in weaks) {
        // Pin this again so it doesn't
        // go away when stack unwinds
        strongs.push(key);
    }
    return countKeys(weaks);
}
```

Demonstration.

Firefox? (SpiderMonkey?)



https://developer.mozilla.org/en-US/docs/Web/JavaScript/Reference/Global_Objects/WeakMap?redirectlocale=en-US&redirectslug=JavaSc

This is an experimental technology, part of the Harmony (EcmaScript 6) proposal.
Because this technology's specification has not stabilized, check the compatibility table for usage in various
note that the syntax and behavior of an experimental technology is subject to change in future version of brow
changes.

Introduction

WeakMaps are key/value maps in which keys are objects.

API

Method	Description
`myWeakMap.get(key [, defaultValue])`	Returns the value associated to the `key` object, `defaultValue` if
`myWeakMap.set(key, value)`	Set the value for the `key` object in `myWeakMap`. Returns `undefine`
`myWeakMap.has(key)`	Returns a boolean asserting whether a value has been associated
`myWeakMap.delete(key)`	Removes any value associated to the `key` object. After such a call,
`myWeakMap.clear()`	Empty the `myWeakMap` from all its elements. Returns `undefined`.

Example

```
1  var wm1 = new WeakMap(),
2      wm2 = new WeakMap(),
3      wm3 = new WeakMap();
4  var o1 = {},
```

“Because of references being weak, WeakMap keys are not enumerable (i.e. there is no method giving you a list of the keys). If they were, the list would depend on the state of garbage collection, introducing non-determinism.”

Solution: Hash Growth Timing

```
897     static const uint8_t  sMaxAlphaFrac = 192; // (0x100 * .75)
…
1023    bool overloaded()
1024    {
1025        return entryCount + removedCount >= ((sMaxAlphaFrac * capacity()) >> 8);
1026    }
…
1178    RebuildStatus checkOverloaded()
1179    {
1180        if (!overloaded())
1181            return NotOverloaded;
…
1193        return changeTableSize(deltaLog2);
1194    }
```

Solution: Hash Growth Timing

```
RebuildStatus changeTableSize(int deltaLog2)
{
…
    uint32_t newLog2 = sHashBits - hashShift + deltaLog2;
    uint32_t newCapacity = JS_BIT(newLog2);
…
    Entry *newTable = createTable(*this, newCapacity);
…
    // Copy only live entries, leaving removed ones behind.
    for (Entry *src = oldTable, *end = src + oldCap; src < end; ++src) {
        if (src->isLive()) {
            HashNumber hn = src->getKeyHash();
            findFreeEntry(hn).setLive(hn, Move(src->get()));
            src->destroy();
        }
    }
```