Everything New is Old Again

A Brief History of Time
(with Javascript Closures)

Wilmington JS - Aug 21, 2018

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CODE
CLOSED
CODE
CLOSURES

Closures are *core* to JavaScript ...

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... and Node.js

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... and Node.js

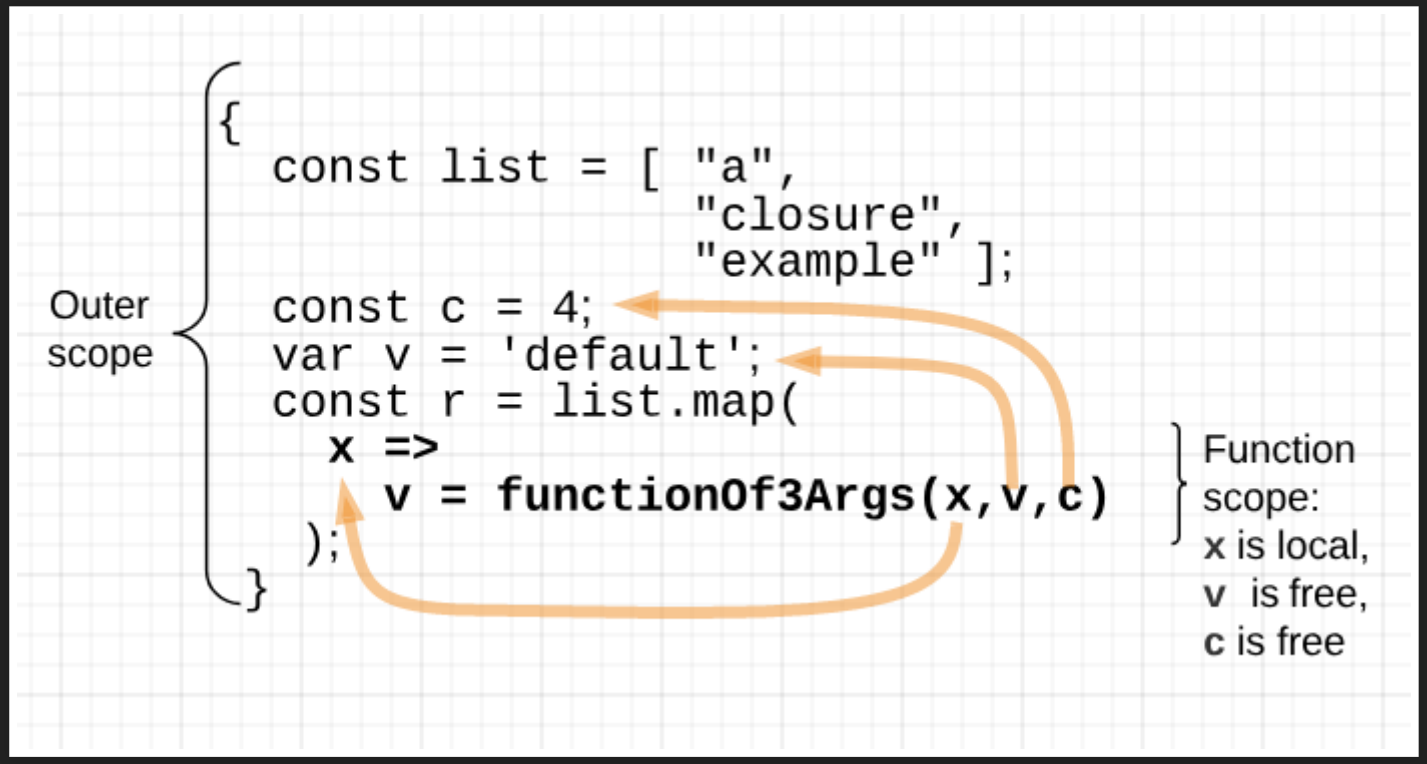
... and functional programming

Closures Explained

A function whose free variables (or open bindings) have been closed (or bound) in its containing lexical environment, resulting in a closed expression (one with no free variables):

```
const list = ["a", "closure", "example"];
var v = 'default';
const c = 4;
const r = list.map(x => v = functionOf3Args(x,v,c));
```

Outer vs. function lexical scope



Necessity is the Mother of Invention

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Nobody mentions Invention's father...

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Conclusion: Javascript Closures are Necessity's Bastard?

The Neccessity Defense

```
<body onload="document.write('<h1>Everthing New</h1>'
                           + '<p>is Old Again</p>')">
```

The `onload` right hand side is a Javascript function body.

`document` is a free variable within that function body.

`document` is bound outside of the function, but available in the function's *environment*.

The Neccessity Defense, Part II

`Array.prototype.forEach(callback)` requires a callback function :

- `callback(item)`
- `callback(item, index, array)`

But what if you want to call a function that requires three arguments?

... or mutate or collect state on each call?

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... or mutate or collect state on each call?

Closures to the rescue:

```
function functionOf3Args(x,v,c) {
  return (x.length > c)
         ? x
         : v;
}
{
  const list = ["a", "closure", "example"];
  const c = 4;
  var v = 'default';
  const r = list.map(x => v = functionOf3Args(x,v,c));
}
```

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function functionOf3Args(x,v,c) {
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`x` is bound in the anonymous function

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  const list = ["a", "closure", "example"];
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  const r = list.map(x => v = functionOf3Args(x,v,c));
}
```

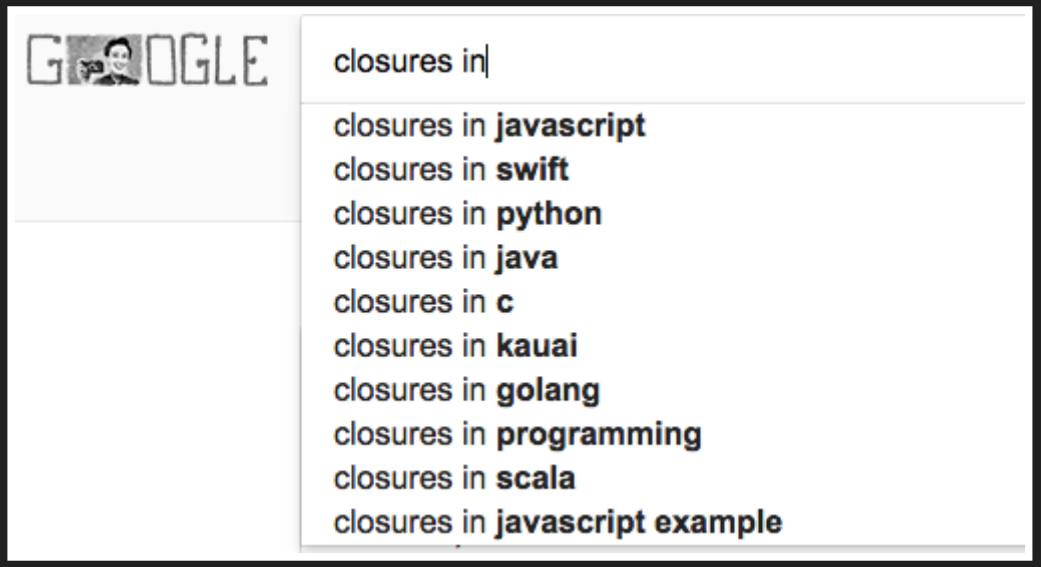
`x` is bound in the anonymous function

`v` and `c` are free in the anonymous function

… But JS is far from the first

History

Everything New... is Old Again


GOOGLE
closures in
closures in javascript
closures in swift
closures in python
closures in java
closures in c
closures in kauai
closures in golang
closures in programming
closures in scala
closures in javascript example

First, Some Historical Context

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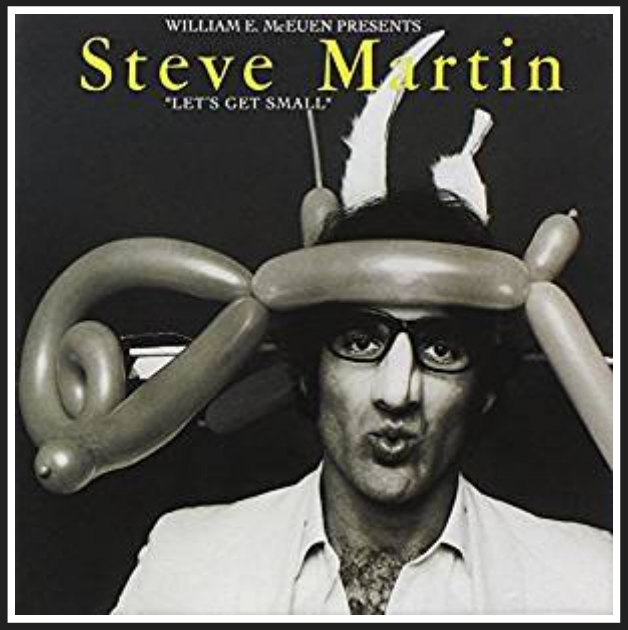
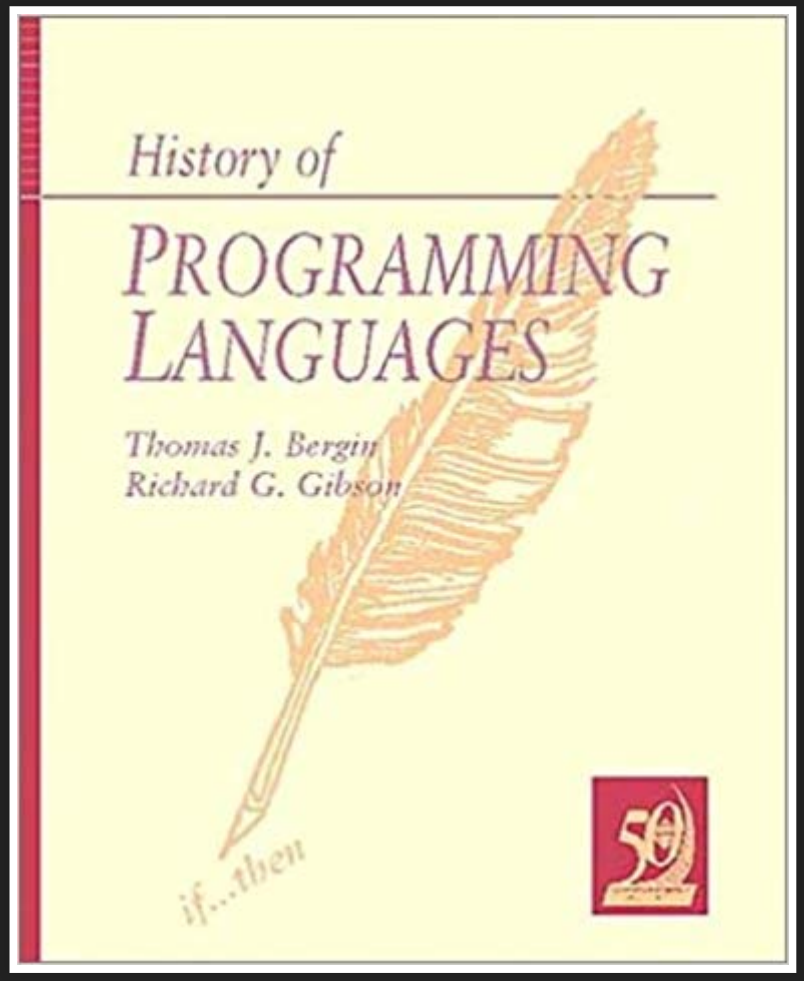


~~First, Some Hysterical Context~~

First, Some Historical Context



"Closure" coined by Peter J. Landin in 1964

A Very Brief History of Our Time With Closures

Lisp was created in the late 1950's by John McCarthy and others at M.I.T. One feature of the language was function-valued expressions, signified by lambda. The name lambda was borrowed from a mathematical formalism known as the lambda calculus. [...]

Although Lisp was not based on an effort to model that formalism, lambda plays approximately the same role in Lisp as it does in the lambda calculus: lambda is the syntax for a function-valued expression. [...]

```
(lambda (x) x)
```

Look familiar?

Now we fast-forward to the mid 1970's. [...] A number of popular Lisp dialects were in use including InterLisp, MacLisp, UCI-Lisp, Stanford Lisp 1.6, and U. Utah's Standard Lisp. All of them were dynamically scoped.

It was in this context that Guy Steele and Gerald Jay Sussman developed Scheme, a very simple Lisp dialect.

Neil Gafter, *A Definition of Closures*

Scheme

First languages to adopt closures, 1975

Revised^3 Report on the Algorithmic Language Scheme

(YF) = (F (YF))

```
(define (y f) (lambda () (funcall f (y f))))
```

Scheme

```
(define (functionOf3Args x v c)
  (if (> (string-length x) c)
      x
      v))

(let ( (l '("a" "closure" "example"))
       (v "value")
       (c 4)
      )
   (map (lambda (x) (write-line (functionOf3Args x v c))) l)
)
```

yields:

```
"value"
"closure"
"example"
```

Lisp

"Lisp was originally created as a practical mathematical notation for computer programs, influenced by the notation of Alonzo Church's lambda calculus." - Wikipedia

Lisp

Common LISP: Newer variant of LISP, with lexical (not dynamic) scoping, closures (Guy Steele, again)

```
(defun functionOf3Args (x v c)
  (if (> (string-length x) c)
      x
      v))

(let ( (l '("a" "closure" "example"))
       (v "value")
       (c 4)
      )
   (map (lambda (x) (write-line (functionOf3Args x v c))) l)
)
```

Lambda Calculus

The granddaddy of them all.

Alonzo Church's formalized the mathematics of functions and variable binding with the Lambda Calculus in the 1930's

λx . x

"the smallest universal programming language of the world."

A Tutorial Introduction to the Lambda Calculus, Raúl Rojas

The λ calculus consists of a single transformation rule (variable substitution) and a single function definition scheme. It was introduced in the 1930s by Alonzo Church as a way of formalizing the concept of effective computability. -- Rojas

The λ calculus helps us understand and model computation, primarily through pure functions.

```
 <expression> := <name> | <function> | <application>
   <function> := λ <name>.<expression>
<application> := <expression><expression>
```

λx.x

is a *function*

(λx.x)y

is an *application* of a function to an *argument*

(λx.x)y = [y/x]x = y

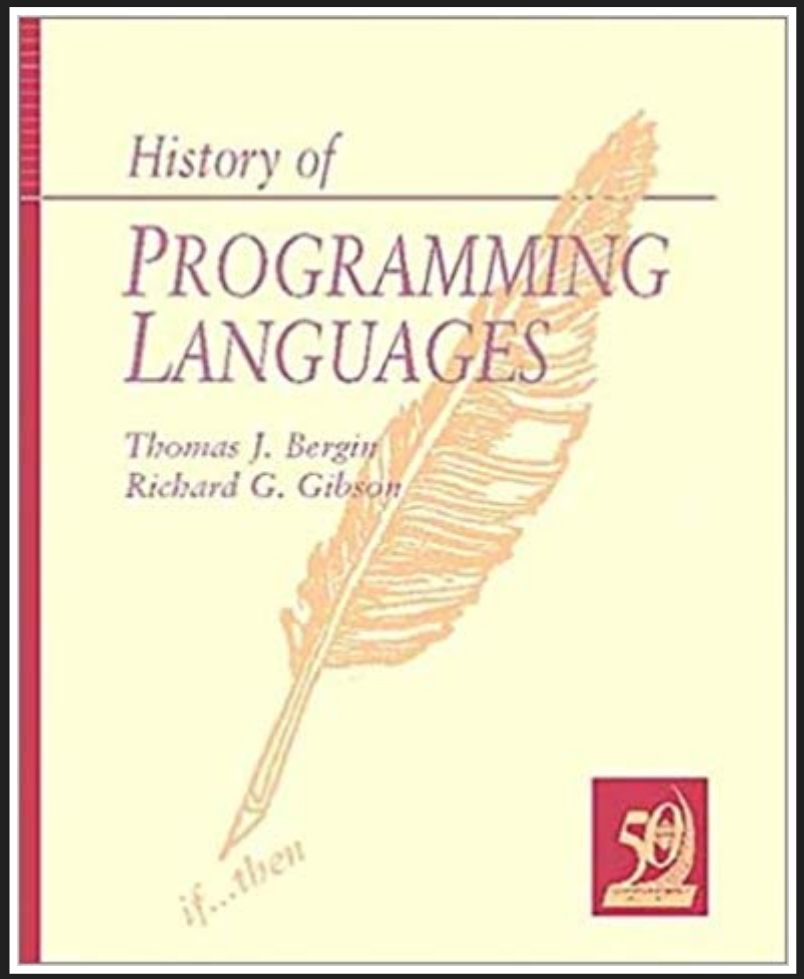
From these roots, a functional model of numbers and even arithmetic and logic functions can be defined in a purely function-based model

- `0` is modeled as a function
- `1` is modeled as the application of a *successor* function to `0`, `S0`
- `2` is modeled as the application of a *successor* function to `1`, `S1` == `SS0`
- ... boolean values true and false, logical operations like less than, greater than
- ... and recursion

A Tutorial Introduction to the Lambda Calculus, Raúl Rojas

Historical Context

This was before programming languages were invented. This was before computers were invented.



Those who remember [the best of] the past of programming languages are *fortunate* to repeat it.

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