Modular Instrumentation of Interpreters in JavaScript

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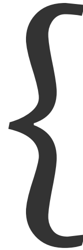
The Instrumentation Problem

The web WWW

Web browsers 

JavaScript engines SpiderMonkey (C++) V8 (C++)

Other JavaScript interpreters:

- Rhino (Java)
- Narcissus (JavaScript)

Narcissus

Metacircular JavaScript interpreter by Mozilla

Breeding ground for testing new language features

Used by Austin and Flanagan to implement the faceted evaluation analysis

The faceted evaluation analysis

Faceted evaluation is a dynamic information flow analysis.

- Each value has two facets.
- The private value is visible only to a set of principals.

- A "program counter" keeps track of the current set of principals in branches.

Faceted evaluation in vivo

Faceted evaluation in vivo

- Standalone concern, scattered code
- Any part of the interpreter liable to change
- Program counter is threaded through calls
- Difficult to compose analyses

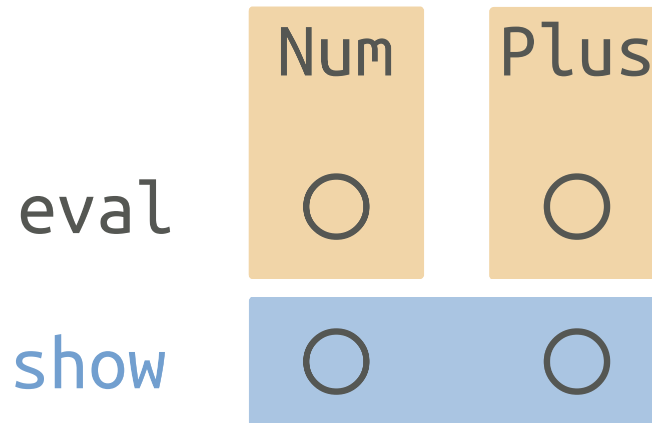
The Instrumentation Problem

Four requirements for modular instrumentation:

- Modularity: interpreter and analysis as modules
- Intercession: can add or alter any part of the interpreter
- Local state: can thread state local to an analysis
- Pluggability: can toggle the analysis dynamically

Building an interpreter with modules

A language of arithmetic expressions



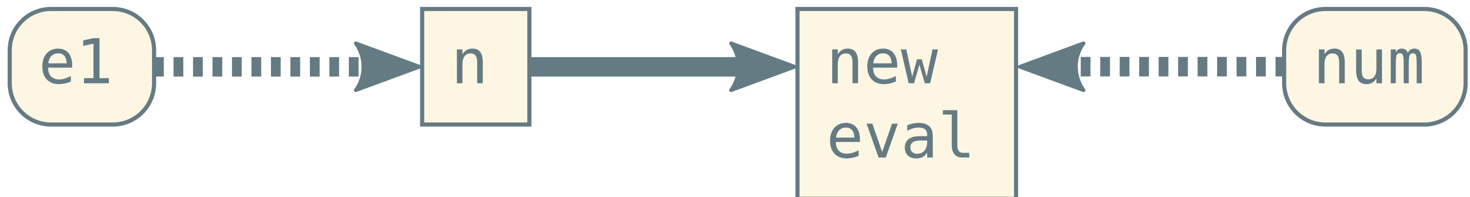
Ingredients

- Dictionary objects as modules
- Delegation via prototypes
- Name shadowing
- Closures
- Late binding

Same client code, different results

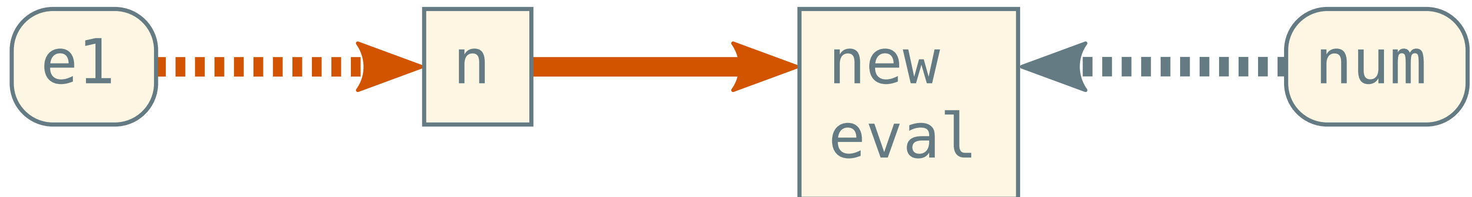
The num data variant

```
var num = {
  new(n) { return {__proto__: this, n} },
  eval() { return this.n }}

var e1 = num.new(3)
e1.eval() //: 3
```



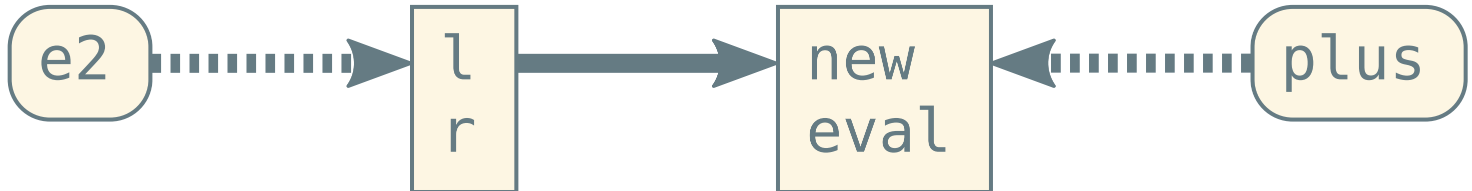
The num data variant

```
var num = {
  new(n) { return {__proto__: this, n} },
  eval() { return this.n }}

var e1 = num.new(3)
e1.eval() //: 3
```



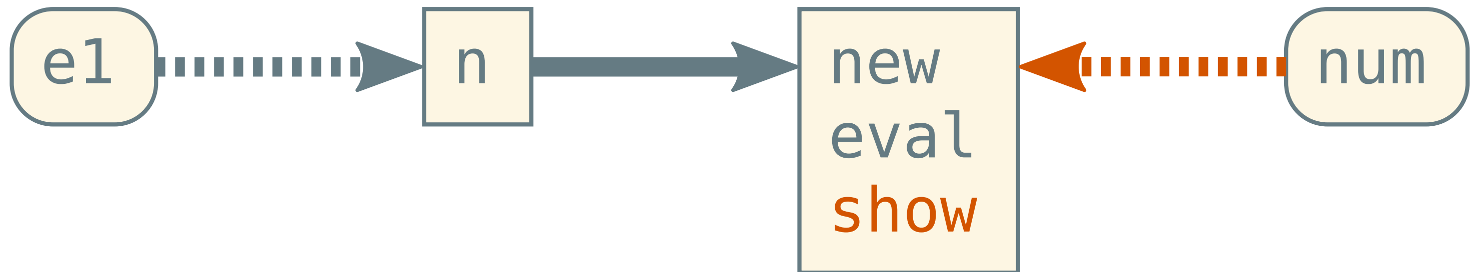
Adding a data variant

```
var plus = {
  new(l, r) { return {__proto__: this, l, r,} },
  eval() { return this.l.eval() + this.r.eval() }}

var e2 = plus.new(num.new(1), num.new(2))
```



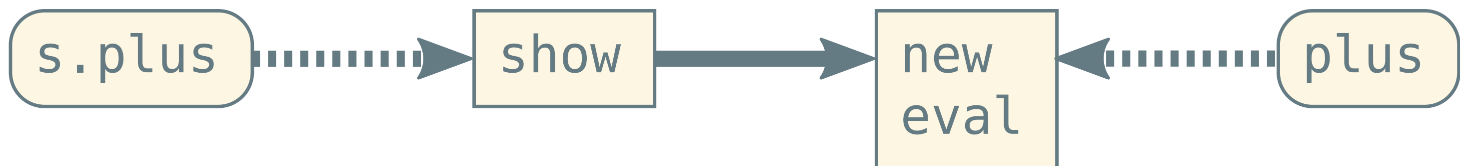
Adding an operation, destructively

```
num.show = function() { return this.n.toString() }
plus.show = function() {…}

e1.show() //: “3”
```



Adding an operation as a module

```
var show = base => {
  var num = {__proto__: base.num,
    show() { return this.n.toString() }}
  var plus = {…}
  return {num, plus} }

var s = show({num, plus})
```



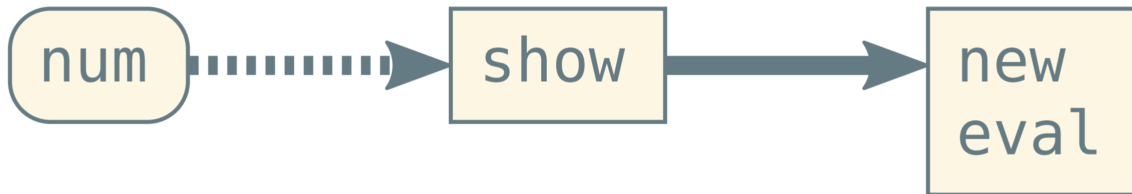
Unsafe mixing of data variants

```
s.plus.new(num.new(1), s.num.new(2)).show()

//: TypeError: this.l.show is not a function
```

A use-case for `with`

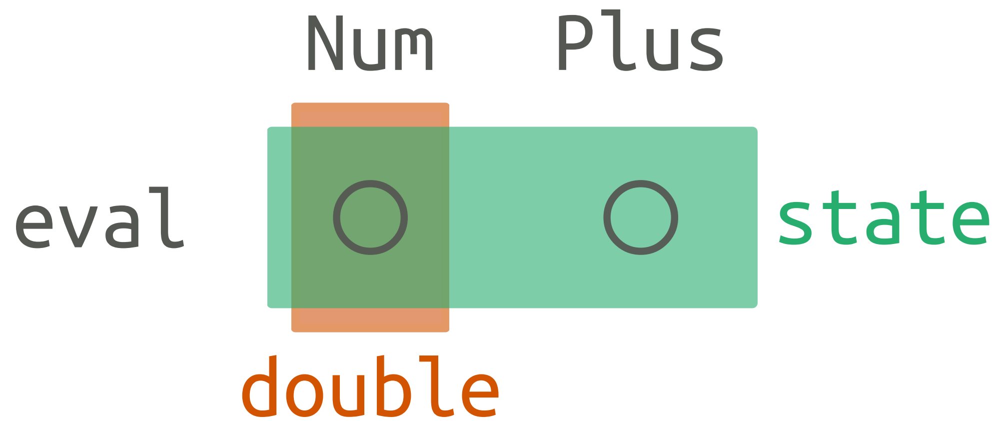
```
with(show({num, plus})) {
  plus.new(num.new(1), num.new(2)).show() }
```

Inside `with`:



Outside `with`:

Instrumented language

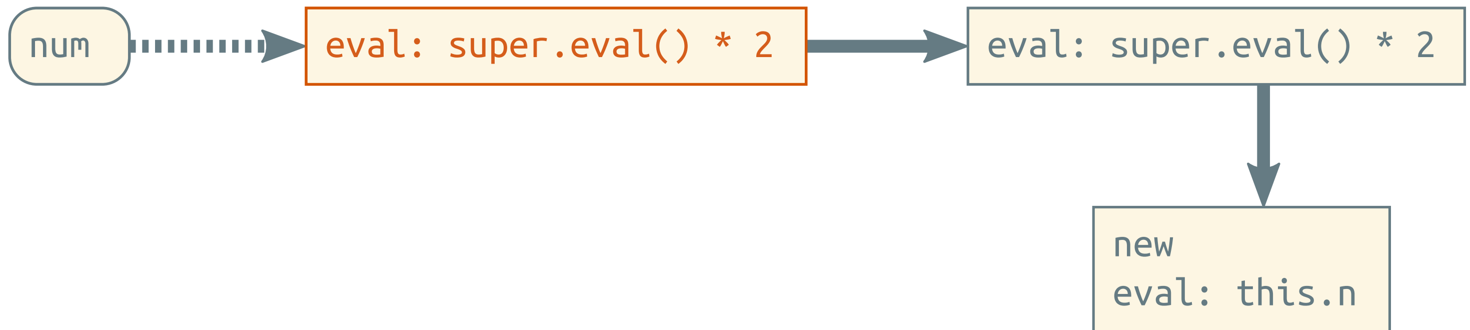


Modifying operations

```
var double = num_orig => {
  var num = {__proto__: num_orig,
    eval() { return super.eval() * 2 }}
  return {num} }

with(double(num)) {
  plus.new(num.new(1), num.new(2)).eval() }
//: 6
```

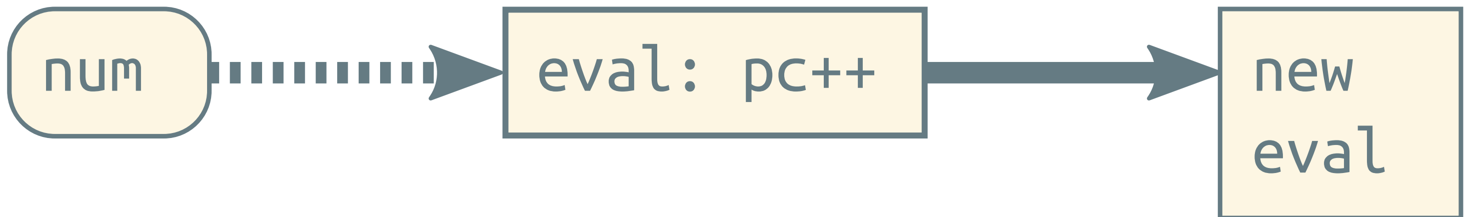
Modifying operations

```
with(double(num)) {
  with(double(num)) {
    plus.new(num.new(1), num.new(2)).eval() }}
//: 12
```



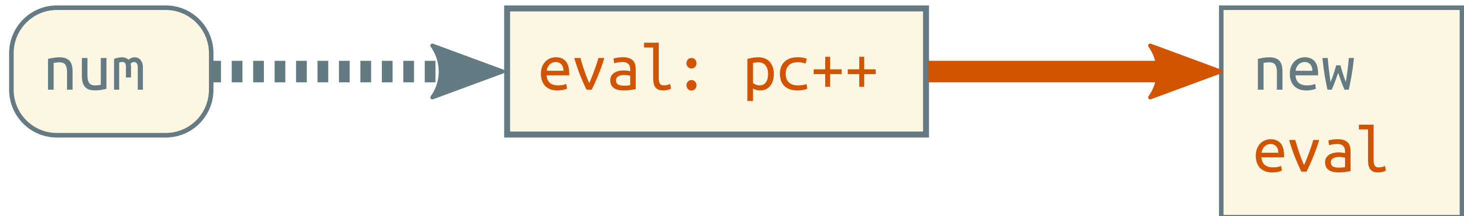
Threading state

```
var state = (base, pc = 0) => {
  var num = {__proto__: base.num,
             eval() { pc++; return super.eval() }}
  var plus = {…}
  var getPC = () => pc
  return {num, plus, getPC} }
```



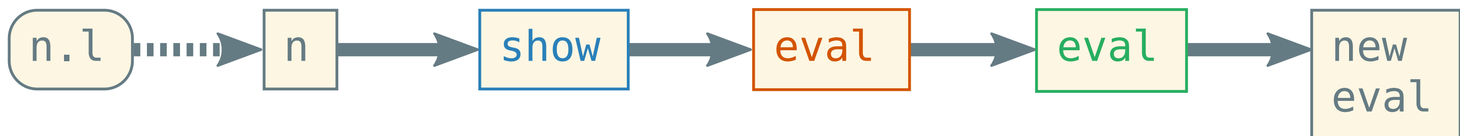
Threading state

```
with (state({num, plus})) {
  getPC() //: 0
  plus.new(num.new(1), num.new(2)).eval() //: 3
  getPC() //: 3
}
```



All combined

```
with (state({num,plus})){
  with (double(num)) {
    with (show({num,plus})){
      getPC()  //: 0
      let n = plus.new(num.new(1), num.new(2))
      n.eval() //: 6
      getPC()  //: 3
      n.show() //: “1 + 2”
    }}}
```

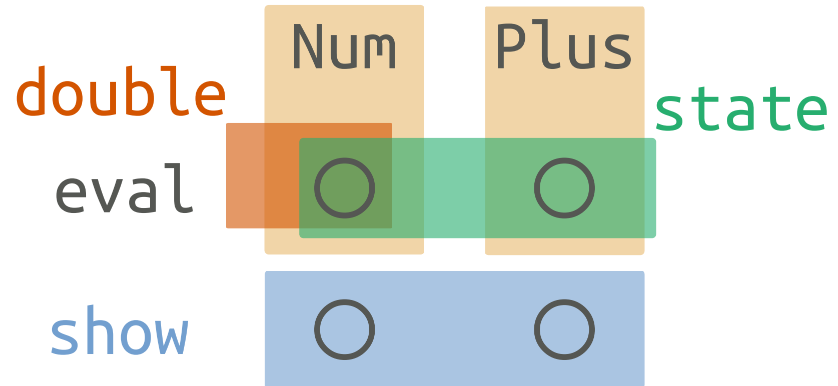


Wrap-up

A simple modular interpreter

The instrumentation problem:

- Modularity
- Intercession
- Local state
- Pluggability



Simple language ingredients:

- Delegation
- Late binding
- Dictionaries as modules
- Closures