Form & Function in Software

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<1>

Confusionists and superficial intellectuals...

...move ahead...

...while the ‘deep thinkers’ descend
into the darker regions of the
status quo...

...or, to express it in a different way,
they remain stuck in the mud.

-Paul Feyerabend

```
(defun factorial (n)
  (cond ((= n 0) 1)
        (t (* n (factorial (- n 1))))))
```

```
(defun  eval (form env)
  (cond
   ((null form) nil)
   ((numberp form) form)
   ((stringp form) form)
   ((eq t form) form)
   ((atom form)
    (cond
     ((get form 'APVAL))
     (t (lookup form env))))
   ((eq (car form) 'quote) (car (cdr form)))
   ((eq (car form) 'cond) (evalcond (cdr form) env))
   (t (apply (car form) (evallist (cdr form) env) env))))

(defun apply (fct parms env)
  (cond
   ((atom fct)
    (cond
        ((eq fct 'car) (car (car parms)))
        ((eq fct 'cdr) (cdr (car parms)))
        ((eq fct 'cons) (cons (car parms) (car (cdr parms))))
        ((eq fct 'get) (get (car parms) (car (cdr parms))))
        ((eq fct 'atom) (atom (car parms)))
        ((eq fct 'error) (error (string parms)))
        ((eq fct 'eq) (eq (car parms) (car (cdr parms))))
        (t (cond
            ((get fct 'EXPR)
             (apply (get fct 'EXPR) parms env) parms env)
            (t (apply (lookup fct env) parms env))))))
   ((eq (car fct) 'lambda)
    (eval (car (cdr (cdr fct)))
      (update (car (cdr fct)) parms env)))
   (t (apply (eval fct env) parms env))))

(defun evalcond (conds env)
  (cond
   ((null conds) nil)
   ((eval (car (car conds)) env)
    (eval (car (cdr (car conds))) env))
   (t (evalcond (cdr conds) env))))
```

```
(defun eval (form env)(cond ((null form) nil) ((numberp form)
form) ((stringp form) form) ((eq t form) form) ((atom form)
(cond ((get form 'APVAL)) (t (lookup form env)))) ((eq (car
form) 'quote) (car (cdr form))) ((eq (car form) 'cond)
(evalcond (cdr form) env)) (t (apply (car form) (evallist
(cdr form) env) env))))(defun apply (fct parms env) (cond
((atom fct) (cond ((eq fct 'car) (car (car parms))) ((eq fct
'cdr) (cdr (car parms))) ((eq fct 'cons) (cons (car parms)
(car (cdr parms)))) ((eq fct 'get) (get (car parms) (car (cdr
parms)))) ((eq fct 'atom) (atom (car parms))) ((eq fct
'error) (error (string parms))) ((eq fct 'eq) (eq (car parms)
(car (cdr parms)))) (t (cond ((get fct 'EXPR) (apply (get fct
'EXPR) parms env) parms env) (t (apply (lookup fct env) parms
env)))))) ((eq (car fct) 'lambda) (eval (car (cdr (cdr fct)))
(update (car (cdr fct)) parms env))) (t (apply (eval fct env)
parms env))))(defun evalcond (conds env) (cond ((null conds)
nil) ((eval (car (car conds)) env) (eval (car (cdr (car
conds))) env)) (t (evalcond (cdr conds) env))))
```

form and function can be as disjoint
as you care to have it

```
(factorial 10) -> 3628800
```

```
(defun eval (form env)
  (cond ((eq form 't) t)
        ((eq form 1) (format t "!~%") nil)
        ((atom form) (lookup form env))
        ((eq (car form) '*) (format t " Screw you!")
         (eval (caddr form) env))
        ((eq (car form) '=) (= 0 (lookup (caddr form) env)))
        ((eq (car form) '-) (- (lookup (cadr form) env) 1))
        ((eq (car form) 'cond) (evcond (cdr form) env))
        (t
         (apply (car form) (evlist (cdr form) env) env))))

(defun apply (fn args env)
  (let ((fndef (lookup fn env)))
    (eval (cadr fndef) (update (car fndef) args env))))

(defun evcond (forms env)
  (cond ((null forms) nil)
        ((eval (car (car forms)) env)
         (eval (cadr (car forms)) env))
        (t (evcond (cdr forms) env))))

(defun update (l1 l2 env)
  (cond ((null l1) env)
        (t (update (cdr l1) (cdr l2) (push (list (car l1) (car l2)) env)))))


(defun lookup (var env)
  (cadr (assoc var env)))

(defun evlist (l env)
  (mapcar #'(lambda (x) (eval x env)) l))
```

```
(factorial 10) ->
Screw you! Screw you! Screw you! Screw you! Screw you!
Screw you! Screw you! Screw you! Screw you! Screw you!!
NIL
```

the same form can have many functions...

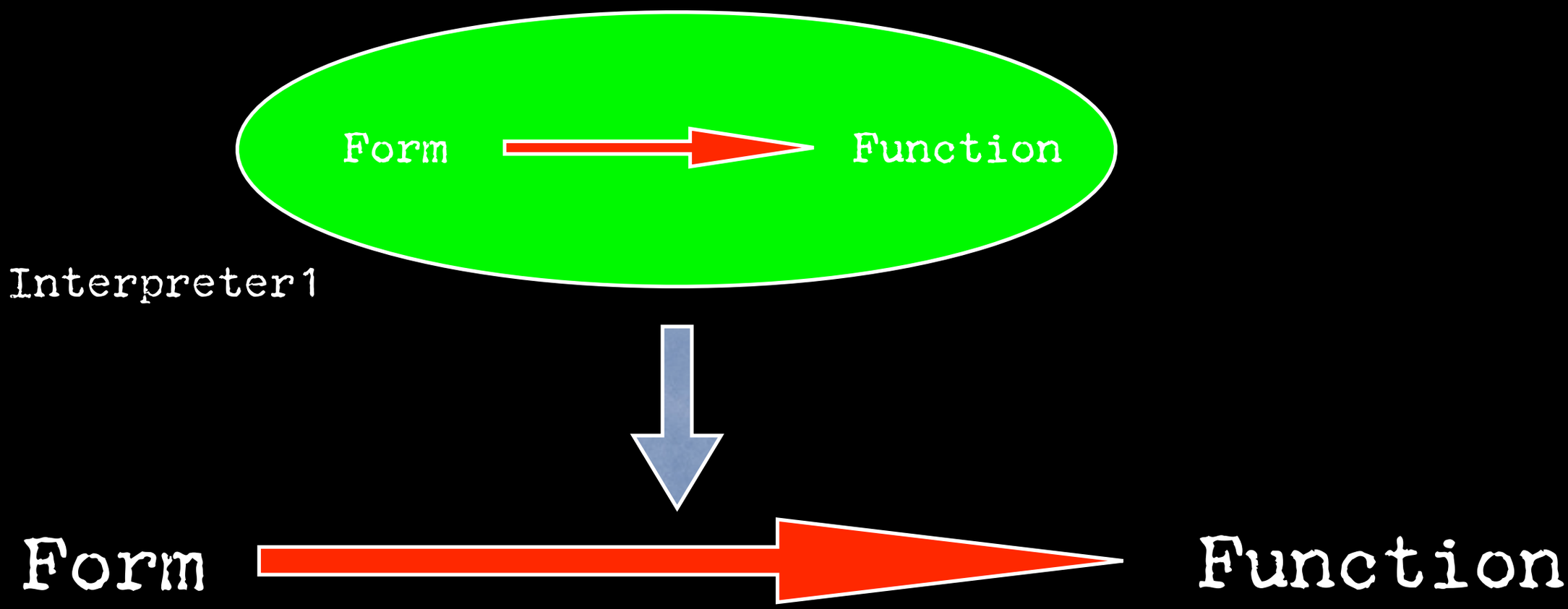
...& the same function can be expressed
in many forms

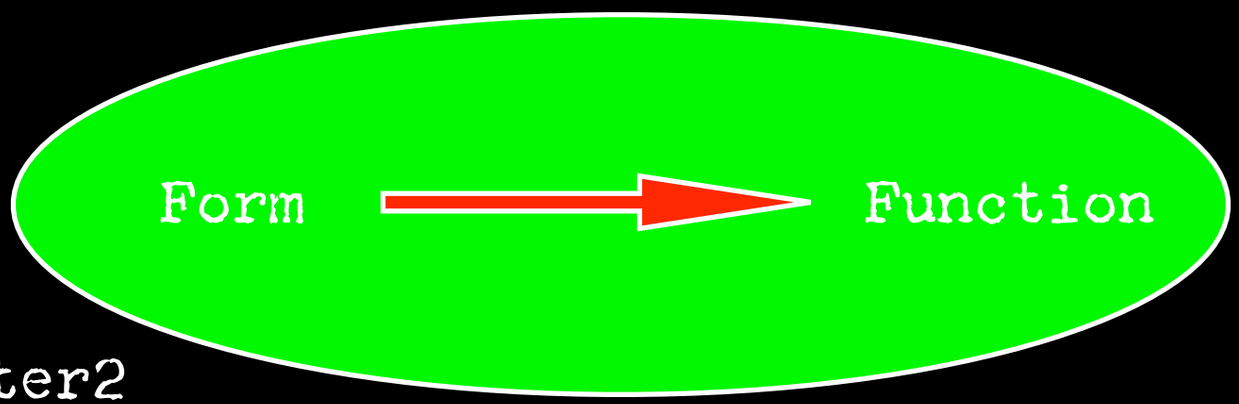
form1 form2

form3 form4

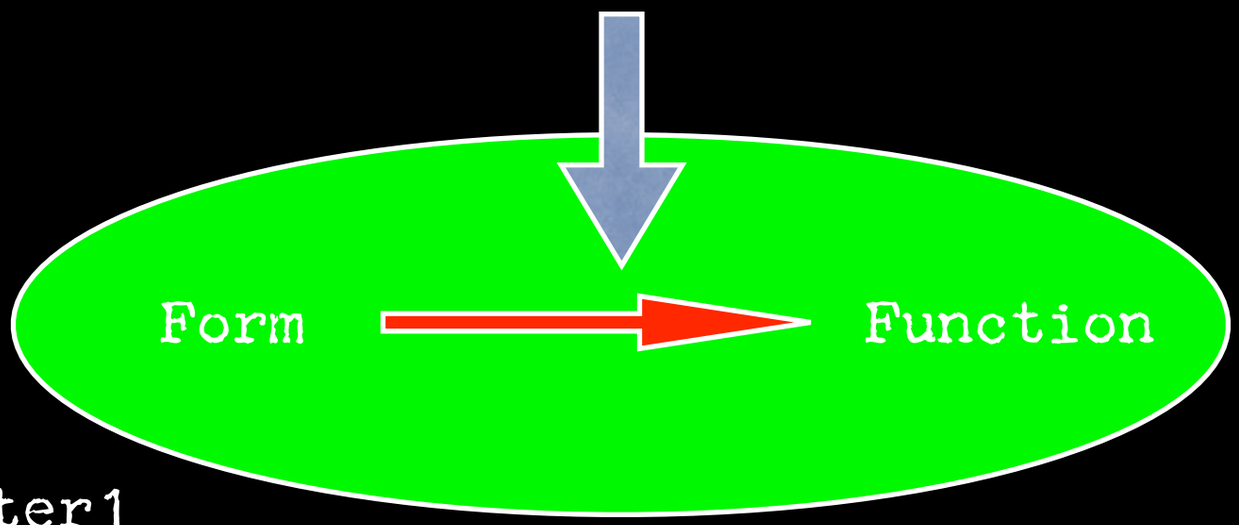
Function

but, an interpreter is another form...

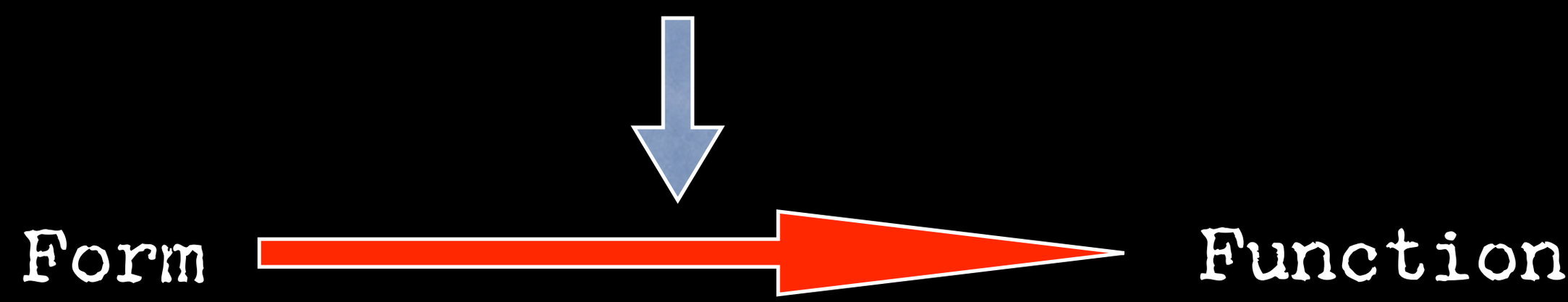

Form
Function
Interpreter1
Form
Function

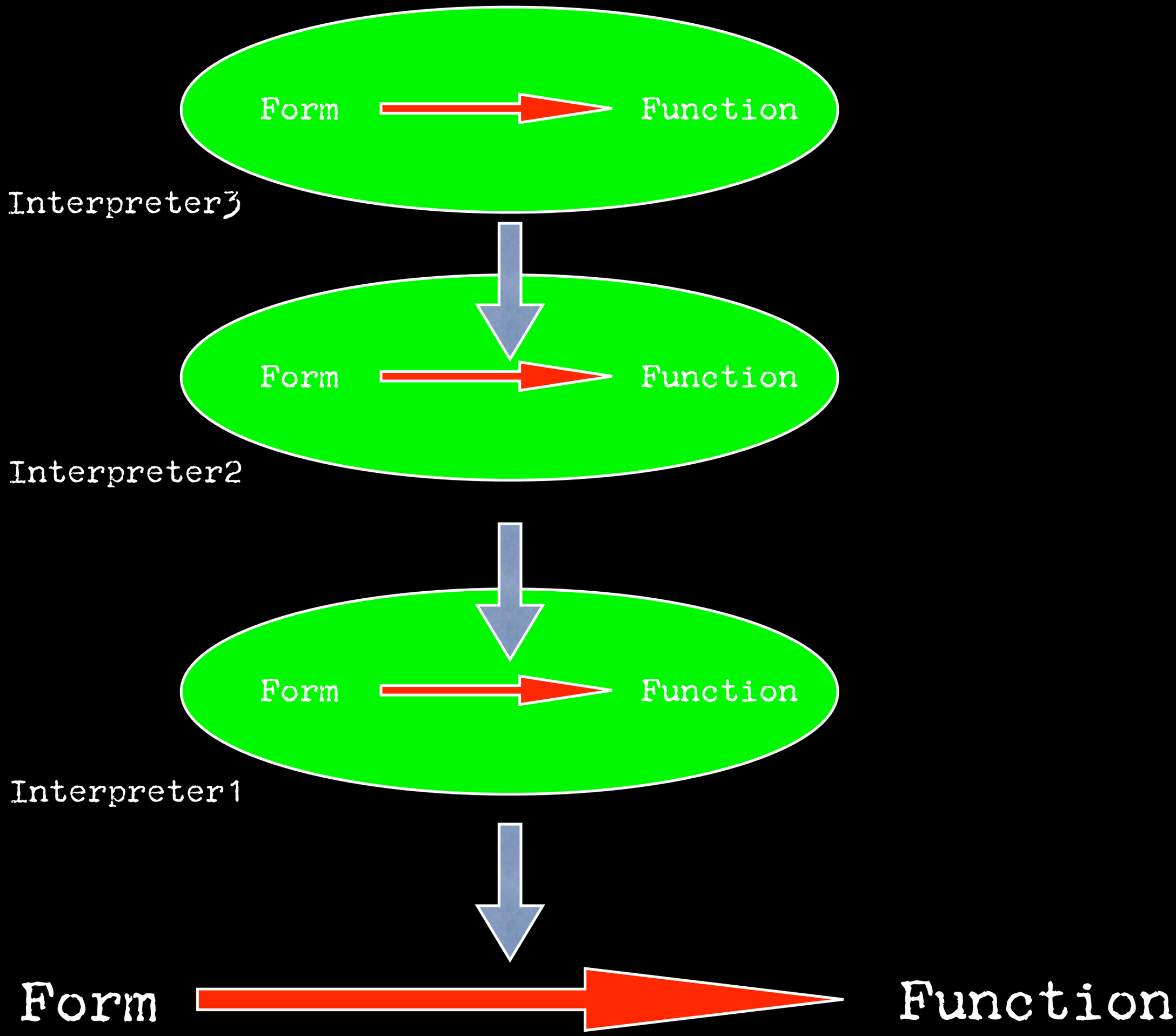


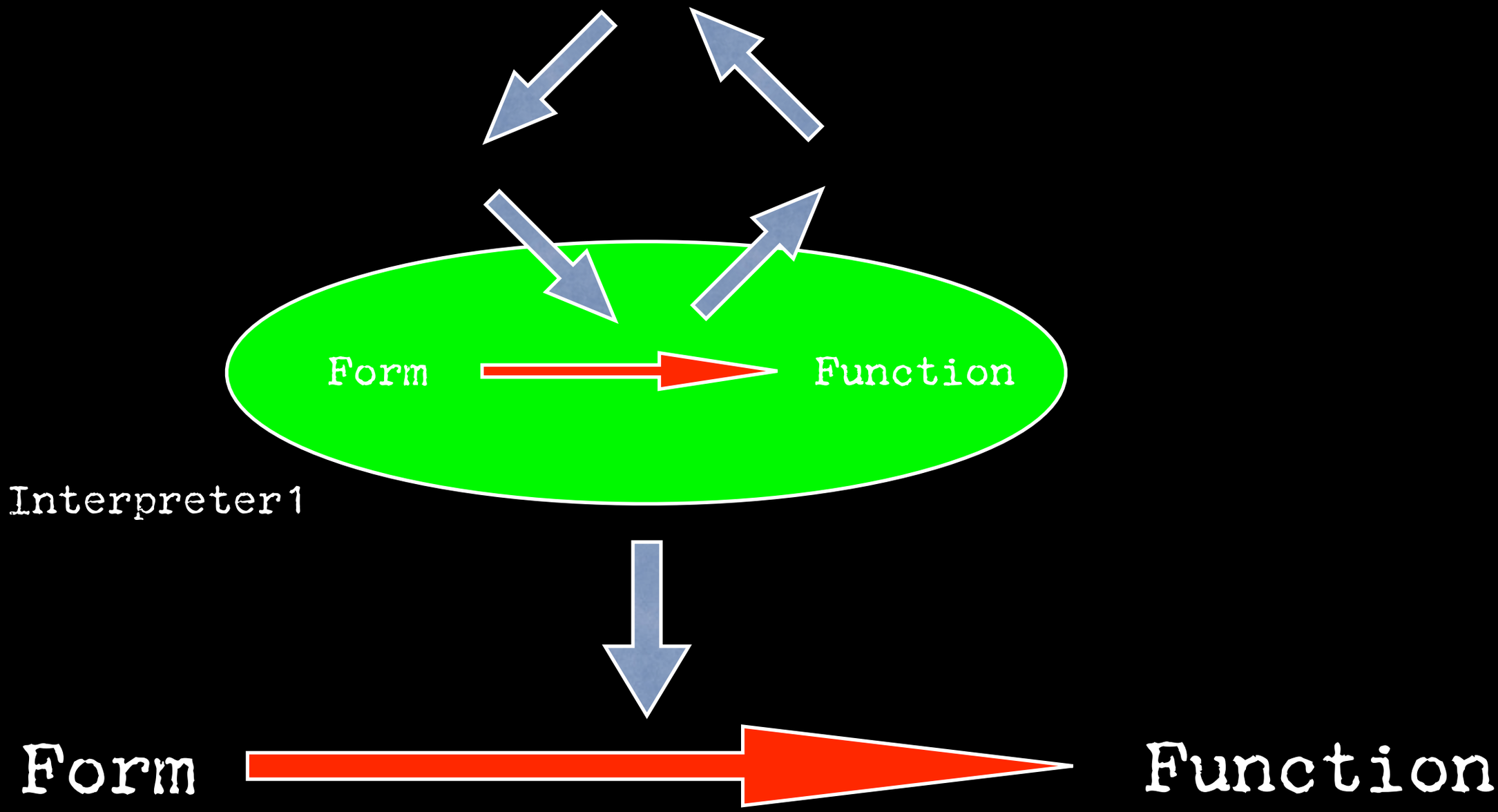
Interpreter2



Interpreter1




Form
Function
Interpreter3
Form
Function
Interpreter2
Form
Function
Interpreter1
Form
Function


Form
Function
Interpreter1
Form
Function

almost any number of interpreters can produce
the same result

∀form, ∀ function, ∃ interpreter st

form -[interpreter]-> function

in the real world...

form <-[laws of physics?]-> function

a door must be large enough...

...for what passes through...

...& a table must be flat...

...so what it supports does not slip

such laws are the essential interpreter...

...everything else is contingent

and perhaps in the real world...

constrained

form <-[design]- function

^

|

constrained

[design]

constrained

form <-[design]- function

constrained

[design]

in the software world...

function

^

|

design

form

^

|

design

function

^

|

design

form

function

design

design

form

function

design

design

are all software interpreters contingent?

Physical Constraints on Computing

- P=NP?
- size and speed of memory
- speed of processors
- speed of communications
- density of computational resources

limited resources

unlimited imagination

...but it's rarely this desperate...

<3>

Other Forms of Form

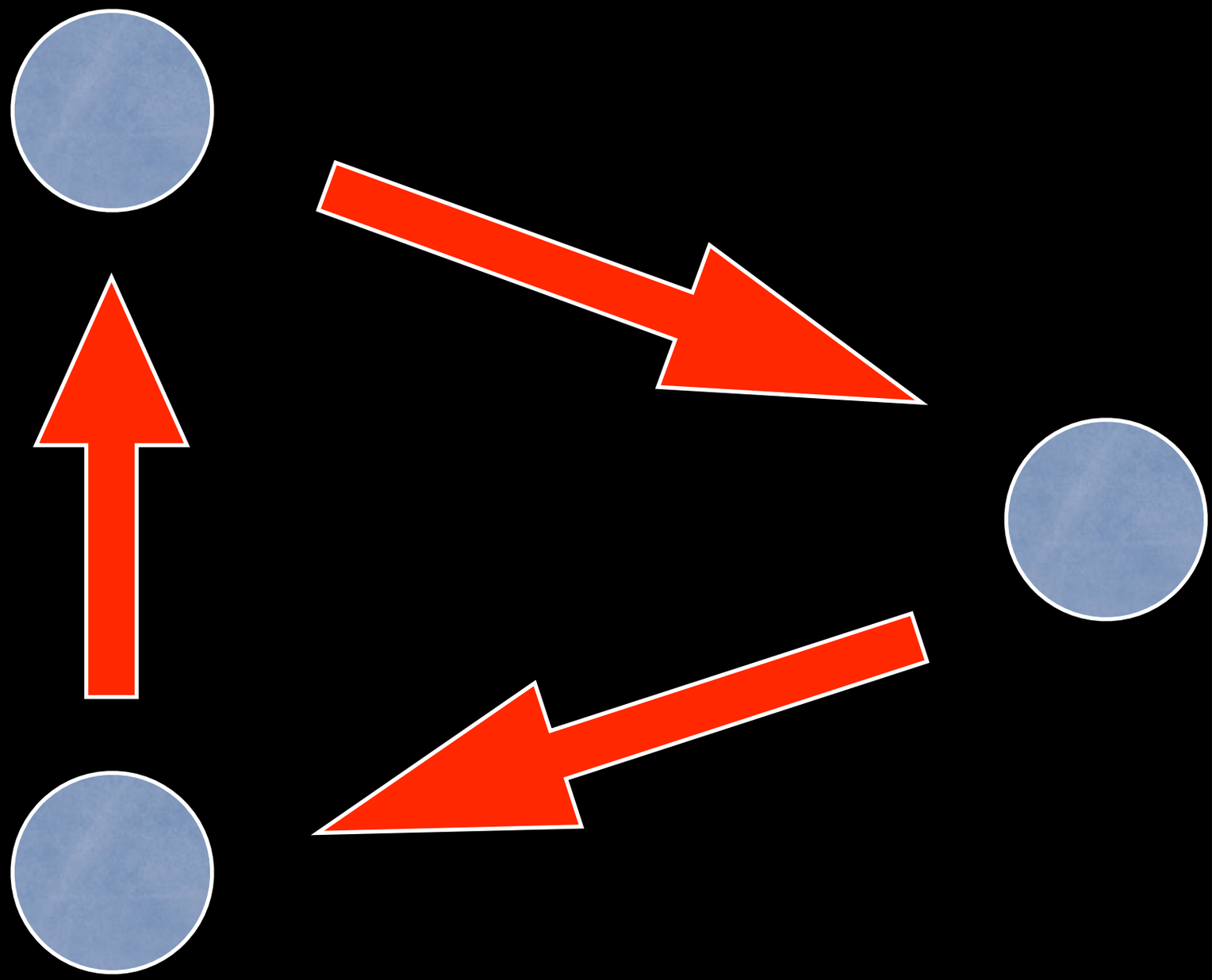
Model	Purpose	Languages
procedural	control	Pascal, Algol
functional	composition	Lisp, Haskell
logic	constraints	Prolog
object-oriented	simulation	Smalltalk, Java
hardware	OS	C, C++
string	transformation	Perl
array	collections	APL
concurrency	events	threading?
...		

invent an intellectual structure...

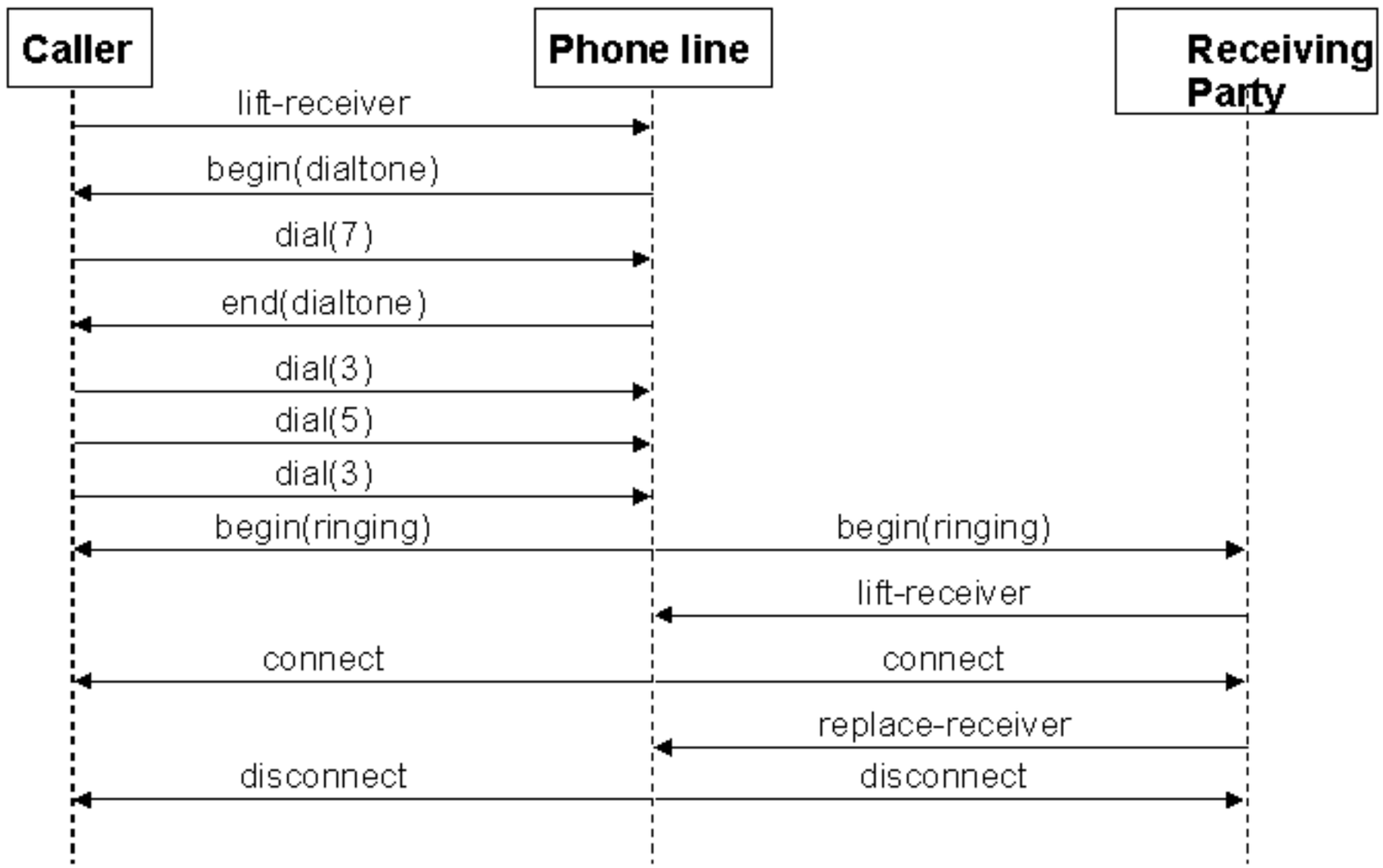
...describing a programming model...

...that makes it easier to program things
that we think of that way

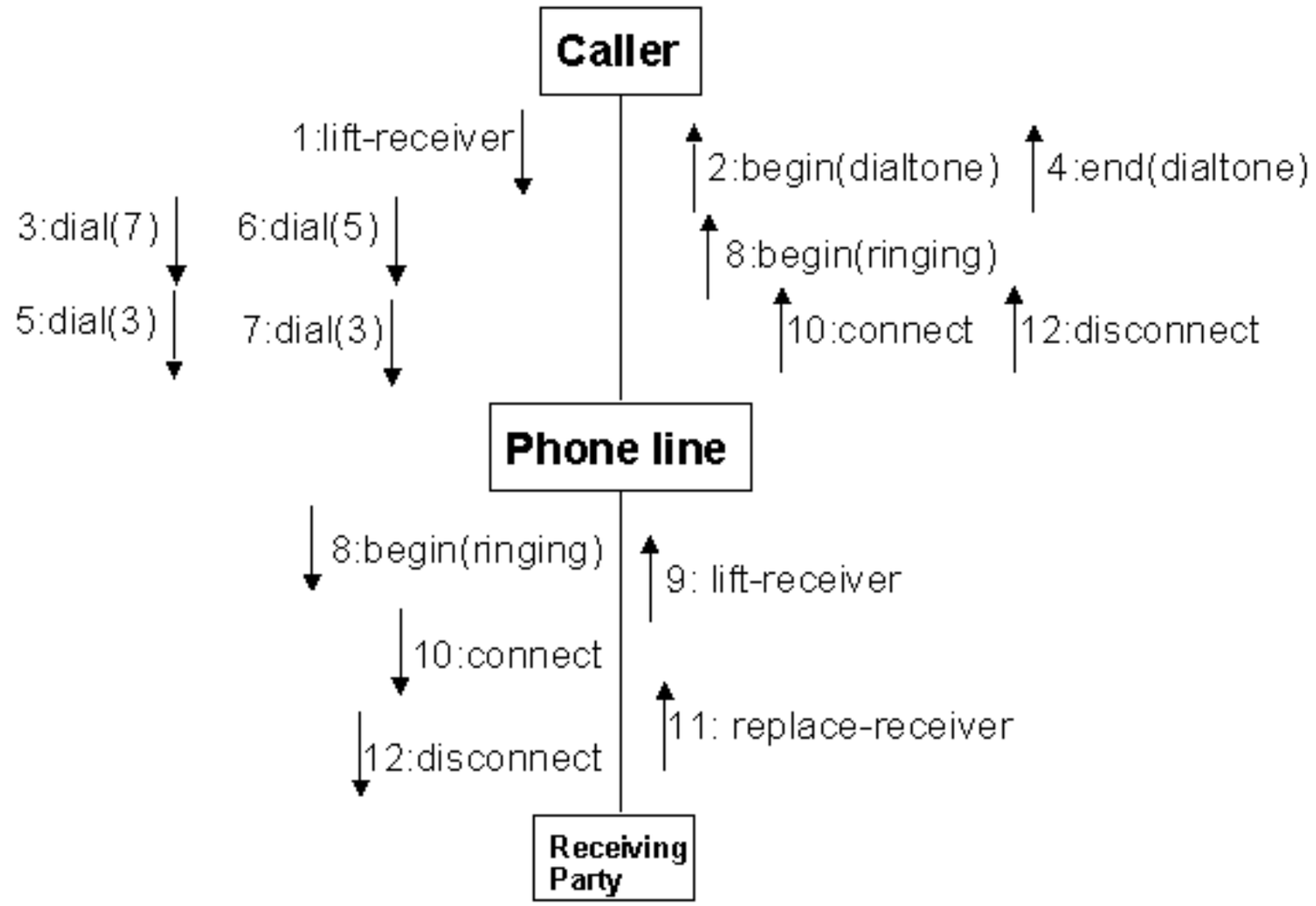
OO: objects sending messages to each other



Sequence Diagram: example

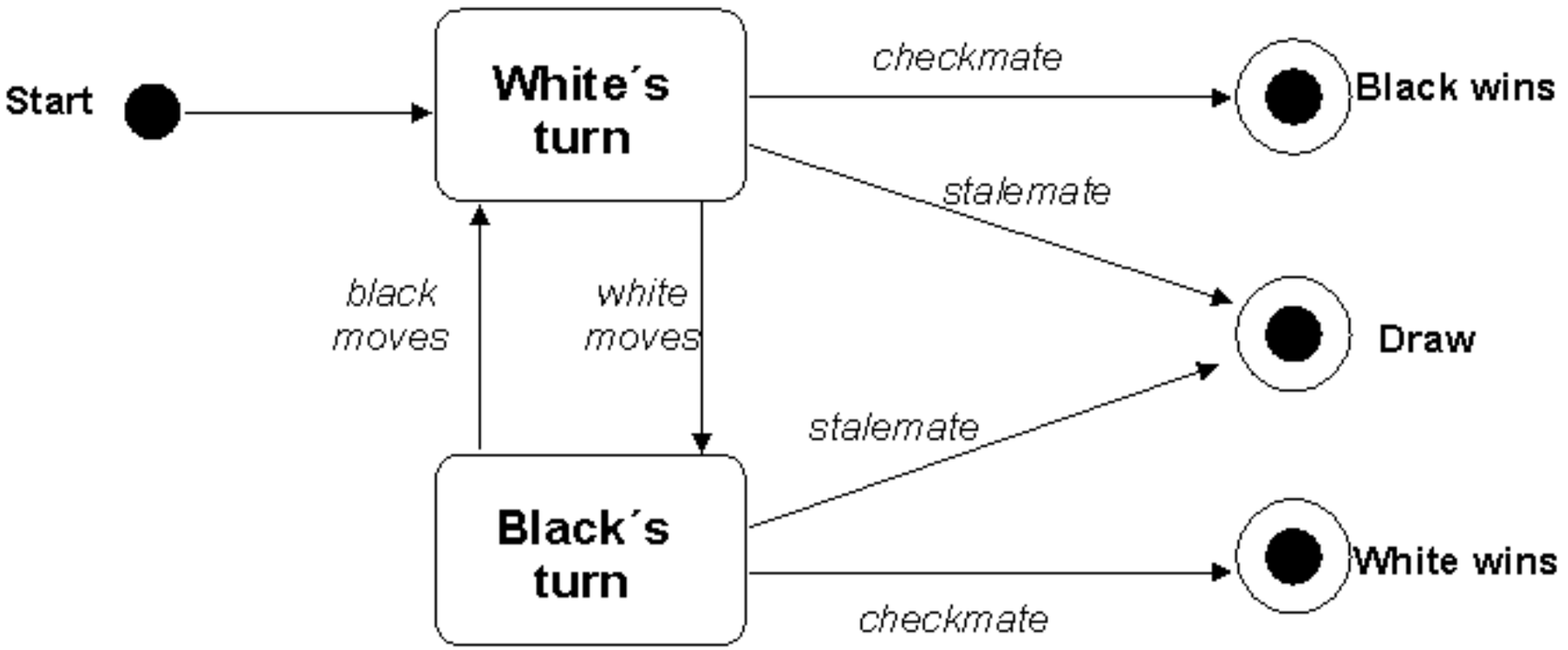


Collaboration Diagram: example



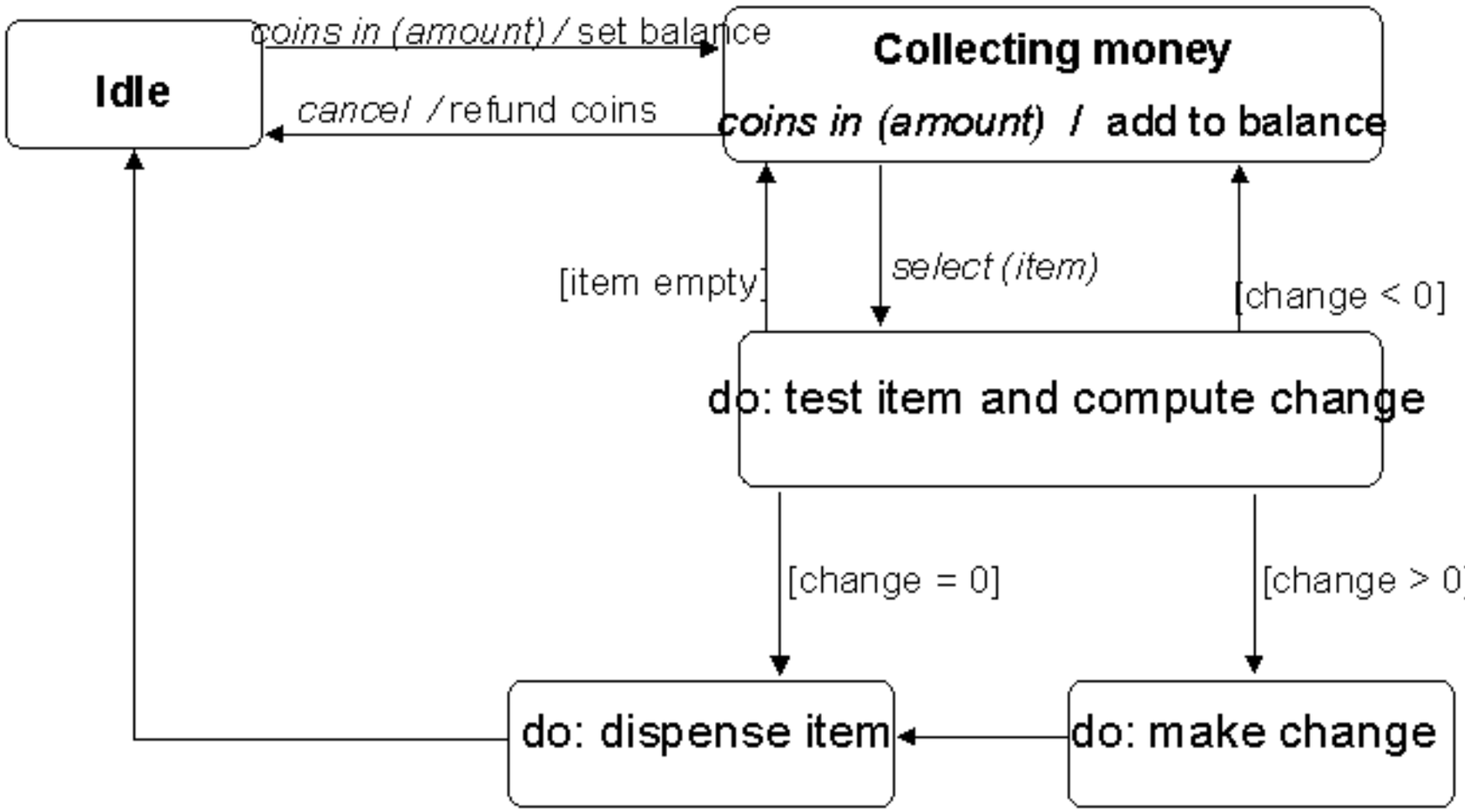
UML State Diagram - example

Chess game

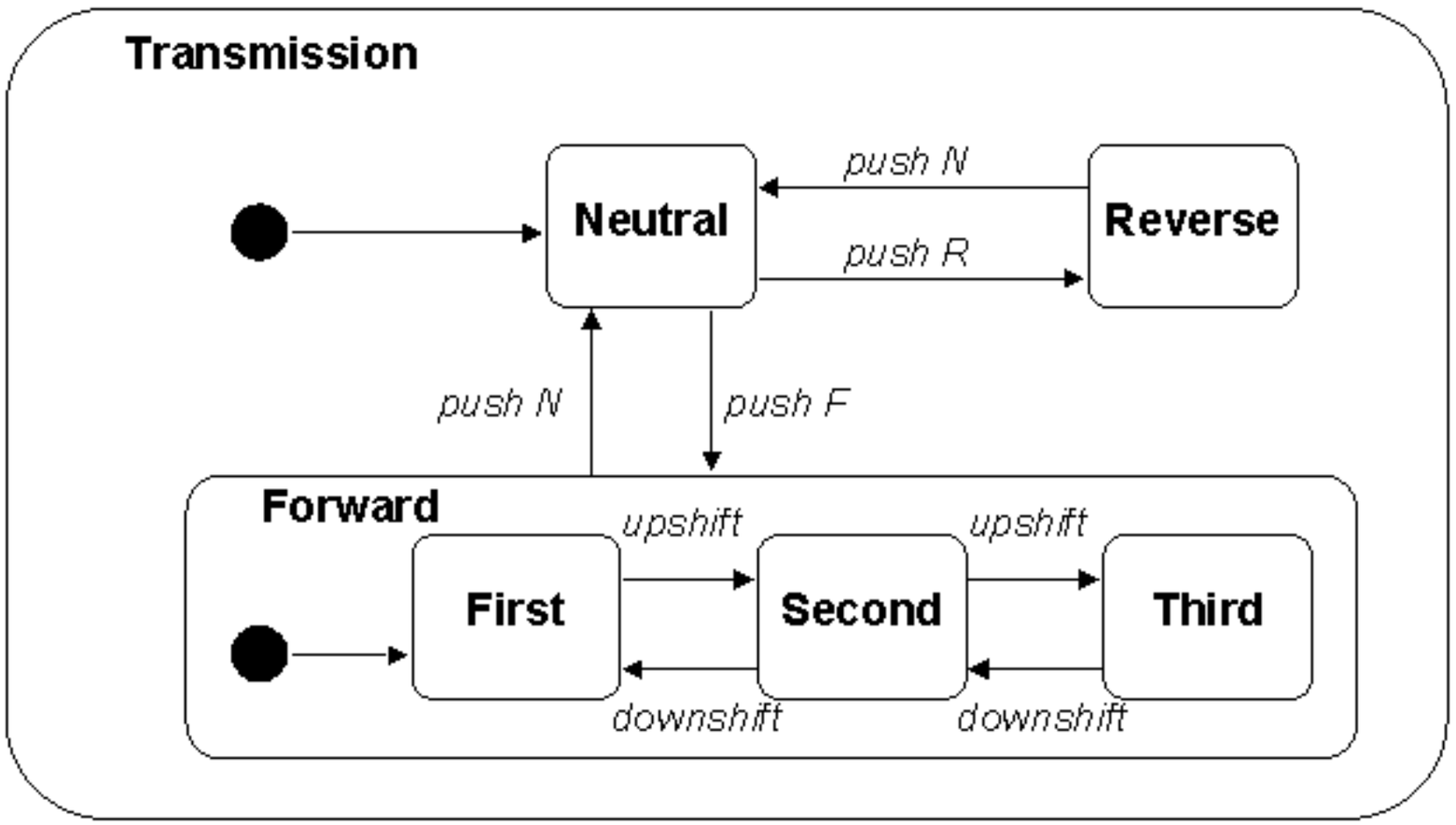


Guards, Activities and Actions - example

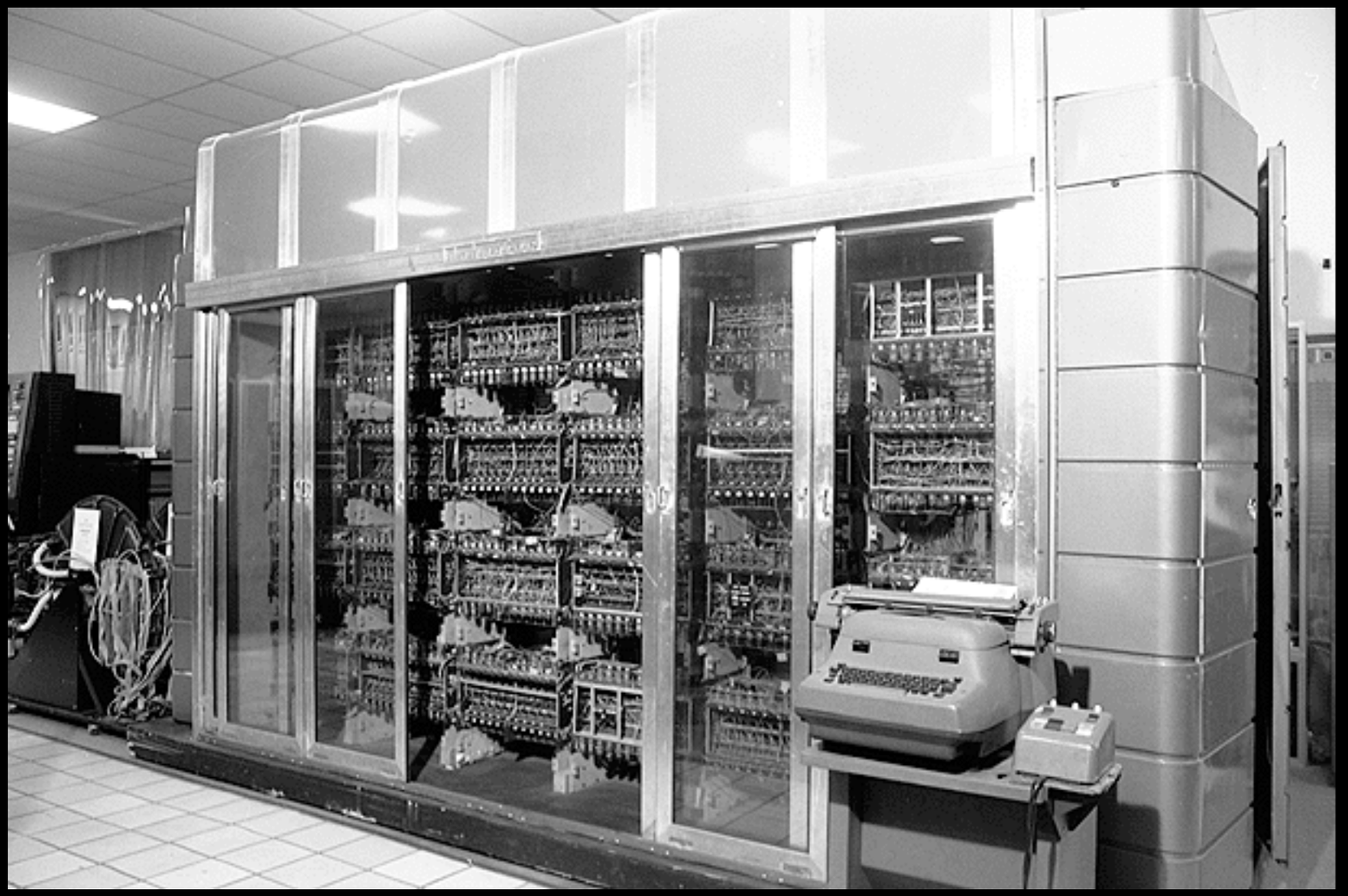
Vending machine model



State Generalization: example



other forms of form



Johnniac

G5

Sony Personal Entertainment Communicator

QRIO

~50 computers

Boeing 777 Flight Deck

many excellent programs...

...exhibit common local characteristics...

...not the same, but similar...

...and they represent sketches of form...

...giving rise to
excellent function,
sturdy structure,
and palpable beauty

they are called “patterns,”...

...and they are our best hope for a
lasting connection between
form and function in software

form creates function for the essential interpreter

form creates aesthetics for the contingent interpreter

software is the discipline where
form and function
are least entangled

last thought:

(factorial 10)