

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

<2>

```
(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))

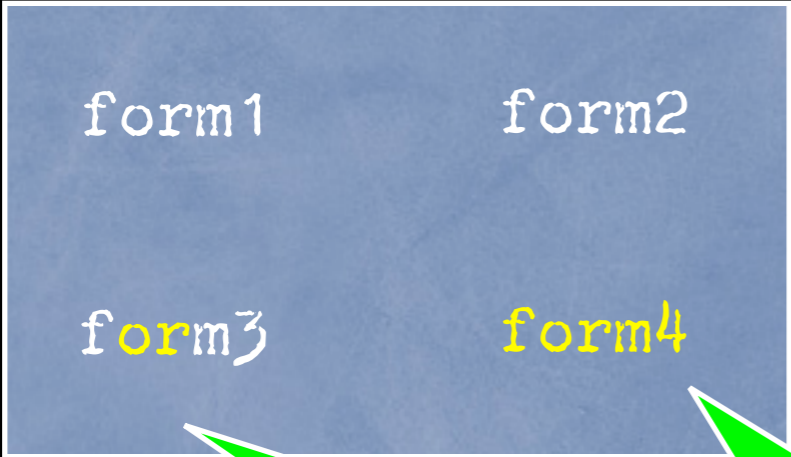
```

(factorial 10) ->

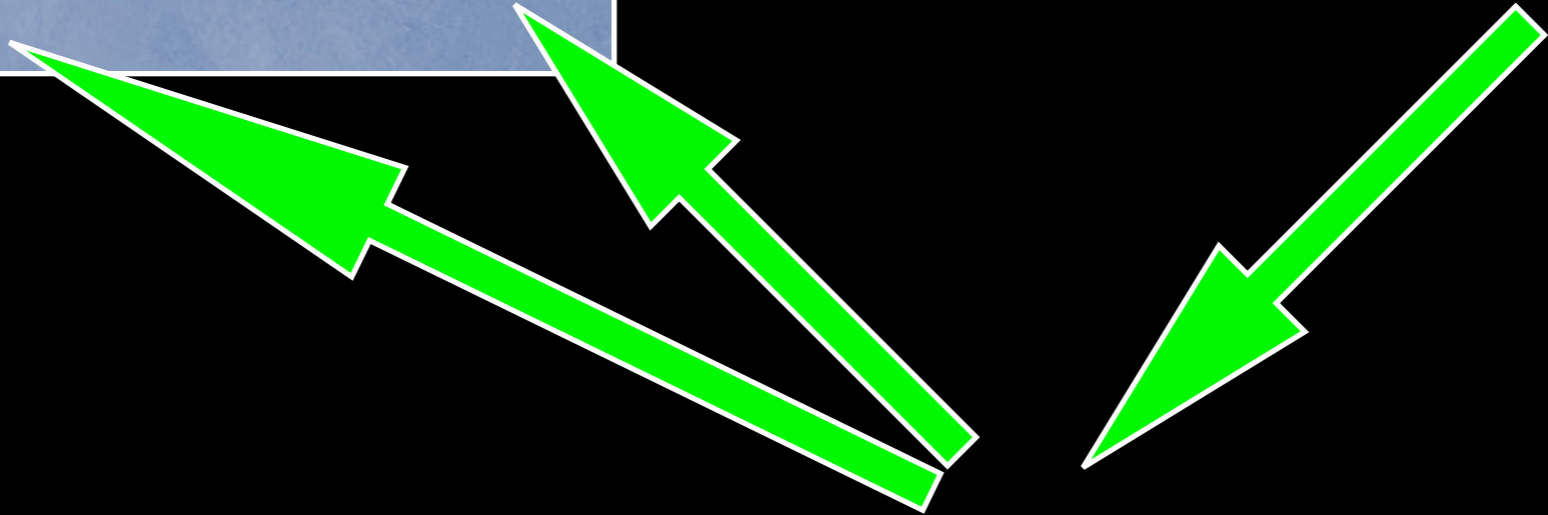
Screw you! Screw you! Screw you! Screw you! Screw you!
Screw you! Screw you! Screw you! Screw you! Screw you!!
NIL

the same form can have many functions...

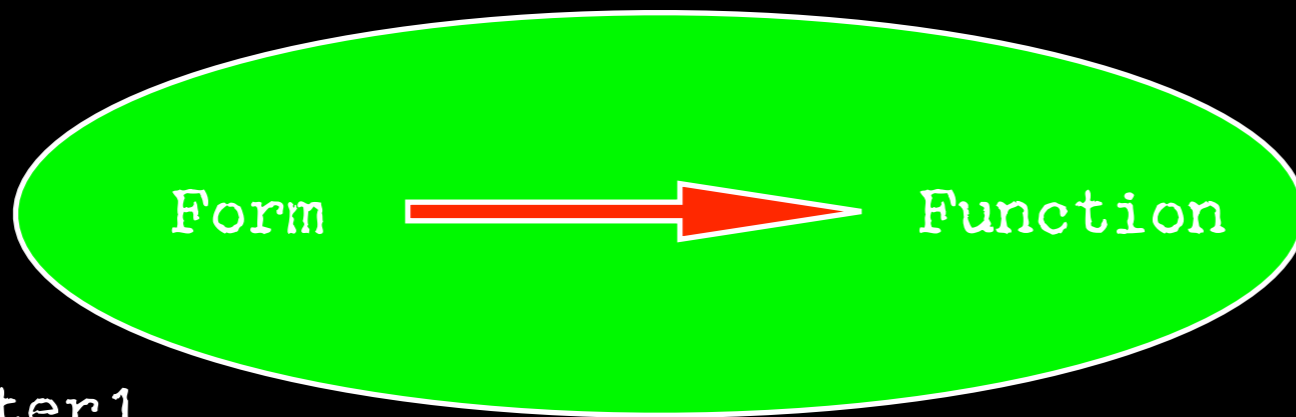
... & the same function can be expressed
in many forms



Function



but, an interpreter is another form. . .



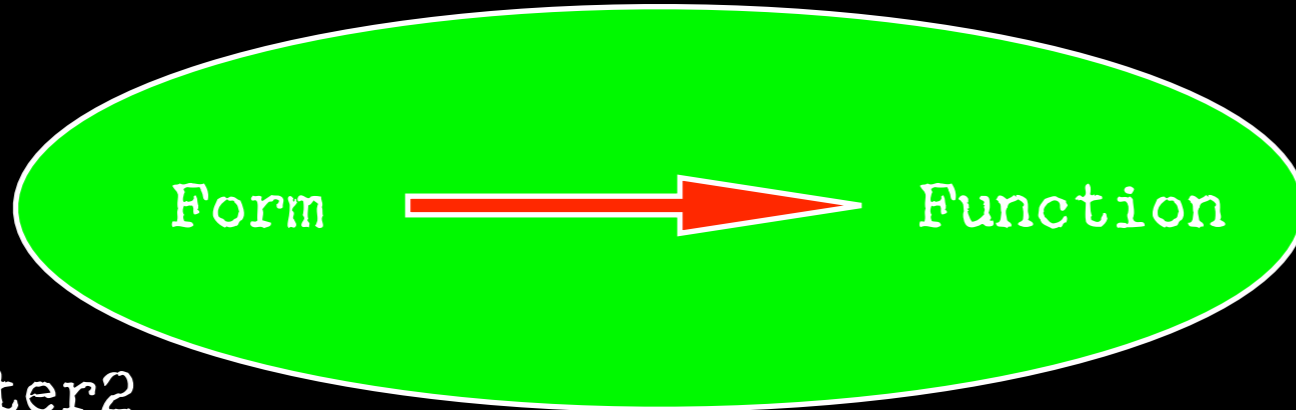
Interpreter 1



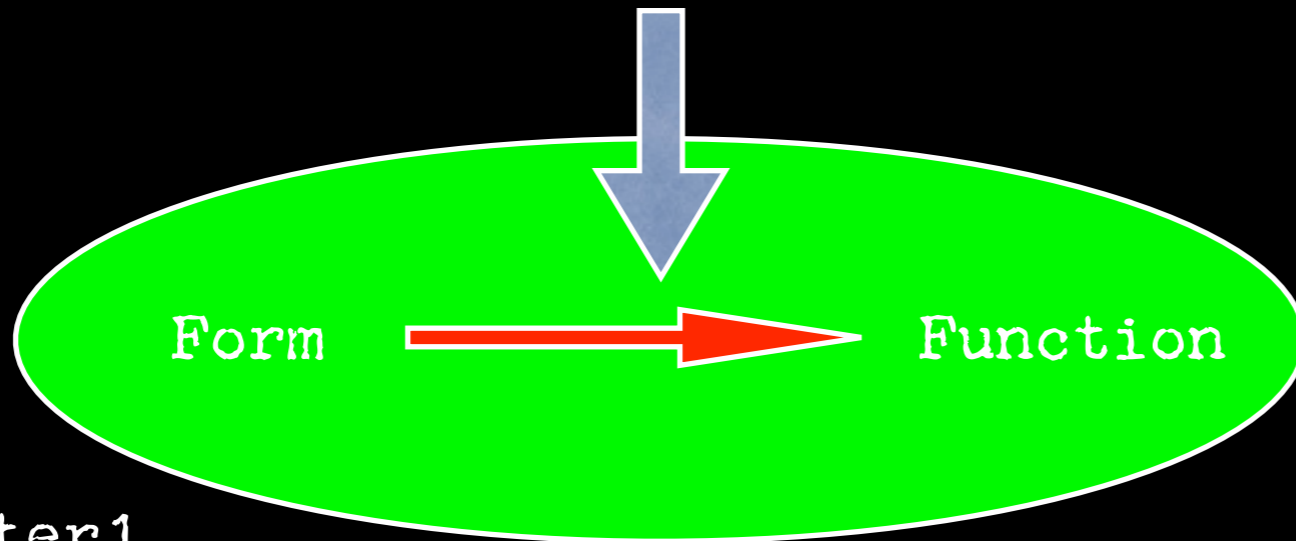
Form



Function



Interpreter2



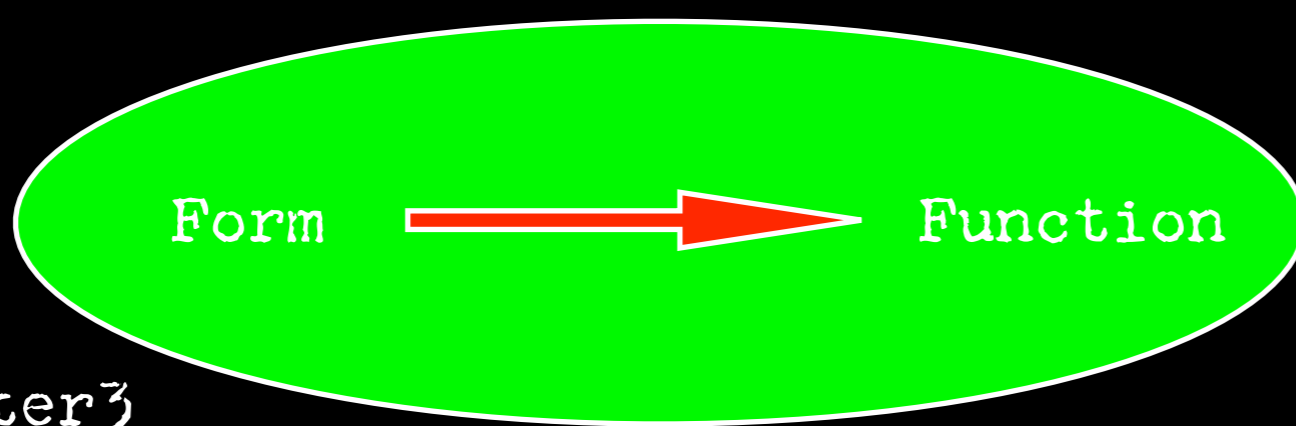
Interpreter1

Form

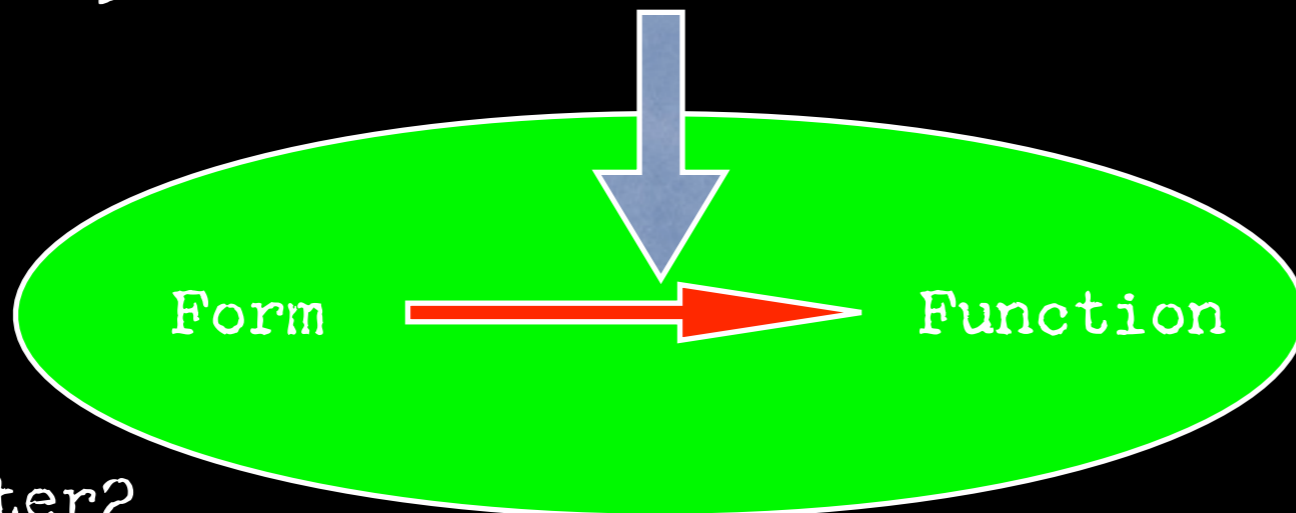


Function

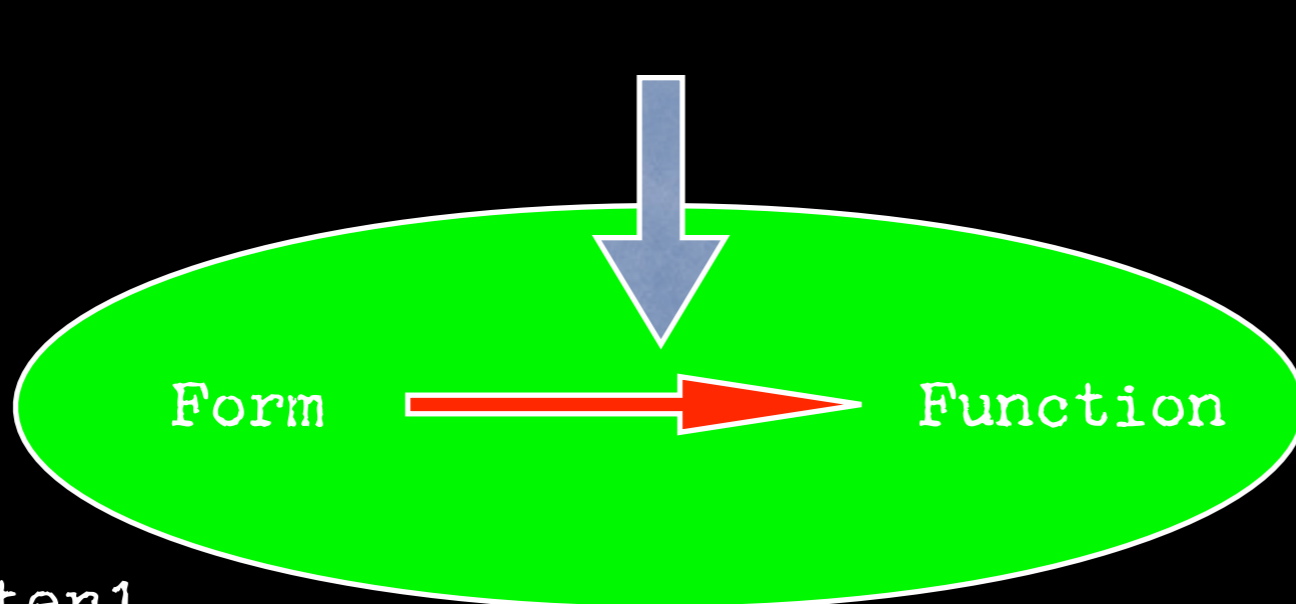
Interpreter3



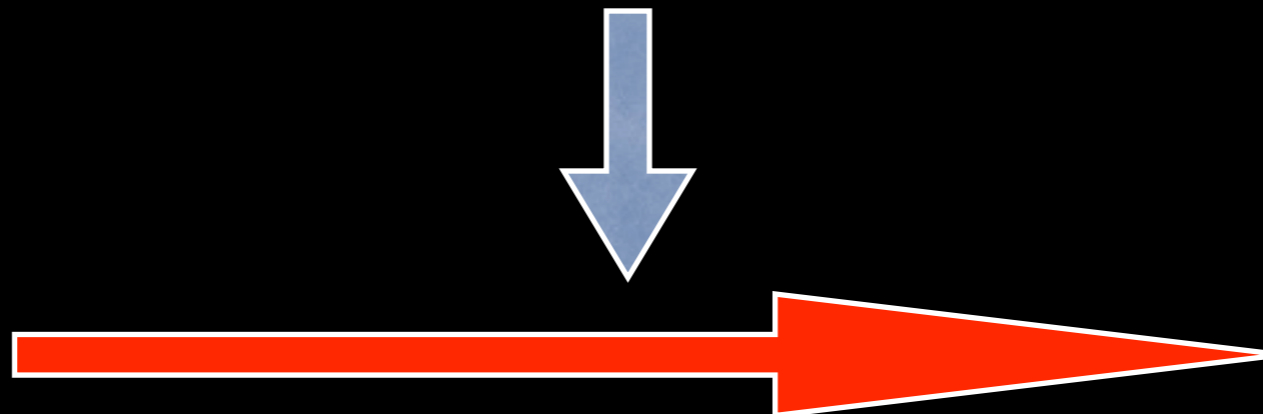
Interpreter2



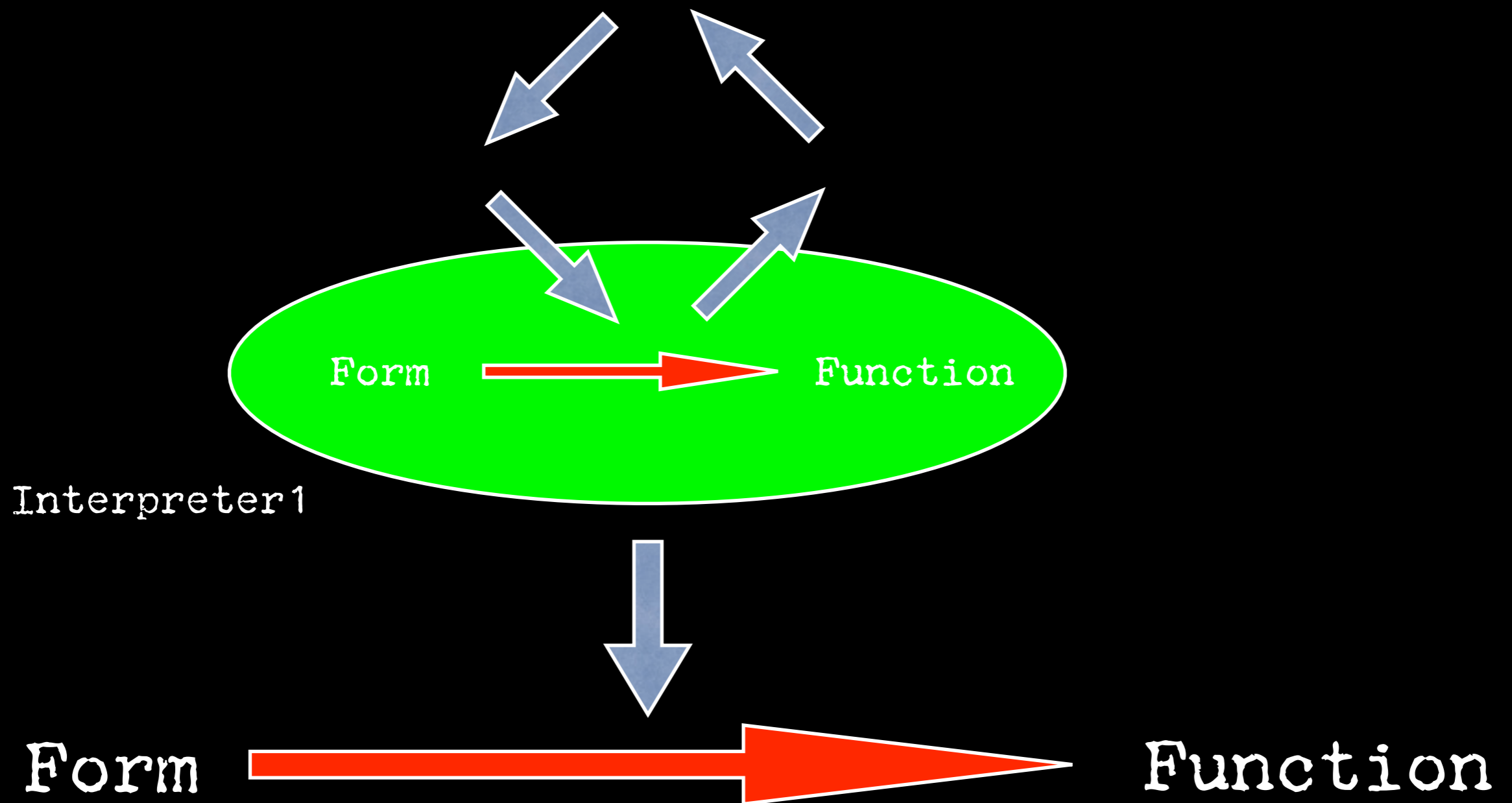
Interpreter1



Form



Function



almost any number of interpreters can produce
the same result

$\forall \text{form}, \forall \text{function}, \exists \text{ interpreter st}$
 $\text{form} \rightarrow [\text{interpreter}] \rightarrow \text{function}$

in the real world...

form \leftarrow [laws of physics?] \rightarrow 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...

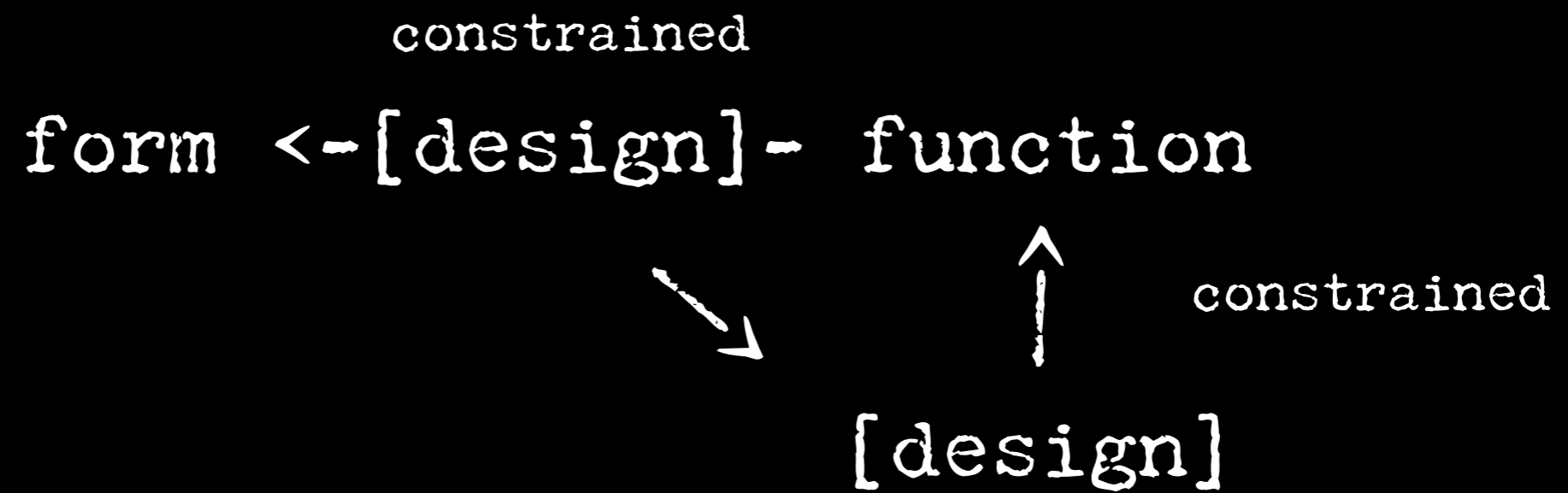
constrained

form \leftarrow [design] - function

↑ constrained

[design]

The diagram illustrates a constrained function form. At the top, the word "constrained" is centered. Below it, the text "form \leftarrow [design] - function" is displayed. Underneath the "[design]" part of this line, there is an upward-pointing arrow. To the right of the arrow, the word "constrained" is written. At the bottom of the diagram, the text "[design]" is centered, indicating that this design is the constraint for the function above.



in the software world...

function

^

|

design

form
^
↓
design

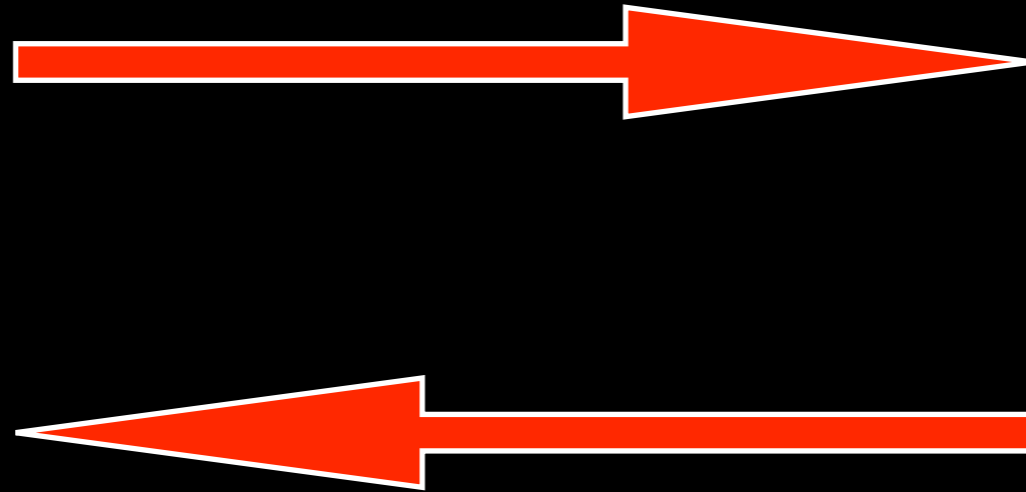
function
^
↓
design

form
^
↓
design



function
^
↓
design

form
^
↓
design



function
^
↓
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

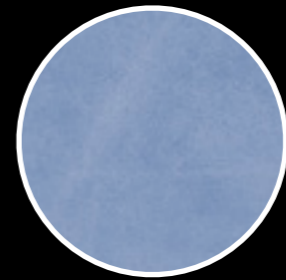
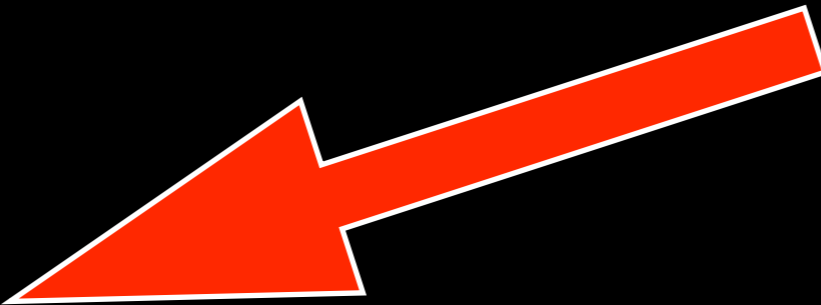
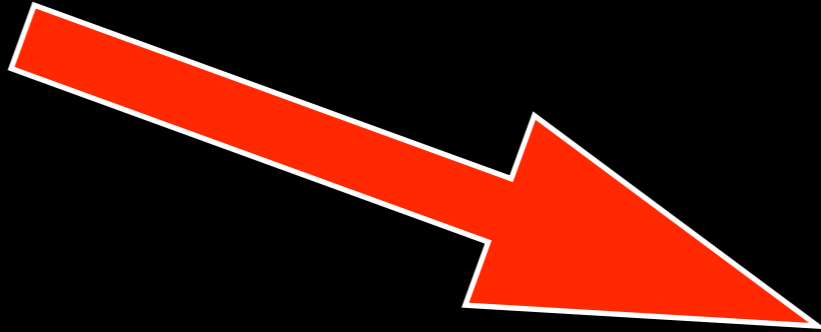
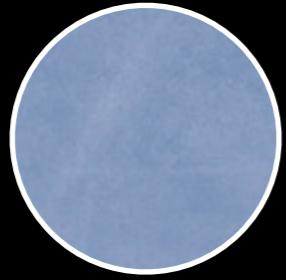
| Model | Purpose | Languages |
|-----------------|----------------|-----------------|
| procedural | control | Pascal, Algol |
| functional | composition | Lisp, Haskell |
| logic | constraints | Prolog |
| object-oriented | simulation | Smalltalk, Java |
| hardware | OS | C, C++ |
| string | transformation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

invent an intellectual structure...

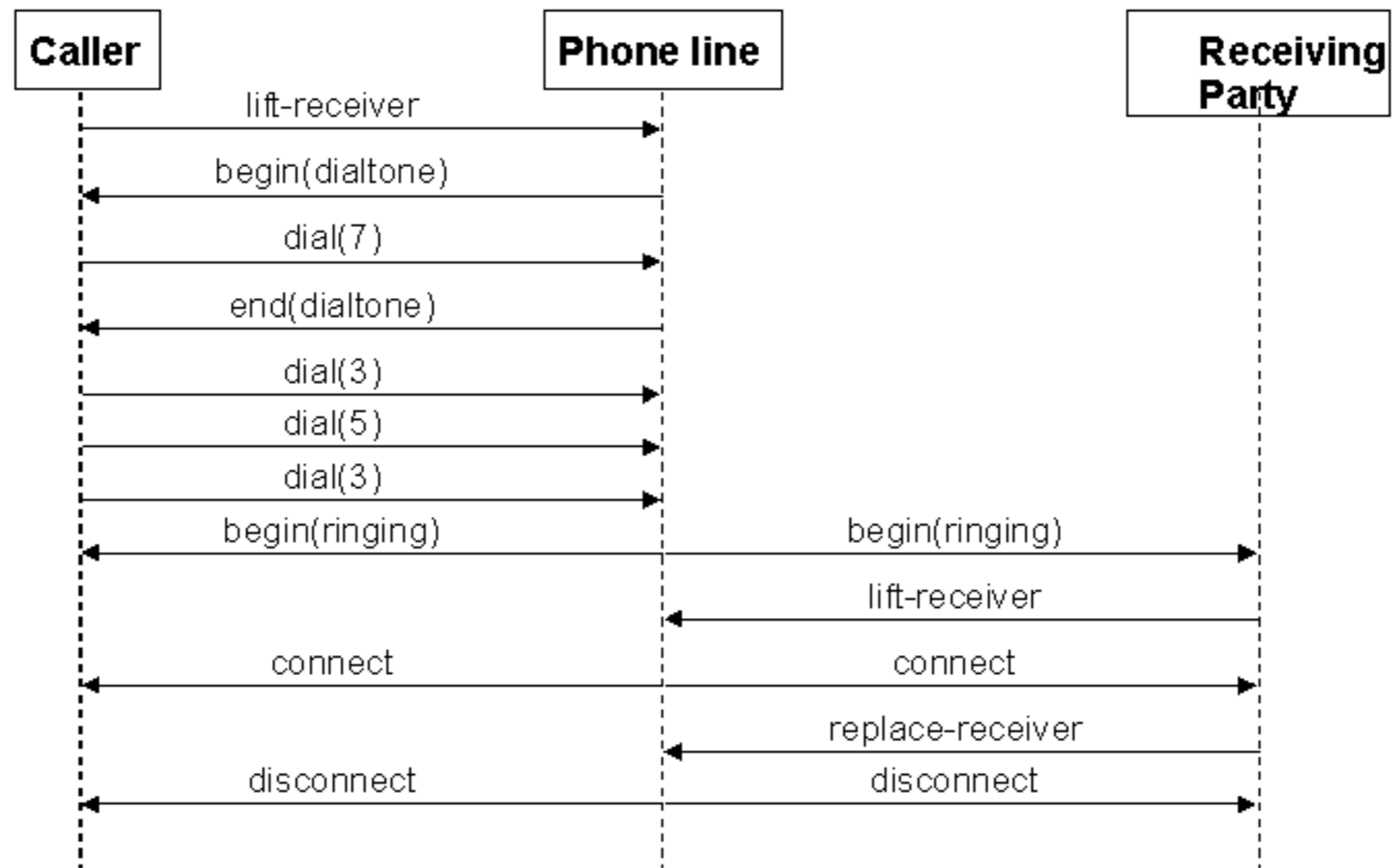
...describing a programming model...

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

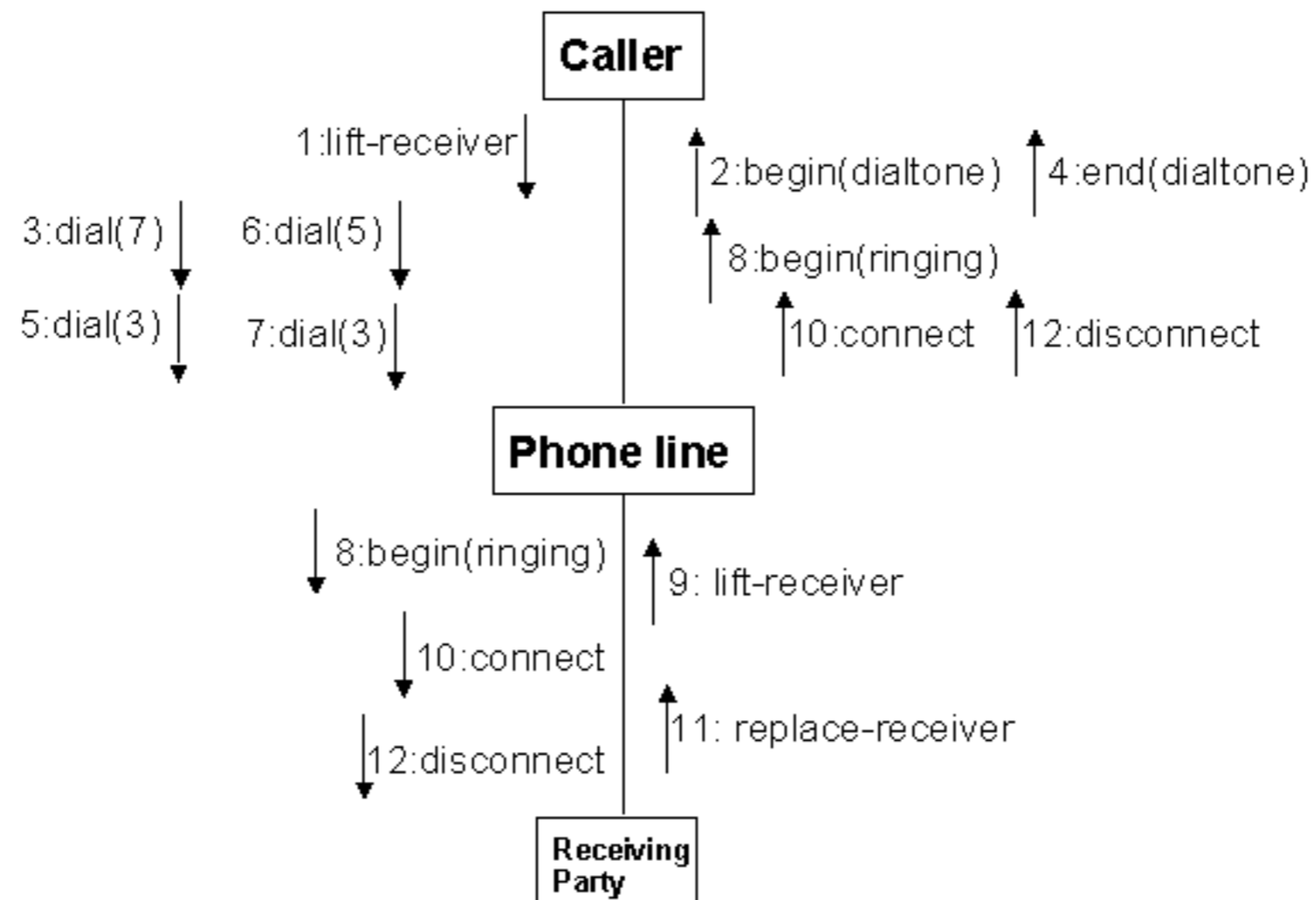
00: objects sending messages to each other



Sequence Diagram: example

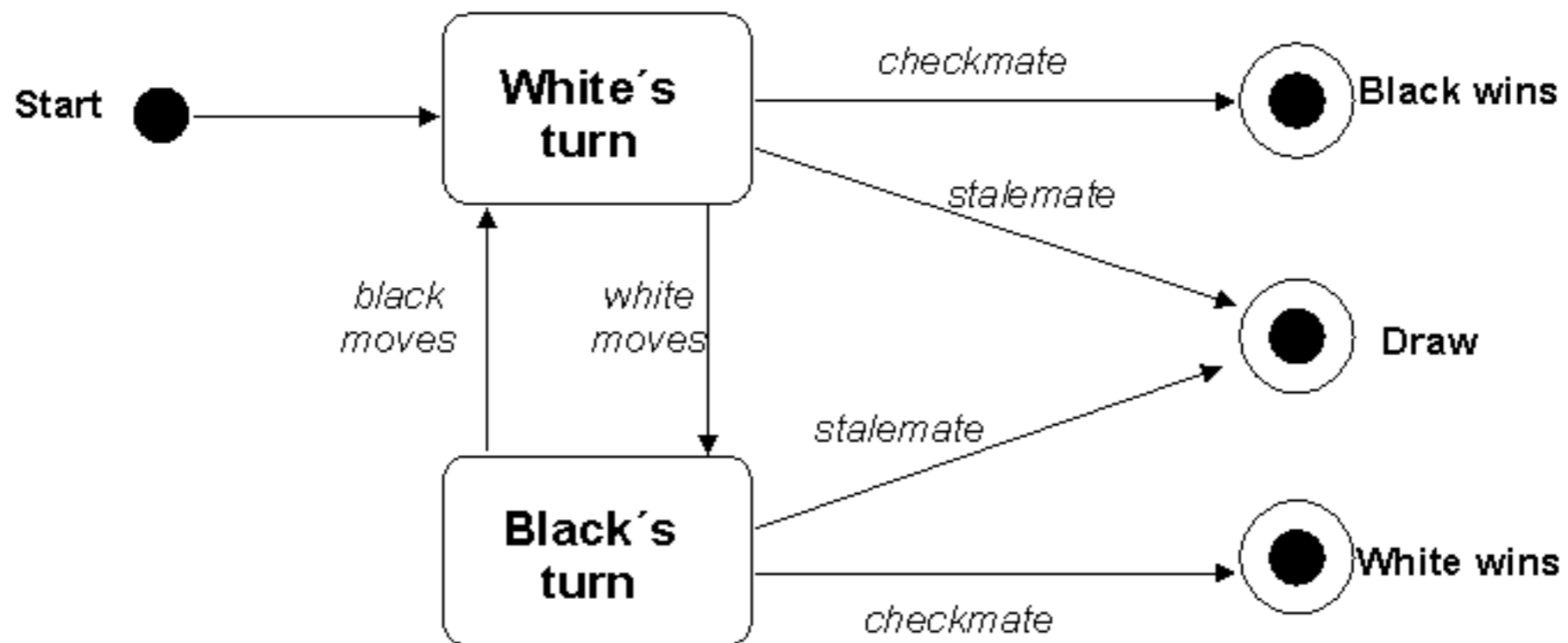


Collaboration Diagram: example



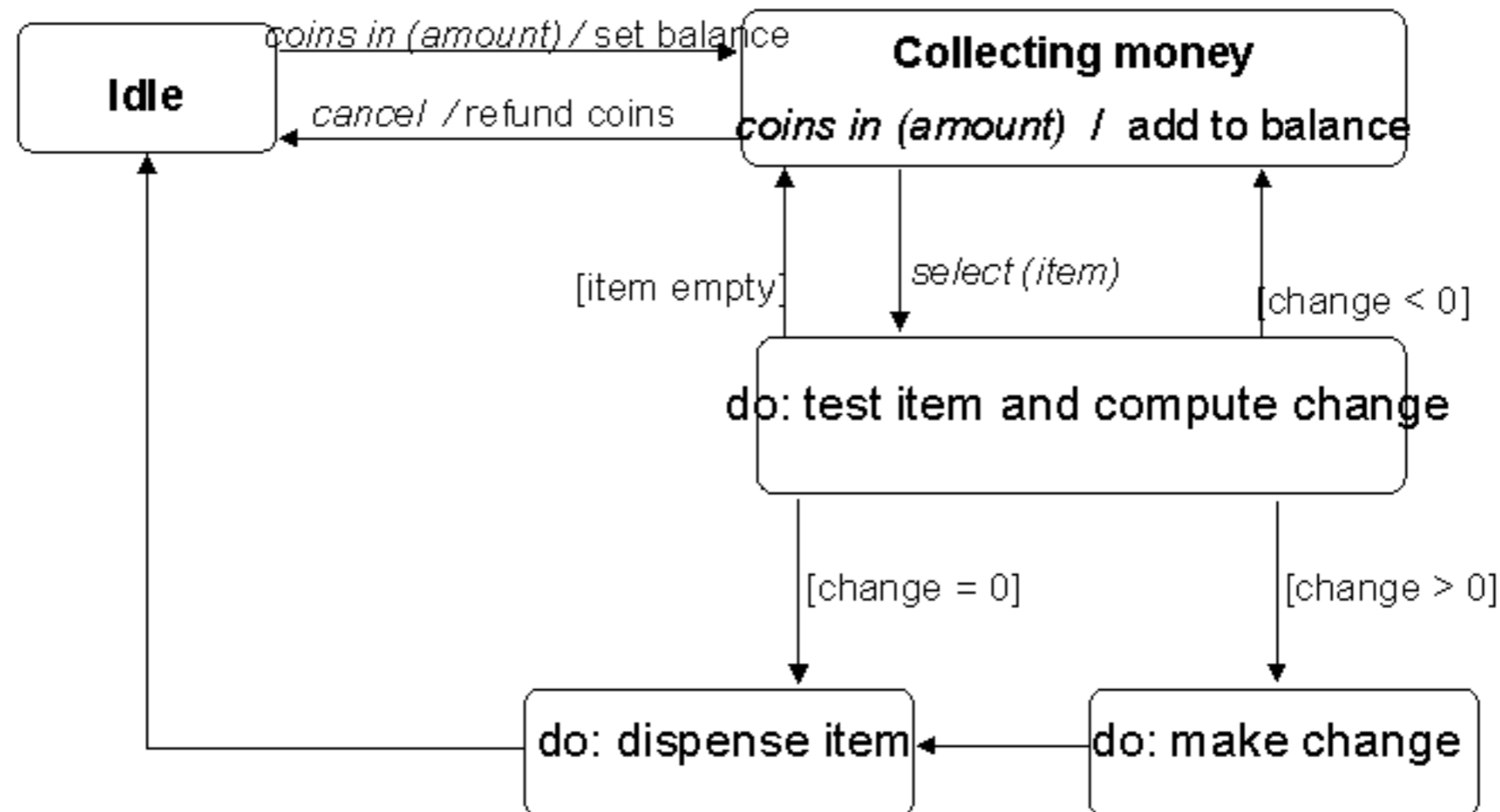
UML State Diagram - example

Chess game

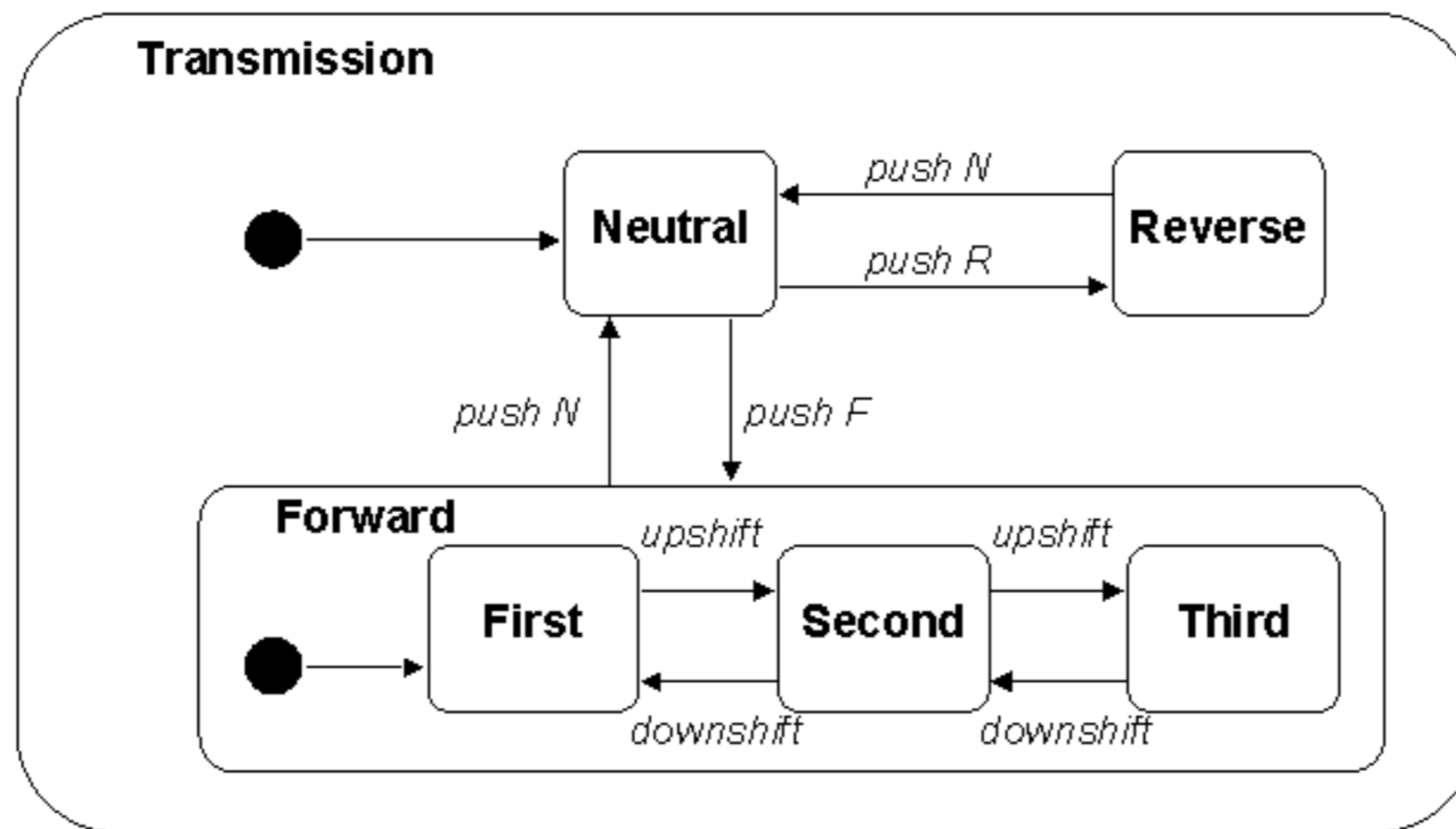


Guards, Activities and Actions - example

Vending machine model

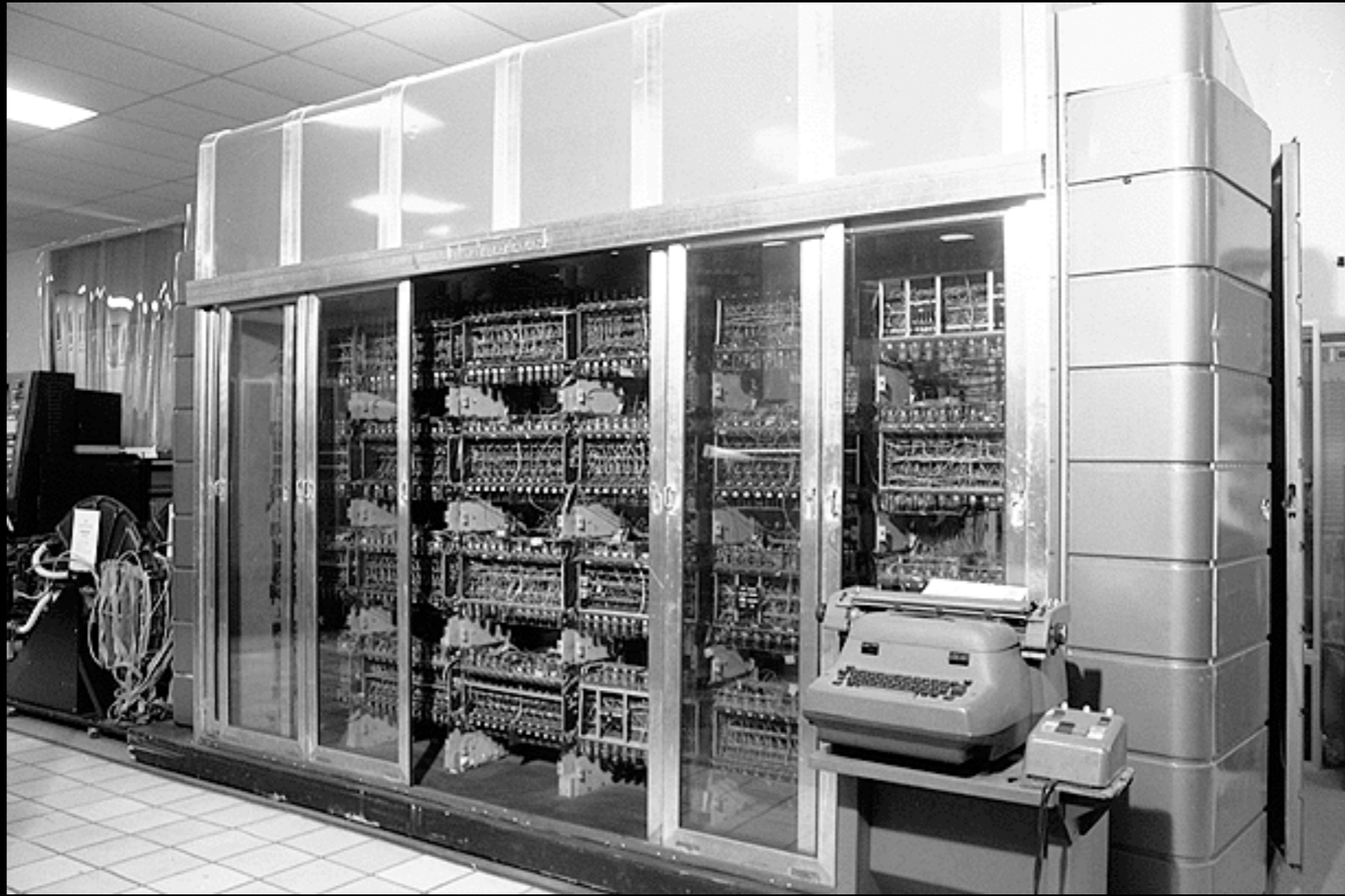


State Generalization: example



<4>

other forms of form



Johnniac



G5



Sony Personal Entertainment Communicator



QRIO



~50 computers



Boeing 777 Flight Deck

<5>

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

<6>

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)

