CS61A Lecture 23

2011-07-28
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scheme-1 Review

```
(define (scheme-1)
  (display "Scheme-1: ")
  (flush)
  (print (eval-1 (read)))
  (scheme-1))
```

Infinite loop

eval-1 evaluated these lists

Whatever you typed in is treated as a list

Metacircular Evaluator (MCE) read-eval-print loop

```
(define (driver-loop)
  (prompt-for-input input-prompt)
  (let ((input (read)))
    (let ((output
           (mc-eval input
                    the-global-environment)))
      (announce-output output-prompt)
      (user-print output)))
  (driver-loop))
```

The big idea!

Today's Plan

- Is mc-eval basically the same as eval-1?
  - Yes
- Is mc-apply basically the same as apply-1?
  - Yes
- How is this different than scheme-1?
  - Everything has its own ADT!
  - We have **environments** and can define things!

The big idea!

```
(define (mc-eval exp env)
  (cond
    ((self-evaluating? exp)...
    ((variable? exp)...
    ((quoted? exp) ...
    ((assignment? exp) ...
    ((definition? exp) ...
    ((if? exp) ...
    ((lambda? exp) ...
    ((begin? exp) ...
    ((cond? exp) ...
    ((application? exp) ...
    (else (error "what?"))))
```

```
(define (mc-eval exp env)
  (cond
    ((self-evaluating? exp)...
    ((variable? exp)...
    ((quoted? exp) ...
    ((assignment? exp) ...
    ((definition? exp) ...
    ((if? exp) ...
    ((lambda? exp) ...
    ((begin? exp) ...
    ((cond? exp) ...
    ((application? exp) ...
    (else (error "what?"))))
```

(mc-eval 'x '())
Is caught by:
A. self-evaluating?
B. variable?
C. quoted?

(mc-eval '(sq 3) '())
Is caught by:
A. quoted?
B. lambda?
C. application?

More things create/use ADTs (makes not-new stuff different)

```
STk> (eval-1 '(lambda (x) (* x x)))
(lambda (x) (* x x))

STk> (mc-eval '(lambda (x) (* x x)) '())
(procedure (x) ((* x x)) ())
```

ADT overkill?
This is tagged with `procedure`, but we already had it tagged with `lambda`.

What do environments look like?

Frames in MCE (below the line)

Global
x: 2
y: 4

E1
a: 5
b: 7
c: 3

```
((x y) . (2 4))          ((a b c) . (5 7 3))
or                       or
((x y)   2 4 )           ((a b c)   5 7 3 )

(define (frame-variables frame)
    (car frame))
(define (frame-values frame)
    (cdr frame))
```

Environments (below the line)

List of frames!

```
(define the-empty-environment '())
(extend-environment
         '(x y) ;; vars
         '(2 4) ;; vals
         the-empty-environment) ;; base-env

(define (extend-environment vars vals base-env)
    (cons
         (make-frame vars vals)
          base-env))
```

Error checking omitted

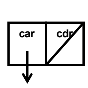
Environments (below the line)

List of frames!

```
(define the-empty-environment '())
(extend-environment
         '(x y) ;; vars
         '(2 4) ;; vals
         the-empty-environment) ;; base-env
```

Global
x: 2
y: 4

Environment



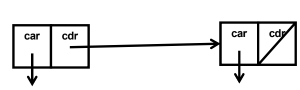
`((x y) . (1 2))`

Frame

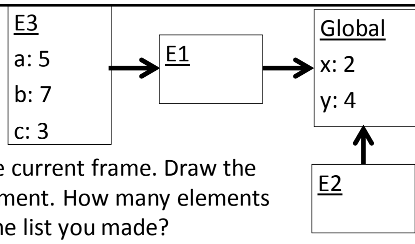
Environments (Below the line)

E1
a: 5
b: 7
c: 3

Global
x: 2
y: 4



`((a b c) . (5 7 3))`   `((x y) . (1 2))`



E3 is the current frame. Draw the environment. How many elements are in the list you made?

A. 1 B. 2 C. 3 D. 4 E. 5

How do we look-up values from environments?

```
(define (scan vars vals)
  (cond
     ((null? vars)
         ...) ;; look in enclosing env.
     ((eq? var (car vars))
        (car vals))
     (else
        (scan (cdr vars) (cdr vals)))))
```

How do we look-up values from environments? (continued)

```
(define (lookup-variable-value var env)
  (define (env-loop env)
    (if (eq? env the-empty-environment)
        (error "Unbound variable" var)
        (let ((frame (first-frame env)))
          (scan (frame-variables frame)
                (frame-values frame)))))
  (env-loop env))
```

How do we look-up values from environments?

```
(define (scan vars vals)
  (cond
     ((null? vars)
        (env-loop
            (enclosing-environment env)))
     ((eq? var (car vars))
        (car vals))
     (else
        (scan (cdr vars) (cdr vals)))))
```

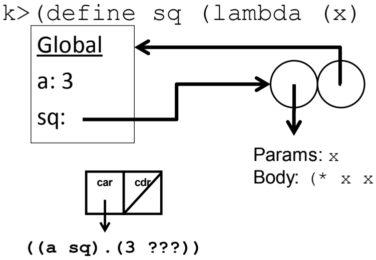
How many times is scan called?

A. Once for each frame
B. Once for each variable in the environment
C. Once for each variable you are looking up

Write a definition for
`(enclosing-environment env)`

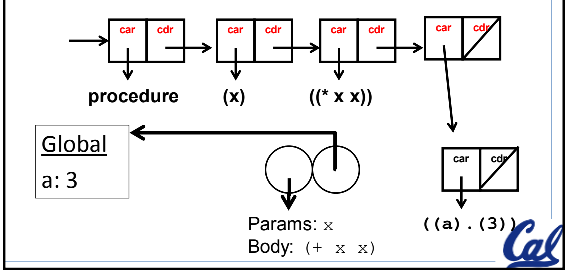
What does this environment look like?

```
STk>(define a 3)
STk>(define sq (lambda (x) (* x x)))
```



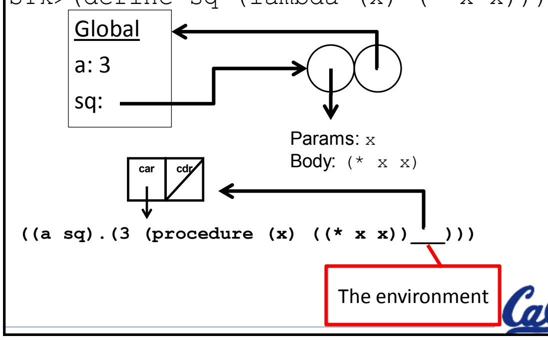
What is a procedure?

```
STk> (mc-eval '(lambda (x) (* x x)) '(((a) 3)))
(procedure (x) ((* x x)) (((a) 3)))
```



What does this environment look like?

```
STk>(define a 3)
STk>(define sq (lambda (x) (* x x)))
```



Printing Environments is…

A. going to be really helpful to see what is going on in `mc-eval`
B. not going to be possible because they are really big
C. not going to be possible because they contain infinite structures

What would scheme print (wwsp)?

```
(define (my-scope x)
  (lambda () x))
(define (current-scope x thunk)
  (thunk))

STk> (define my-thunk (my-scope 3))
my-thunk
STk> (current-scope 4 my-thunk)
```

Prints:

A. 3 B. 4 C. error D. ???

Lexical vs. Dynamic Scope

- **Scheme – Lexical Scope**
  - Extend the frame that the procedure was created in
- **Logo – Dynamic Scope**
  - Extend the frame that the procedure was called from

LOGO

Demo

Commands versus Operations

- In LOGO procedures are divided into
  - Operations – return values
  - Commands – don't return values
- You have to start each instruction with a command

```
print sum 2 3
```

Parentheses *can* be used

```
print (sum 2 3 4 5)
print 3*(4+5)
```

Variables vs. Procedures

- We can have a function and a variable with the same name in LOGO.
- How to make a variable:

```
make "x 10
print :x
make "sum 15
print sum :x :sum
```

Quoting things in LOGO

- We use " instead of single quotes.

```
make "name "colleen
print :name

make "my-sent [a b c]
print :my-sent
```

There are no special forms!

- We can just quote things by putting them in [] and then they won't be evaluated –WOW!

```
ifelse 2=3 [print "hi] [print "bye]
```

Defining a function

- We use the word "to" - "to teach logo a new word".

```
? to add-up :x :y :z
> sum :x :y :z
> end
? print add-up 1 2 3
```

Scope - We have frames

- We have frames so calling a function creates a new bind – it doesn't change the global frame

```
? make "x 10
? to add-up :x :y :z
> sum :x :y :z
> end
? print add-up 1 2 3
? print :x
```

New frames extend the CURRENT environment (not the environment in which they were created)

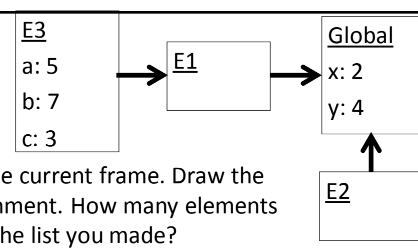
```
? make "pi 3.14
? to area
> :radius * :pi
> end
? to mess-up :pi
> area 5
> end
? mess-up 4
```

THE BIG IDEA!

Will LOGO return:

A. 20 B. 15.70 C. ??

Solutions



E3 is the current frame. Draw the environment. How many elements are in the list you made?

A. 1 B. 2 C. 3 D. 4 E. 5