MASSACHVSETTS INSTITVTE OF TECHNOLOGY
Department of Electrical Engineering and Computer Science
6.001—Structure and Interpretation of Computer Programs
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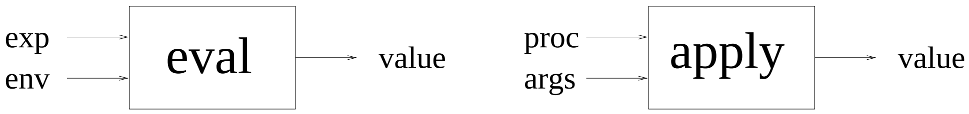
1. Some Meta-Circular Evaluator Code

The heart of the Scheme language is an interpreter, that is, a process that evaluates legal expressions of the language. In lecture, we saw a Scheme interpreter built around the use of two basic procedures, which we will call `mc-eval` and `mc-apply`. Examples of these, without data abstractions, are given below:




```
(define (mc-eval exp env)
  (cond ((number? exp) exp)                     ;base case for numbers
        ((symbol? exp) (lookup exp env))        ;base case for variables
        ((eq? (car exp) 'quote) (car (cdr exp)))      ;special forms
        ((eq? (car exp) 'lambda)
          (list 'procedure (cadr exp) (caddr exp) env))
        ((eq? (car exp) 'define) (eval-define (cdr exp) env))
        (else (mc-apply (mc-eval (car exp) env)       ;procedure application
                        (list-of-values (cdr exp) env)))))

(define (mc-apply proc args)
   (cond ((atom? proc) (apply proc args))       ;primitive case
         ((eq? (car proc) 'procedure)           ;compound procedure
          (mc-eval (caddr proc)                         ;procedure body
                   (extend-environment (cadr proc)      ;formal parameters
                                       args             ;supplied arguments
                                       (cadddr proc)))) ;saved environment
         (else (error "Unknown procedure"))))

(define (eval-define exp env)
  (define-variable! (cadr exp)
                    (mc-eval (caddr exp) env)
                    env))

(define (define-variable! var val env)
  (set-car! (car env) (cons var (caar env)))
  (set-cdr! (car env) (cons val (cdar env))))

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

(define (make-frame vars vals) (cons vars vals))
```

2. An Example using the Meta-Circular Evaluator

Use the table below to trace what the Meta-Circular Evaluator does on the following three expressions. Also, use the space below the table to draw the mc-evaluator's environment.

```
(mc-eval '(define z (+ 1 3)) the-global-environment)
(mc-eval '(define mult (lambda (x y) (* x y))) the-global-environment)
(mc-eval '(mult z 3) the-global-environment)
```

MC-Eval		MC-Apply	
Expression	Env	Procedure	Args
(define z (+ 1 3))	GE		
(define mult (lambda (x y) (* x y)))	GE		
(mult z 3)	GE		

Draw the mc-evaluator's environment diagram for evaluating the above expressions.

Draw the box-and-pointer diagrams that **represent** the mc-evaluator's environment.

3. Adding `let` to the Meta-Circular Evaluator

Often we will want to add a special form to our evaluator. For example, say we want to add `let`. In general to add a special form, follow these steps.

1. Specify the syntax of the new special form
2. Define the data abstraction.
3. Write `eval-foo` where `foo` is your new special form either by desugaring the expression or explicitly evalating it using the rules defined by the special form.
4. Add a `cond` clause to `mc-eval` to support the new special form.

Let Form

What is the form of a let?

```
(let ((<var1> <exp1>)
        ...
      (<varn> <expn>))
   <body>)
```

Let Abstractions

You can think of `let` as a **data-abstraction** that holds three things: A list of variables, a list of expressions, and a body. We need to write the selectors for this abstraction.

```
(let? '(let ((a (+ 3 4)) (b 5)) (+ a b)))           ==> #t
(let-variables '(let ((a (+ 3 4)) (b 5)) (+ a b)))  ==> (a b)
(let-exps '(let ((a (+ 3 4)) (b 5)) (+ a b)))       ==> ((+ 3 4) 5)
(let-body '(let ((a (+ 3 4)) (b 5)) (+ a b)))       ==> (+ a b)
```

Write the code for the following selectors:

```
(define (let? exp)

)

(define (let-variables let-exp)

)
```

```
(define (let-exps let-exp)

)

(define (let-body let-exp)

)
```

Writing Eval-Let (Take 1)

Write `eval-let` by desugaring:

```
(define (eval-let exp env)






)
```

Writing Eval-Let (Take 2)

Write `eval-let` without desugaring:

```
(define (eval-let exp env)






)
```

4. Brain Teasers (I have an extra page)

1. Write a scheme expression that prints itself.

(Hint: Consider how a cell reproduces. It contains its own blueprint (the DNA strand in the nucleus); reproduction involves (a) copying the blueprint, (b) implementing the blueprint. That is, it uses the blueprint twice.)

2. Write a scheme expression that goes into an infinite loop **without** using a `define`, `let`, or `set!`

3. Write a `lambda` expression that, when applied to a number, computes the factorial of that number **without** using `define`, `let`, or `set!` (Hint: Answer #2 first!).

4. Write the procedure `list` **without** using `list` or `cons`. (This should produce a real scheme list.)

5. Write the procedure `car` **without** using `car`.

6. Write the procedure `cdr` **without** using `cdr`.

7. Write `map` using `accumulate` (no recursion).

8. Write `filter` using `accumulate` (no recursion).