

Project  
 SNU 4910.210, Spring 2017  
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**due: 6/22(Thu) 23:59**

**Problem 1 (30 Points)** In Scala, implement an interpreter `myeval` for the programming language  $E$  given below.

$\text{myeval} : E \rightarrow V$

- A parser is provided to translate a string to  $E$ .
- Design the value type  $V$ , and implement the `ConvertToScala` type class for  $V$ .
- For ill-typed inputs, you can return arbitrary values, or raise exceptions.

$C$	$::=$	$n$	Integer
		<code>true</code>	true
		<code>false</code>	false
		<code>nil</code>	list nil
$E$	$::=$	$C$	constant
		$x$	name
		<code>(if E E E)</code>	conditional
		<code>(cons E E)</code>	pair construction
		<code>(hd E)</code>	head of a pair
		<code>(tl E)</code>	tail of a pair
		<code>(fun (x*) E)</code>	function
		<code>(E E*)</code>	function call
		<code>(let (B*) E)</code>	name binding to def/val
		<code>(+ E E)</code>	integer addition
		<code>(- E E)</code>	integer subtraction
		<code>(* E E)</code>	integer multiplication
		<code>(= E E)</code>	integer equality
		<code>(&lt; E E)</code>	integer less-than
		<code>(&gt; E E)</code>	integer greater-than
$B$	$::=$	<code>(def x E)</code>	def
		<code>(val x E)</code>	val

- $A^*$ :  $A$  appears several times (including 0 times). For example, the `(fun (x*) E)` rule constructs both `(fun (a b) (+ a b))` and `(fun () 3)`.
- `let` creates a new scope, like a ‘block’ in Scala. `def` and `val` work in the same way as Scala.
  - `def` assigns a name to an expression.
  - `val` assigns a name to a value obtained by evaluating the given expression. The evaluation of `vals` in one `let` should be performed in sequential order: a latter `val` can refer names assigned by former `vals`. 반대 방향으로도 되어야 하나?  
기존에 입력한 val 에 대해서도 계산을 해야하나?
  - To make a closure from an expression, just write the assigned name. (Unlike Scala, do not put ‘\_’ after the name.)
- For additional information, post questions on the GitHub course webpage.

Example programs:

- `myeval( (hd (cons 1 2)) )`  
Result: 1
- `myeval( (let (val p (cons 1 (cons true nil))) (cons 0 p)) )`  
Result: (0, (1, (2, nil)))
- `myeval( (if true 10 20) )`  
Result: 10
- `myeval( ((fun (x y) (+ x y)) 1 2) )`  
Result: 3  
여러개가 들어오면, 앞것을 무시한다는게 아니라  
지금 (E E\*)  
에서 E가 function 을 인자로 받는 function이다.
- `myeval( (let (val f (fun () (+ 1 2))) (f)) )`  
Result: 3
- `myeval( (let ((val a 10) (val b (+ a 1))) (* b 3)) )`  
Result: 33
- `myeval( (let ((def f (fun (x) (if (= x 0) 0 (+ x (f (- x 1))))))  
(f 5)) )`  
Result: 15
- `myeval( (let ((def f (fun (n) (g n 1))) (def g (fun (a b) (> a b)))) (f 3)) )`  
Result: true
- `myeval( (fun (f) (fun (x) (f x))) (fun (x) (+ x 1)) )`  
Result: function (that increments the input by 1)

You can find the actual code of every example program in this document from `Test.scala` in the skeleton code.

**Problem 2 (10 Points)** Optimize `myeval` to handle tail recursive input programs, such as the example code shown below.  
(Hint: Use Scala's tail recursion.)

- `myeval( (let ((def f (fun (x n) (if (= x 0) n (f (- x 1) (+ n x)))))) (f 9999 0)) )`  
Result: 49995000

**Problem 3 (10 Points)**

Implement another interpreter `myeval.memo` that uses the 'memoization' technique to optimize the evaluation time.

A memoized function records input-output pairs every time it is called. When the function is called with a recorded input, it just returns the recorded corresponding output, instead of computing it again.

`myeval.memo` do not have to be tail-recursive.

(Hint: You can use `scala.collection.immutable.HashMap` in this problem.)

- `myeval( (let ((def f (fun (n) (if (= n 0) 1 (if (= n 1) 0 (if (> (f (- n 1)) (f (- n 2))) 0 1))))) (f 100)) )`  
Result: 1