CS3:
Introduction to Symbolic Programming

Lecture 9:
More HOF
tic-tac-toe

Fall 2007

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Schedule

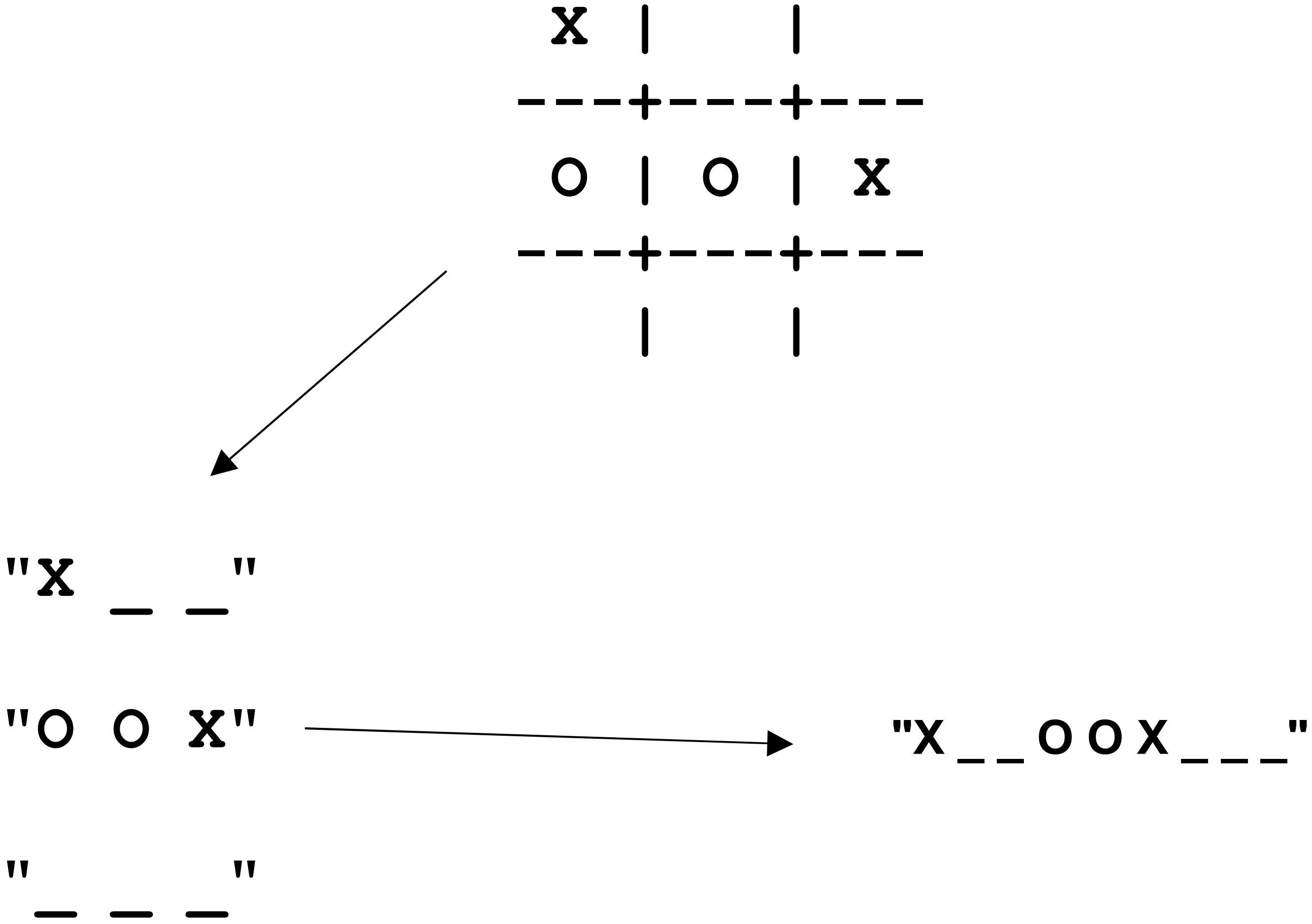
8	Oct 15-19	Lecture: Higher Order Functions Lab: Introduction to HOF, lambda Reading: Simply Scheme, Ch 8, 9 (for Tue/Wed) Simply Scheme, Ch 7 (for Thur/Fri)
9	Oct 22-26	Lecture: Advanced HOF Lab: Difference between Dates, Tic Tac Toe Miniproject #3 is introduced Reading: “DbD” case study (HOF version) Simply Scheme, Ch 10
10	Oct 29 – Nov 2	Lecture: Tree Recursion, Midterm review Lab: Tree recursions Finish Miniproject #3
11	Nov 5 – 9	Lecture: *Midterm #2* Lab: Introduction to Lists

Work on mini-project #3 in lab this week!

	Tue/Wed	Thur/Fri
This week		Miniproject introduced, ½ lab to work on it
Next Week	Full day of tree recursion!	A few review materials introduced. Otherwise, open lab MP#3 due at end of lab.
MIDTERM #2…		

Tic Tac Toe

The board



```
 X |   |
---+---+---
 O | O | X
---+---+---
   |   |
```

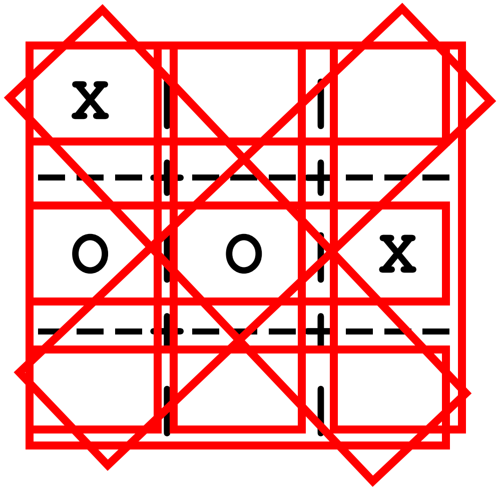
```
"X _ _"

"O O X"

"_ _ _"
```

```
"X__OOX___"
```

Triples (another representation of a board)



```
 X |   |
---+---+---
 O | O | X
---+---+---
   |   |
```

"X__OOX___"

```
( x23 oox 789 xo7 2o8 3x9 xo9 3o7 )
```

Tic-tac-toe hints

- Read the chapter!
- You will need to be familiar with vocabulary
  - positions, triples, "forks", "pivots", and so on
- This chapter in the book comes *before* recursion.
  - You would solve things differently if you used recursion
- The code (at the end of the chapter) has no comments.

Higher-order functions: review

Higher order function (HOFs)

- A HOF is a procedure that takes a procedure as an argument.
- There are three main ones that work with words and sentences:
  - `every`
    - take a one-argument procedure that returns a word
    - do something to each element
  - `keep`
    - takes a one-argument predicate
    - return only certain elements
  - `accumulate`
    - takes a two-argument procedure
    - combine the elements

A definition of every

```
(define (my-every proc ws)
  (if (empty? ws)
    '()
    (se (proc (first ws))
        (my-every (bf ws))
        )))
```

- **HOFs do a lot of work for you:**
  - Checking the conditional
  - Returning the proper base case
  - Combing the various recursive steps
  - Invoking themselves recursively on the smaller problem

Accumulate: right to left!

- The *direction* matters: right to left
  - `(accumulate / '(4 2 2))` does not equal `1`, but `4`.

- Think about expanding an accumulate

```
(accumulate + '(1 2 3 4))
  ➔ (+ 1 (+ 2 (+ 3 4)))

(accumulate / '(4 2 2))
  ➔ (/ 4 (/ 2 2))
```

Consider how accumulate is written…

```
(define (my-accum1 accum-proc sent)
  (if (= (count sent) 1)  ;;last element

    (first sent)

    (accum-proc
       (first sent)
       (my-accum1 accum-proc (bf sent)) ) ) )
```

Accumulate: returning sentences

- `accumulate` can return a sentence…

```
(accumulate ?? '(a b c d))
          ➔ (ab bc cd)
```

  - the *first* time accumulate is run, it reads the last two words of the input sentence

  - in *later* calls, it uses the return value of its procedure (which is a sentence) as one of its arguments

Any questions from Tue/Wed last week?

- You wrote and played with `every`, `keep`, and `accumulate`
- You used them in combination:

```
(remove-adj-dupls 'mississippi)
 ➔ misisipi

(gpa '(A A F C B))
    ➔ 2.6   (average of 4, 4, 0, 2, 3)

(gpa-with-p/np '(A A F NP P C B))
    ➔ 2.6   (average of 4, 4, 0, 2, 3)

(true-for-all? even? '(2 4 6 8))
    ➔ #t
```

Which HOFs would you use? (1/2)

1) **capitalize-proper-names**

```
(c-p-n '(mr. smith goes to washington))
     ➔ (mr. Smith goes to Washington)
```

- **count-if**

```
(count-if odd? '(1 2 3 4 5)) ➔ 3
```

- **longest-word**

```
(longest-word '(I had fun on spring
   break)) ➔ spring
```

- **count-vowels-in-each**

```
(c-e-l '(I have forgotten everything))
    ➔ (1 2 3 3)
```

Which HOFs would you use? (2/2)

1) **squares-greater-than-100**

```
(s-g-t-100 '(2 9 13 16 9 45))
    ➔ (169 256 2025)
```

- **root of the sum-of-squares**

```
(sos '(1 2 3 4 5 6 7))
    ➔ (sqrt (+ (* 1 1) (* 2 2) …)
    ➔ 30
```

- **successive-concatenation**

```
(sc '(a b c d e))
    ➔ (a ab abc abcd abcde)
```

Any questions from Thur/Fri last week?

- You wrote and played with `lambda` and `let`

Three ways to define a variable

- In a procedure call (e.g., the variable `proc`):

```
(define (doit proc value)
        ;; proc is a procedure here…
        (proc value))
```

3. As a global variable

```
(define *alphabet* '(a b c d e … ))
(define *month-name* '(january … ))
```

- With `let`

the `lambda` form

- "`lambda`" is a special form that returns a function:

```
(lambda (arg1 arg2 …)
   statements
       )
```

`(lambda`	`(x)`	`(*`	`x`	`x))`
➪	➪	➪	➪	➪
a procedure	that takes one argument	and multiplies	it	by itself

Use lambda anywhere you need a function

```
(define square
        (lambda (x) (* x x)))
```

```
(every (lambda (x) (* x x))
       '(1 2 3))
  ➔ (1 4 9)
```

```
((lambda (x) (* x x))  3)
  ➔ 9
```

You *need* lambda when…

…you need a procedure to make reference to more values than you can pass it.

For instance, when a procedure for use in an `every` needs two parameters

```
(prepend-every 'sir- '(sam mary loin))
     ➔ (sir-sam sir-mary sir-loin)
```

Write `prepend-every`

Write `appearances`

`make-bookends` (a *small* problem)

- **Write `make-bookends`, which is used this way:**

```
((make-bookends 'o) 'hi) ➔ ohio

((make-bookends 'to) 'ron) ➔ toronto

(define tom-proc (make-bookends 'tom))
(tom-proc "") ➔ tomtom
```

Problems

Write successive-concatenation

```
(sc '(a b c d e))
➔   (a ab abc abcd abcde)

(sc '(the big red barn))
➔  (the thebig thebigred thebigredbarn)
```

```
(define (sc sent)
   (accumulate
      (lambda ??
         )
      sent))
```