CSCI 334: Principles of Programming Languages

Lecture 10: Functional Programming

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Williams

Announcements

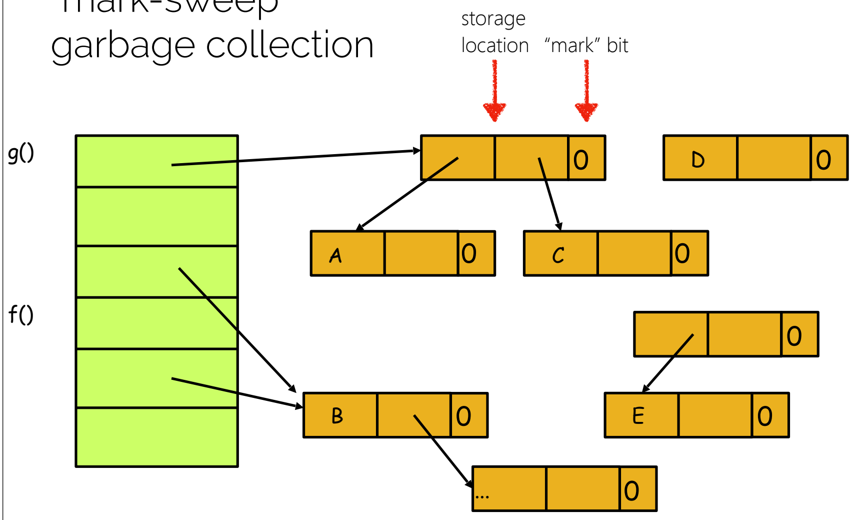
Midterm exam *next class*

You should have feedback for all HW—
if not, please let me know!

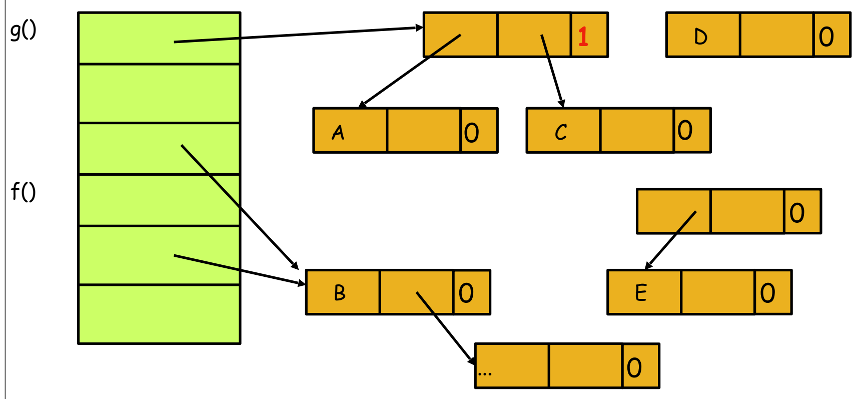
"Recursive Functions [...]" (McCarthy)

Lisp	C
`car`	`head`
`cdr`	`tail`
`cons`	`prepend`

"mark-sweep" garbage collection



1. Mark reachable cells



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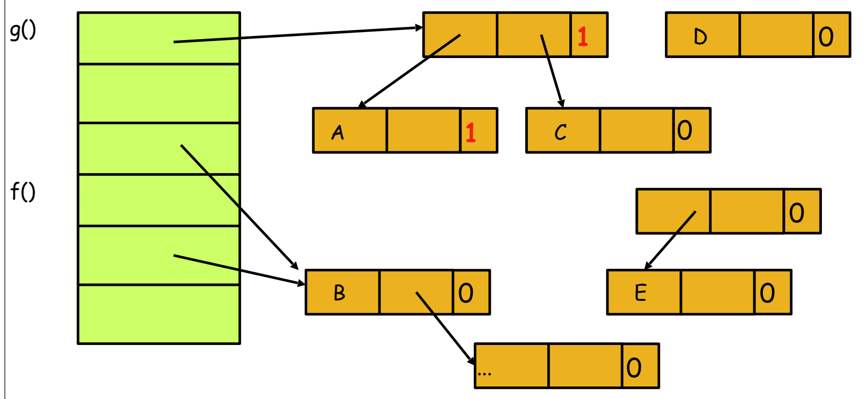

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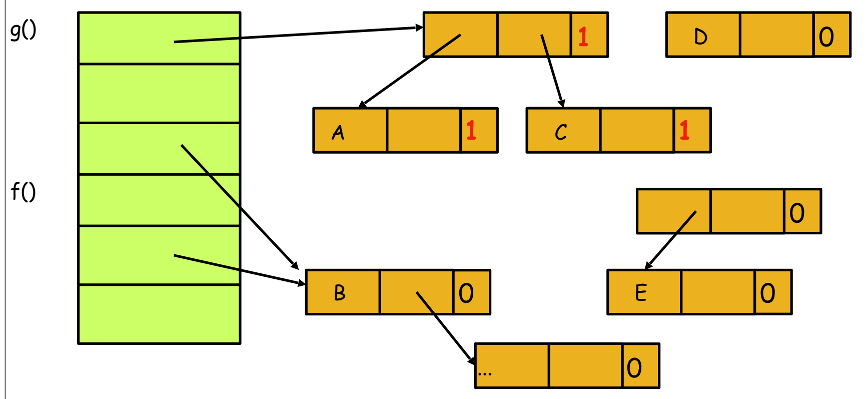

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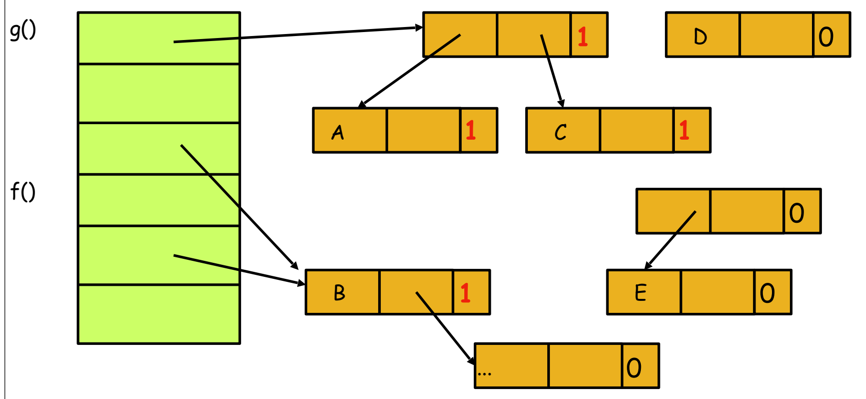
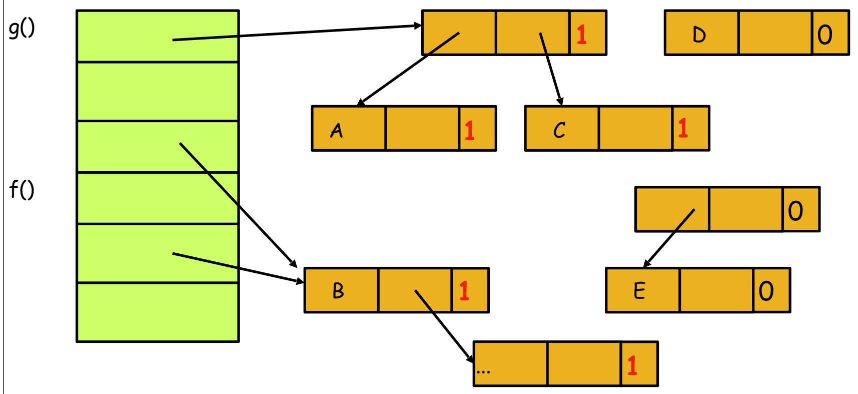
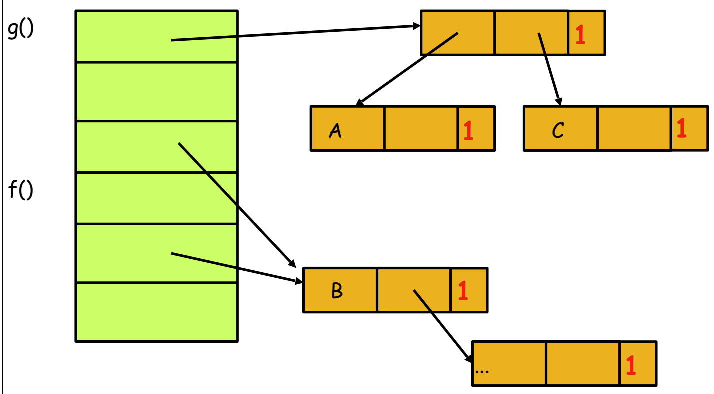


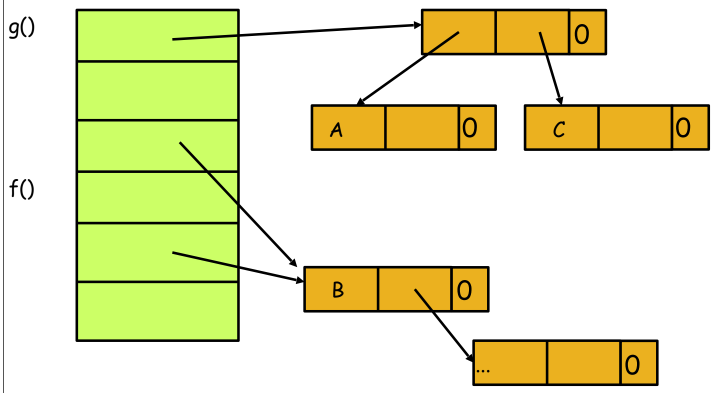
1. Mark reachable cells



2. Free ("sweep") unreachable cells



3. Clear tags



Activity

list length

`(length-list '(1 2 3 4 5 6))` ↠ 6

Mental technique #4

“Growth” mindset

“In a fixed mindset students believe their basic abilities, their intelligence, their talents, are just fixed traits. They have a certain amount and that's that, and then their goal becomes to look smart all the time and never look dumb. In a growth mindset students understand that their talents and abilities can be developed through effort, good teaching and persistence.”

— Carol Dweck (Lewis and Virginia Eaton Professor of Psychology at Stanford University)

Individuals with a "growth" mindset are more likely to continue working hard—and succeed—despite setbacks.

Mental technique #4

“Growth” mindset

Your brain is a machine designed to accommodate to a changing world.

Mental technique #4

Demonstration

Mental technique #4

Demonstration (again)

If that made sense to you, raise your hand.

Mental technique #4

Demonstration (ungarbled)

Mental technique #4

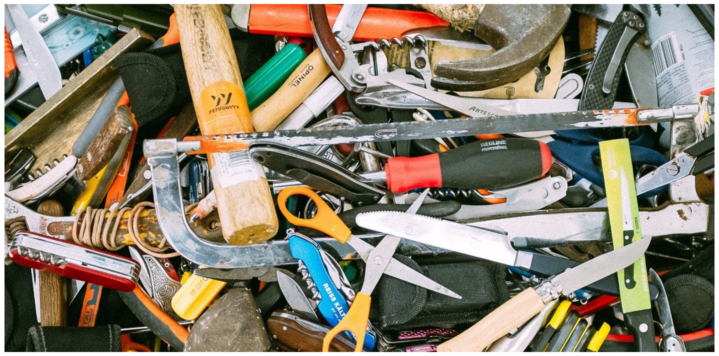
Demonstration

Mental technique #4

Demonstration (again)

Anil Seth, “Your brain hallucinates your conscious reality”

Why am I telling you this?



This course is about priming your brain with different ways of thinking about programming.

Why am I telling you this?

You can be a programmer without these ideas.

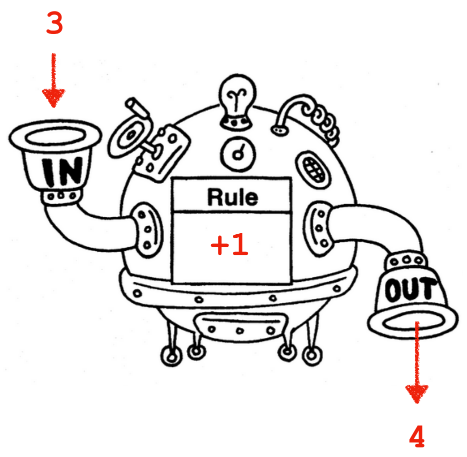
But make the effort to internalize these concepts and you will see their application everywhere.

You will be a *clearer* thinker
and a *better* programmer.

Three amazing concepts from FP

- First-class functions
- Higher-order functions
  - map
  - fold

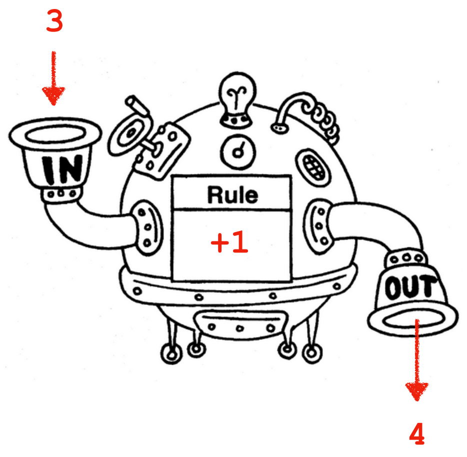
a function



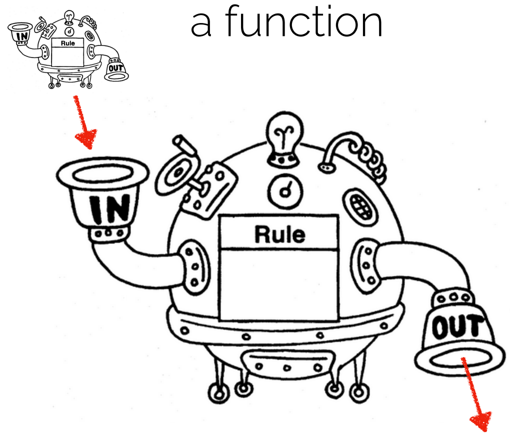
"first class" function

Functions are values in a programming language

a function

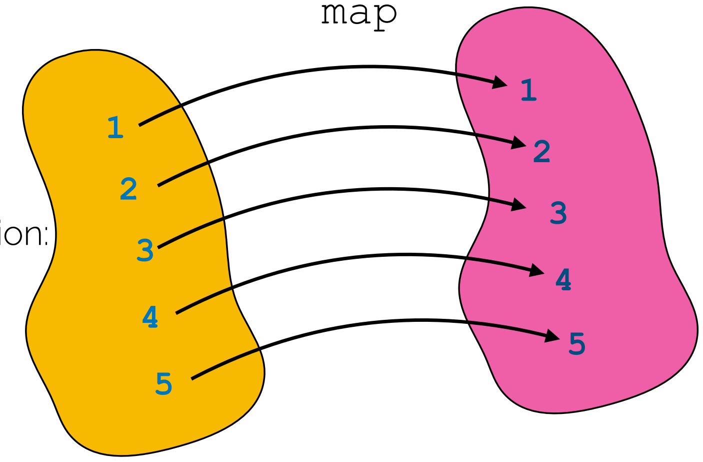


a function



map

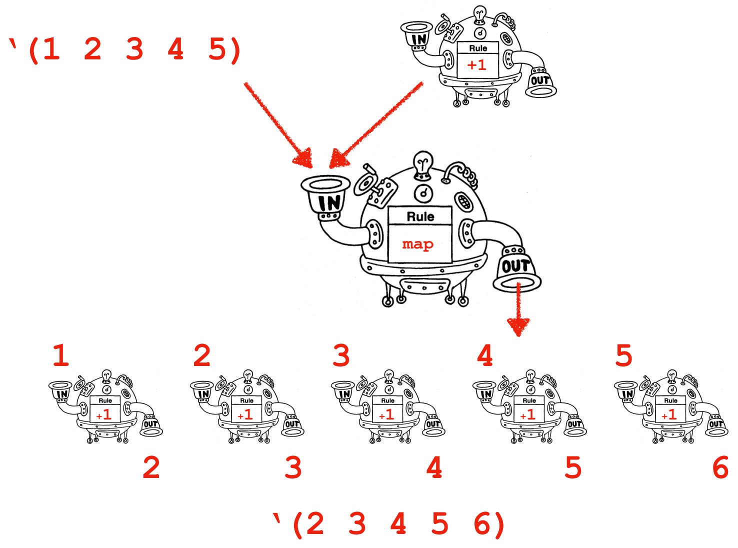
Intuition:



Like a `for` loop, but without mutable variables

```
(mapcar (lambda (x) (+ x 1) '(1 2 3 4 5))
```

map



fold

Intuition:

fold left

```
(reduce #'+ '(1 2 3) :initial-value 0)
```

```
acc = 0, `(1 2 3)
acc = 0+1, `(2 3)
  acc = 1+2, `(3)
   acc = 3+3, nil
  returns acc = 6
```

fold right

```
(reduce #'+ '(1 2 3):initial-value 0
                     :from-end t)
```

```
`(1 2 3), acc = 0
`(1 2), acc = 0+3
`(1), acc = 2+3
nil acc = 5+1
returns acc = 6
```

what does this print?

```
(reduce #'append '((1) (8))
    :initial-value '(w i l l i a m s))
```

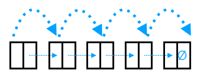
how about?

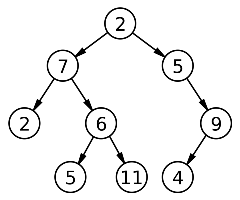
```
(reduce #'append '((1) (8))
    :initial-value '(w i l l i a m s)
    :from-end t)
```

fold

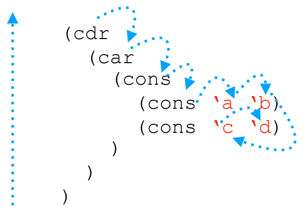
structural recursion ➞ fold it!

(in a nutshell: any problem that recurses on a subset of input)


list length



tree height



```
(cdr
  (car
    (cons
      (cons 'a 'b)
      (cons 'c 'd)
    )
  )
)
```

evaluation