Functional Programming--Scheme

(Variable, Expression, and Function)

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Why Study Functional Programming ?

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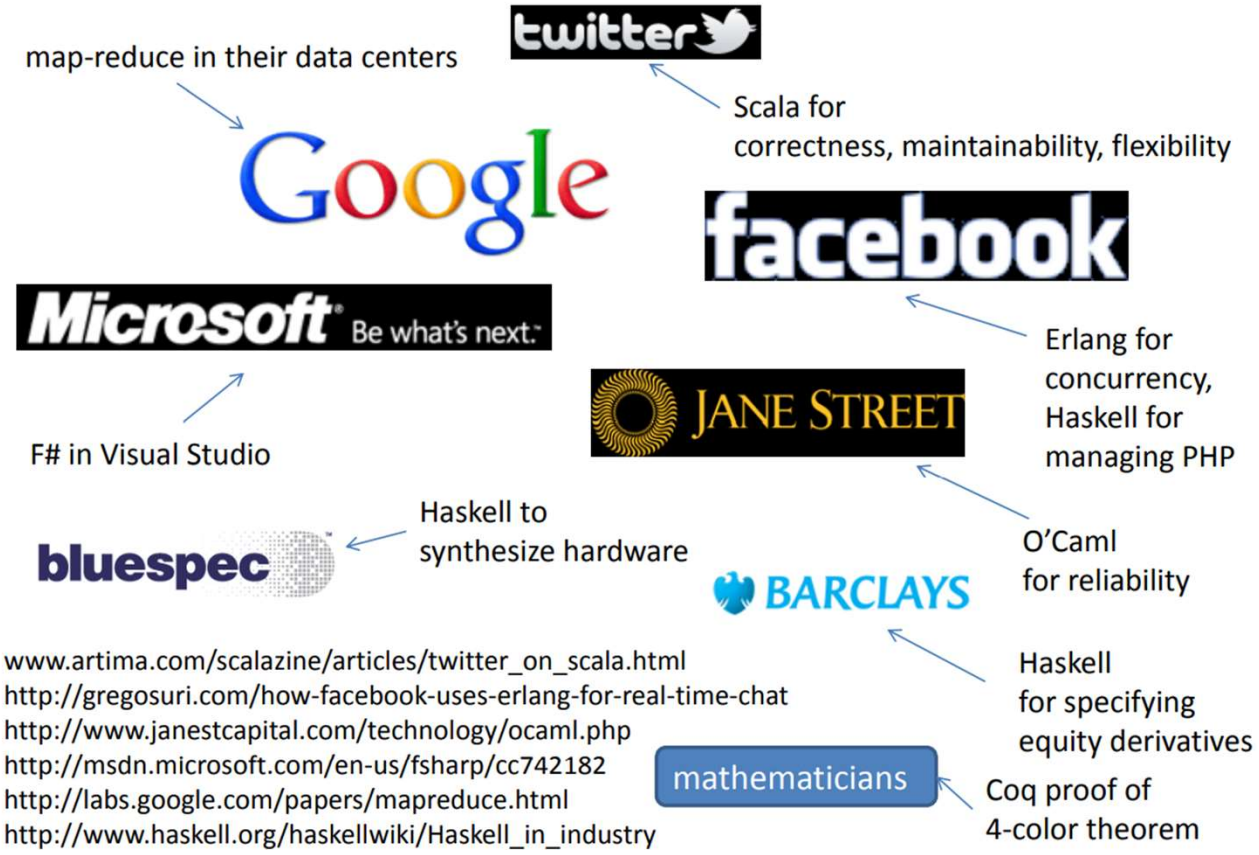
- Expose you to a new programming model
  - Functional Programming (FP) is drastically different
    - Scheme: no loops; recursion everywhere
- FP has had a long tradition
  - Lisp, Scheme, ML, Haskell, …
  - The debate between FP and imperative programming
- FP continues to influence modern languages
  - Most modern languages are multi-paradigm languages
  - Delegates in C#: higher-order functions
  - Python: FP; OOP; imperative programming
  - Scala: mixes FP and OOP
  - C++11: added lambda functions
  - Java 8: added lambda functions in 2014
  - Erlang: behind WhatsApp

Who's using them?



www.artima.com/scalazine/articles/twitter_on_scala.html
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http://msdn.microsoft.com/en-us/fsharp/cc742182
http://labs.google.com/papers/mapreduce.html
http://www.haskell.org/haskellwiki/Haskell_in_industry

A Functional Programming Language

Scheme

DrRacket

- An interactive, integrated, graphical programming environment for Scheme
- Installation
  - You could install it on your own machines
    - http://racket-lang.org/
- Be sure that the language “Standard (R5RS)” is selected
  - Click Run

Scheme is Simple

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- Design for teaching” “A language for describing processes”
- Almost minimally simple syntax
- Only one thing you can do
- Only one data structure

Scheme is Simple:
The one thing you can do

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(operator operand1 operand2 …)

Simple - Scheme Expressions

- Prefix notation (Polish notation):
  - *3+4* is written in Scheme as (+ 3 4)
  - Parentheses are necessary
  - Compare to the infix notation: (3 + 4)
- *4+(5 * 7)* is written as
  - (+ 4 (* 5 7))
  - Parentheses are necessary

Simple – Arithmetic

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- (+ 3 4)

7

- (* 3 4)

12

- (+ 5 (* 2 2))

?

Your Turn

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- In Scheme, “(3+8)+2” is written as

A. (+ (3 + 8) 2)
B. (+ 2 (+ 3 8))
C. (+ (+ 3 8) 2)
D. + (+ 3 8) 2
E. (+ + 3 8 2)

Your Turn

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- In Scheme, “3+8/2” is written as

A. (+ (8 / 2) 3)
B. (+ 3 (/ 8 2))
C. (+ (/ 8 2) 3)
D. (+ 3 (/ 2 8))
E. 3 + (/ 8 2)

Scheme Variables

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- Variables
  - (define pi 3.14)
  - No need to declare types
- Variables are case insensitive
  - pi is the same as Pi

Simple – Defining values

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- (define foo 3)

- foo

3

- (* foo 4)

?

Scheme Expressions

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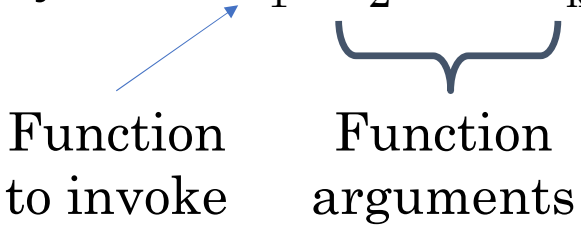
- General syntax: $(E_1 \ E_2 \ \ldots \ E_k)$



  - Applying the function E1 to arguments E2, …, Ek
  - Examples: (+ 3 4), (+ 4 (* 5 7))
  - Uniform syntax, easy to parse

User-Defined Functions

- Mathematical functions
  - Take some arguments; return some value
- E.g., $f(x) = x^2$
  - $f(3) = 9; f(10) = 100$
- Scheme syntax
  - `(define (square x) (* x x))`
- A two-argument function: $f(x,y) = x + y^2$
  - `(define (f x y) (+ x (* y y)))`
  - calling the function: `(f 3 4)`

Simple – Defining function

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- (define (square x) (* x x))

- (square 4)

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- (+ (square 2) (square 3))

?

Built-in Functions

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- +, *
  - take 0 or more parameters
  - applies operation to all parameters together
  - (+ 2 4 5)
  - (* 3 2 4)
  - zero or one parameter?
    - (+)
    - (*)
    - (+ 5)
    - (* 8)

Simple – Flow control

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- (define (abs x)
  (if (< x 0)
  (- x)
  x))

- (abs -3)

3

- (abs 3)

3

Scheme is Simple:
The one data structure

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```
(value1 value2 value3 …)
; To make one, we write:
(list value1 value2 value3 …)
```

Simple – Using data

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- (sort (list 4 6 5))

(4 5 6)

- (length (list 1 2))

2

Scheme is Weird

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- Functional
- Dynamic typing
- Functions are values

Weird – Functional – list manipulation

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- (define my-list (list 1 2 3 4 5))

- my-list

(1 2 3 4 5)

- (car my-list)

1

- (cdr my-list)

(2 3 4 5)

Weird – Dynamic typing

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- (define (improved-code q) (* q 2))
- (define code-quality 4)
- (improved-code code-quality)

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- (define code-quality “poor”)
- (improved-code code-quality)

**: expects type as 1st argument, give…..*

Weird – Functions are values

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- (define (double value) (* 2 value))
- (define (apply-twice fn value) (fn (fn value)))
- (apply-twice double 2)

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Scheme is Cool

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- Generic without all that syntax

➢(sort (list 5 4 3 2 1) <)

(1 2 3 4 5)

➢(sort (list “abc” “a” “ab”) string<?)

(“a” “ab” “abc”)

Anonymous Functions

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- Syntax based on Lambda Calculus: $\lambda x.\ x^2$
- Anonymous functions
  - (lambda (x) (* x x))
  - are small function can take any number of arguments, but can only have one expression
  - are often arguments being passed to higher-order function
  - are not bound to an identifier
  - can be used only once: ((lambda (x) (* x x)) 3)
  - Introduce names
    - (define square (lambda (x) (* x x)))
    - Same as (define (square x) (* x x))

Top Hat

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Scheme Parenthesis

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- Scheme is very strict on parentheses
  - which is reserved for function call (function invocation)
  - (+ 3 4) vs. (+ (3) 4)
  - (lambda (x) x) vs. (lambda (x) (x))
    - the second treats (x) as a function call
  - (lambda (x) (* x x)) vs. (lambda (x) (* (x) x))

Defining Recursive Functions

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- (define diverge (lambda (x) (diverge (+ x 1))))
  - Call this a diverge function