

# Haskell Introduction

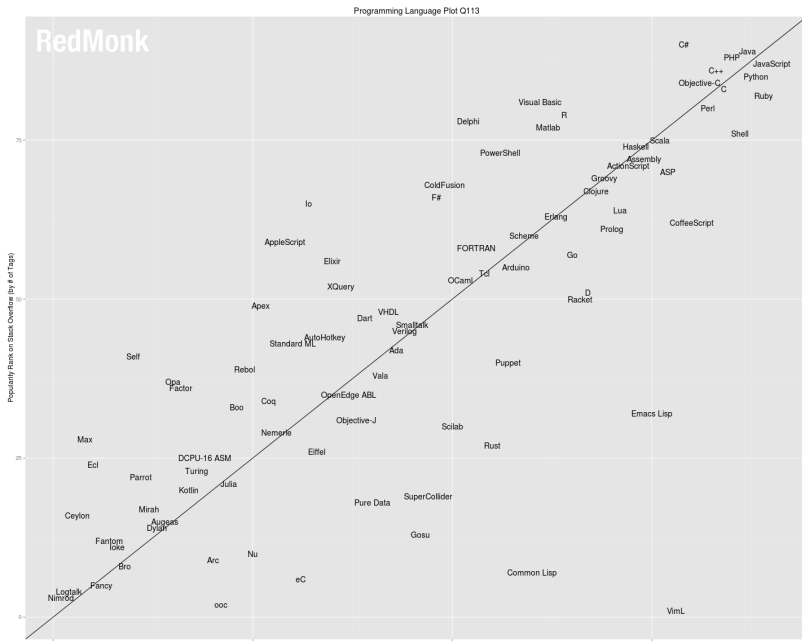
Mihai Maruseac

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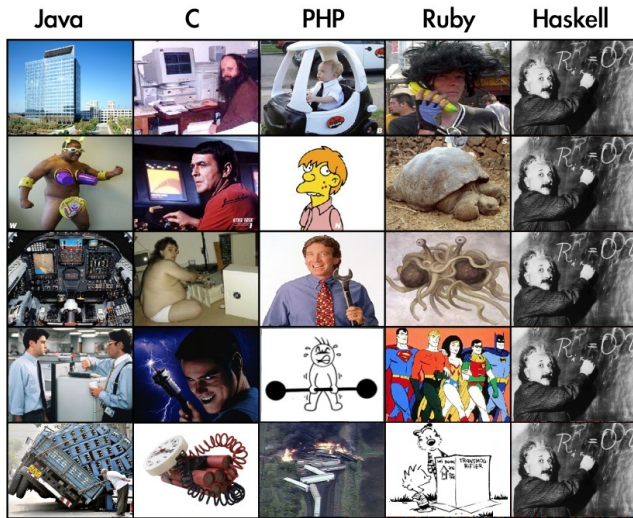
# Layout

- ▶ 4 days of topics
  - ▶ moving from theoretical to practical
- ▶ 1 day of hackathon
  - ▶ you can propose your own subject

## Language Popularity



# Language Matrix



as seen  
by...

Java fans

C fans

PHP fans

Ruby fans

Haskell fans

# History

- ▶ 1930s, Alonzo Church,  $\lambda$ -calculus
- ▶ 1950s, John McCarthy, LISP
  - ▶ Scheme, Dylan, Scala, Racket
- ▶ 1960s, IPL, APL
- ▶ 1970s, FP, John Bachus
  - ▶ *Can Programming Be Liberated From the von Neumann Style? A Functional Style and its Algebra of Programs*
  - ▶ J
- ▶ 1970s, Robin Milner, ML
- ▶ 1970s, David Turner, Miranda
- ▶ 1990s, committee, Haskell
  - ▶ open standard for functional programming research

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- ▶ second birth

# Users

- ▶ NASA
- ▶ Galois
- ▶ Jane Street
- ▶ Microsoft
- ▶ Facebook
- ▶ Google

# Success Stories

- ▶ Perl6 interpreter
- ▶ Hermit Reasoner
- ▶ xmonad
- ▶ Pandoc
- ▶ detexify
- ▶ grammarly

# Why

- ▶ declarative style

```
sort    [] = []  
sort (x:xs) = lesser ++ x : greater  
  where  
    lesser = sort [ a | a <- xs, a < x]  
    greater = sort [ a | a <- xs, a >=x]
```

# Why

- ▶ declarative style

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- ▶ correctness guarantee
  - ▶ if it compiles it should be right

# Features

- ▶ static typing



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- ▶ lazy evaluation
- ▶ performance

# Books

- ▶ Learn You A Haskell
- ▶ Real World Haskell
- ▶ and others

# GHC

- ▶ *The Glorious Glasgow Haskell Compilation System, version 7.4.1*
- ▶ Haskell Platform (GHC, cabal, common libraries)
- ▶ ghc - compiler
  - ▶ ghc -make file.hs
- ▶ ghci - interpreter

# ghci interpreter

- ▶ `:load`, `:l`, `:reload`
- ▶ `:type`
- ▶ `:quit`

# Hands-On (1)

- ▶ open ghci



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- ▶ test some arithmetic operations
- ▶ test boolean operations
- ▶ equality examples
- ▶ type errors examples
- ▶ calling functions (`not`, `min`)

# Infix and Prefix Functions

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- ▶ operators - infix
- ▶ functions - prefix
- ▶ operators made prefix: (+)
- ▶ functions made infix: 'min'
- ▶ sections: (+ 3), (3 -), ('min' 42)

# Lists

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# Lists

- ▶ constructors
- ▶ `[]`, `:`
- ▶ `[]` - the empty list
- ▶ `x:xs` - the list formed by appending an `x` to a list (of) `xs`
- ▶ all elements must have the same type

# Functions (1)

- ▶  $\lambda$  expressions

```
sum2 = \x y -> x + y
```

- ▶ explicit arguments

```
sum2' x y = x + y
```

- ▶ mixed style

```
sum2'' x = \y -> x + y  
sum2''' = \x -> \y -> x + y
```



## Functions (2)

- ▶ curry functions
- ▶ can call with fewer arguments
- ▶ returning function asking for more arguments

## Functions (3)

- ▶ function composition

```
f x = 2 * x
```

```
g x = x + 4
```

```
h = f . g
```

- ▶ \$ operator

```
f $ x = f x
```

```
(expression1) (expression2) == expression1 $ expression2
```

## Functions (4)

- ▶ in Haskell, functions are *first order values*
  - ▶ list of functions
  - ▶ functions as arguments
  - ▶ functions as returned values

# List Functions (1)

```
sum [] = 0  
sum (x:xs) = x + sum xs
```

```
sum [] = 0  
sum (x:xs) = (+) x (sum xs)
```

```
sum [] = 0  
sum (x:xs) = (+) x $ sum xs
```

## List Functions (2)

```
product [] = 1  
product (x:xs) = x * product xs
```

```
product [] = 1  
product (x:xs) = ( * ) x $ product xs
```

## List Functions (3)

```
length    [] = 0  
length (x:xs) = 1 + length xs
```

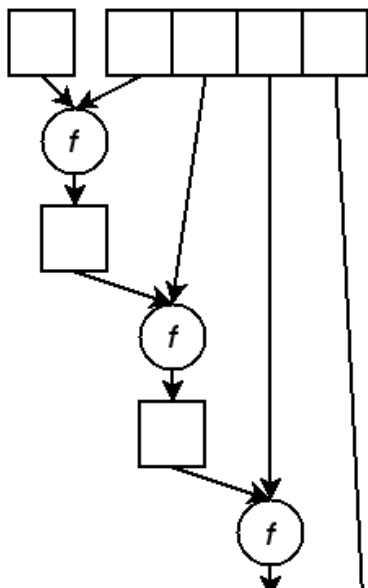
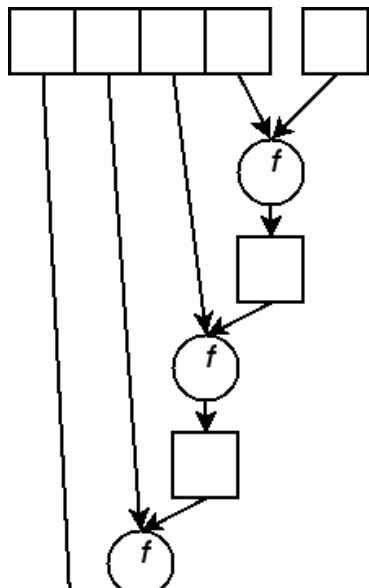
```
length    [] = 0  
length (x:xs) = (+) 1 $ length xs
```

## List Functions (4)

```
pattern    [] = initial_element  
pattern (x:xs) = combining_function x $ pattern xs
```

## List Functions (5)

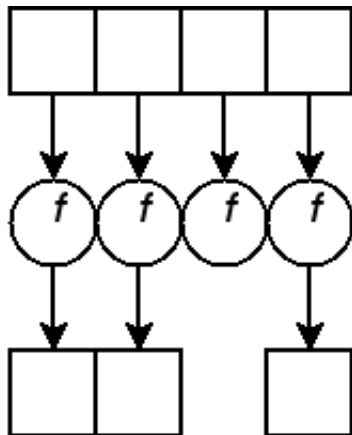
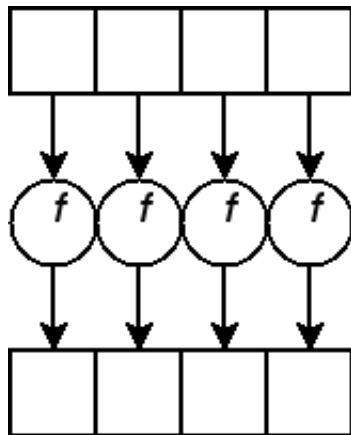
- foldl, foldr





## List Functions (6)

- ▶ `map`
- ▶ `filter`



## List Functions (7)

- ▶ `take`
- ▶ `drop`
- ▶ `head`
- ▶ `tail`
- ▶ `takeWhile`
- ▶ `dropWhile`
- ▶ `zip`
- ▶ `unzip`

## List Functions (8)

```
map (+ 1) [1, 2, 3, 4] == [2, 3, 4, 5]
filter (> 2) [1, 3, 1, 5, 2] == [3, 5]
foldl (+) 0 [1, 2, 3, 4, 5] == 15
take 5 $ map (+ 1) [1..] == [2, 3, 4, 5, 6]
takeWhile (< 10) $ map (2 *) [1,3 .. 100] == [2, 6]
takeWhile (< 10) $ map (2 *) $ [1,3 .. 100] == [2, 6]
takeWhile (< 10) . map (2 *) $ [1,3 .. 100] == [2, 6]
```

## Syntax in Functions (1)

```
factorial x = if x < 1 then 1 else x * factorial (x - 1)
```

```
factorial x = if x < 1  
  then 1  
  else x * factorial (x - 1)
```

```
factorial x =  
  | x < 1 = 1  
  | otherwise = x * factorial (x - 1)
```

```
factorial 1 = 1  
factorial x = x * factorial (x - 1)
```

## Syntax in Functions (2)

```
sum l = case l of  
  [] -> 0  
  (x:xs) -> x + sum xs
```

```
length l = case l of  
  (_:xs) -> 1 + length xs  
  _ -> 0
```

# Local Bindings

```
f x = let double = 2 * x in double + 1
```

```
f x = double + 1  
  where  
    double = 2 * x
```

# Printf Debugging

```
import Debug.Trace
```

```
-- trace text value
```

```
f x = trace ("f called with " ++ show x) $ x + 1
```

## Hands-On (2)

- ▶ square a list
- ▶ sum the odd numbers of a list (odd)
- ▶ find the first perfect palindrome
- ▶ ROT13 encryption (Strings are list of Chars, ord, chr)



## Hands-On (3)

- ▶ square a list

```
square = map (^ 2)
```

- ▶ sum the odd numbers of a list

```
sumOdd = sum . filter odd
```

## Hands-On (4)

- find the first perfect palindrome

```
isPerfect x = x == sumDiv x
  where
    sumDiv n = sum [ x | x <- [1..n 'div' 2],
                        n 'mod' x == 0]

isPalindrome x = x == (read . reverse . show $ x)

number = head $ filter both [1..]
  where
    both x = isPalindrome x && isPerfect x
```

## Hands-On (5)

- ▶ ROT13 encryption

```
import Data.Char (ord, chr)

translate c = chr (newVal + ord 'a')
  where
    newVal = (oldVal + 13) `mod` 26
    oldVal = ord c - ord 'a'

rot13 msg = map translate msg
```