

FizzBuzz In Haskell

Owen Lynch

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Introducing Haskell

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fact :: Int -> Int
fact 0 = 1
fact n = n * fact (n-1)
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Equivalent python code:

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Notable Features

- ▶ Types
- ▶ Pattern Matching

The Anatomy of a Haskell Definition

Type Signature

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Name

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The Anatomy of a Haskell Definition

Value

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- ▶ Haskell is for academic ivory-towerists who do too much category theory for their own good
 - ▶ Haskell is actually a very practical language for all sorts of tasks, and it has been battletested in industry for decades

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- ▶ This is a silly tour of some neat features in Haskell.
- ▶ I am not expecting all of this talk to make sense to you right away.
- ▶ When you see something you don't understand, don't think "Agghhh Haskell is way to hard", think "Cool, I have something to figure out!"

Introducing FizzBuzz

- ▶ Make a list of the numbers from 1 to 100, except...

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 - ▶ For every number divisible by 5 and 3, put “FizzBuzz” instead

Introducing FizzBuzz

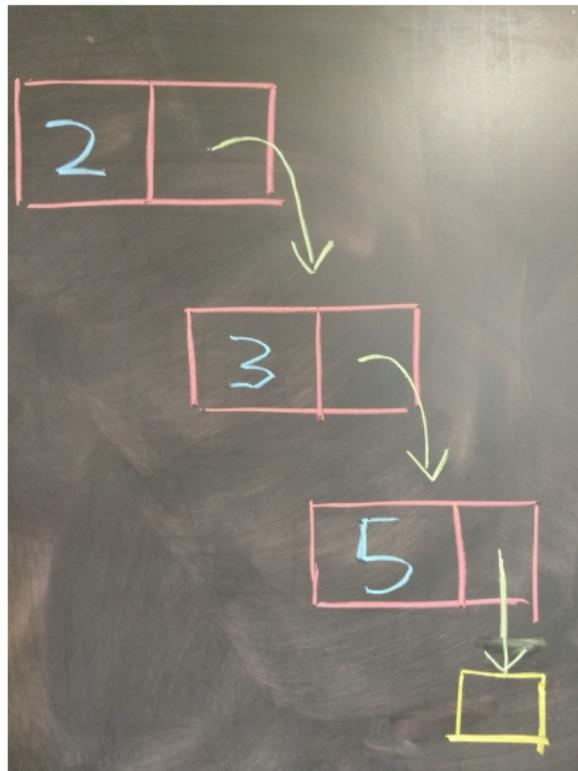
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- ▶ How would you solve FizzBuzz?

Lists

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Lists in Python

```
class ConsCell:  
    def __init__(head, tail)  
        self.head = head  
        self.tail = tail  
  
class EmptyList:  
    def __init__():  
        return  
  
oneTwo = ConsCell(1, ConsCell(2, EmptyList))
```

Lists in Haskell

```
data [a] = [] | a : [a]
-- data List a = Empty | Cons a (List a)
-- (:) x xs == x : xs
-- ([] a = [a]

firstFourPrimes :: [Int]
firstFourPrimes = 2:(3:(5:(7:[])))

type String = [Char]
-- "abc" = 'a':('b':('c':[]))

everyFlavoredBeanFlavors :: [String]
everyFlavoredBeanFlavors =
  ["earwax", "marmalade", "spinach"]
```

How do we work with it?

Recursion!

Our first step is generating all of the numbers from 1 to 100.

```
range :: Int -> Int -> [Int]
range n m
| n == m      = [n]
| otherwise    = n:(range (n+1) m)
-- range n m == [n..m]
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 - ▶ Guard Notation

List Transformations

Now, we need to do something to each of those numbers.

```
map :: (a -> b) -> [a] -> [b]
map f [] = []
map f (x:xs) = (f x):(map f xs)
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```

- ▶ New stuff:
 - ▶ Functions applied to functions!

The first solution

```
fizzbuzz1 :: Int -> String
fizzbuzz1 n
| rem n 15 == 0 = "FizzBuzz"
| rem n 5 == 0 = "Buzz"
| rem n 3 == 0 = "Fizz"
| otherwise      = show n

sol1 :: [String]
sol1 = map fizzbuzz1 [1..100]
```

Discuss first solution

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 - ▶ Recursion!
 - ▶ Combinators that allowed us to not do recursion!
 - ▶ Case syntax!
- ▶ What did we not like?
 - ▶ Not extensible enough! (What about Bazz??)

FizzBuzzBazz

```
fizzbuzzbazz1 :: Int -> String
fizzbuzzbazz1 n
| rem n 105 == 0 = "FizzBuzzBazz"
| rem n 35 == 0 = "BuzzBazz"
| rem n 21 == 0 = "FizzBazz"
| rem n 15 == 0 = "FizzBuzz"
| rem n 7 == 0 = "Bazz"
| rem n 5 == 0 = "Buzz"
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This is terrible!

How should we solve this?

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- ▶ That’s a recipe for a...
- ▶ Monoid!

Monoid Hype

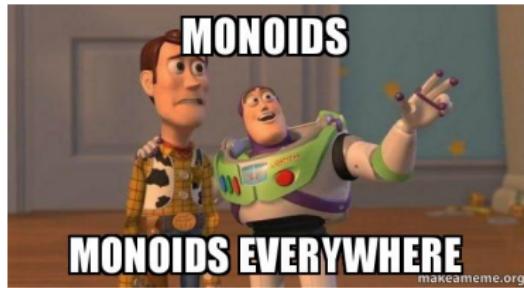
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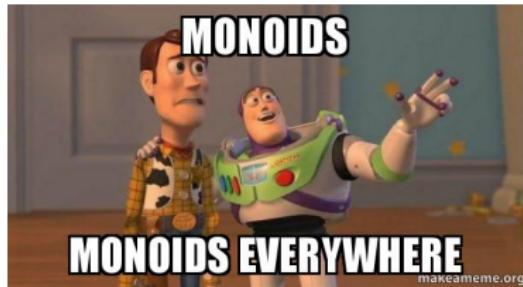
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Monoid Mary
@argumatronic

A lways
B e
C onsidering monoids

You already know lots of monoids!

Take a couple minutes and think of monoids

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- ▶ Any ordered set along with min and a “positive infinity” element as identity

Some nitty-gritties...

In Haskell, we write the definition of a Monoid like this

```
class Monoid m where
    mempty :: m
    (<>>>) :: m -> m -> m
```

Unfortunately, we can't write down the laws... we just have to trust that whenever someone implements a Monoid they make sure they satisfy them!

List Monoid

```
instance Monoid [a] where
  mempty = []
  [] <>> ys = ys
  (x:xs) <>> ys = x:(xs <>> ys)
```

Maybe Monoid

```
data Maybe a = Just a | Nothing

instance (Monoid a) => Monoid (Maybe a) where
    mempty = Nothing
    Nothing <>> Nothing = Nothing
    (Just a) <>> Nothing = Just a
    Nothing <>> (Just b) = Just b
    (Just a) <>> (Just b) = Just (a <>> b)
```

Working with Maybes

```
fromMaybe :: a -> Maybe a -> a
fromMaybe def Nothing = def
fromMaybe _ (Just y) = y
```

Combining lists

```
foldl :: (a -> b -> a) -> a -> [b] -> a
foldl f acc [] = acc
foldl f acc (x:xs) = foldl f (f acc x) xs
-- sum == foldl (+) 0
-- length == foldl (\n _ -> n + 1) 0

mconcat :: (Monoid m) => [m] -> m
mconcat = foldl (<>) mempty
-- mconcat ["tweedle", "dee"] == "tweedledee"
```

FizzBuzz Revisited

```
fizzbuzz2 :: [(Int, String)] -> Int -> String
fizzbuzz2 conds n = fromMaybe (show n) mdesc
where
    mdesc = mconcat (map maybeWord conds)
    maybeWord (k, word)
        | rem n k == 0 = Just word
        | otherwise     = Nothing

sol2 :: [String]
sol2 = map (fizzbuzz2 conds) [1..100]
where conds = [(3, "Fizz"), (5, "Buzz")]
```

Reflections on take 2

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- ▶ What do we not like?
 - ▶ Still not extensible enough!

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FizzBuzz: Hard Mode

- ▶ FizzBuzz, but...
 - ▶ For every prime number, put “Buzz” instead
 - ▶ For every fibonacci number, put “Fizz” instead
 - ▶ For every number that is a fibonacci number and a prime number, put “FizzBuzz” instead

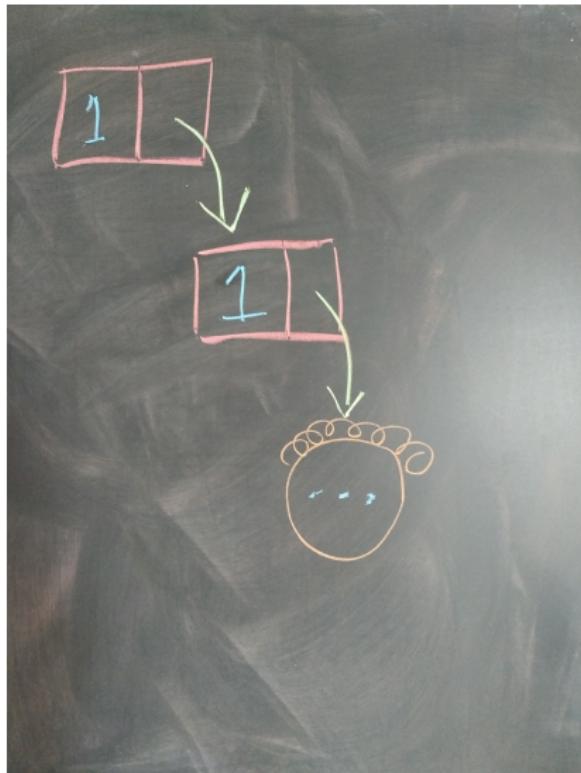
Infinity and Beyond!

```
repeat :: a -> [a]
repeat x = x:(repeat x)
-- take 3 (repeat 1) = [1,1,1]
```

Infinite list illustration



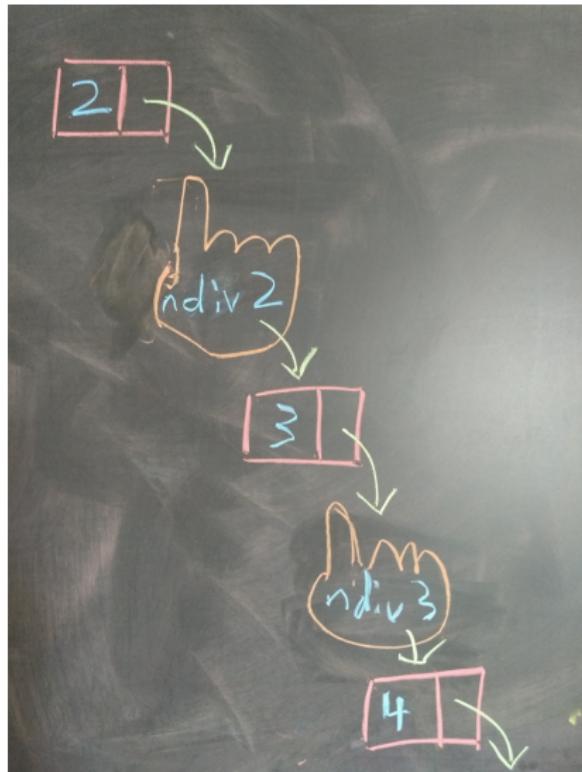
Infinite list illustration



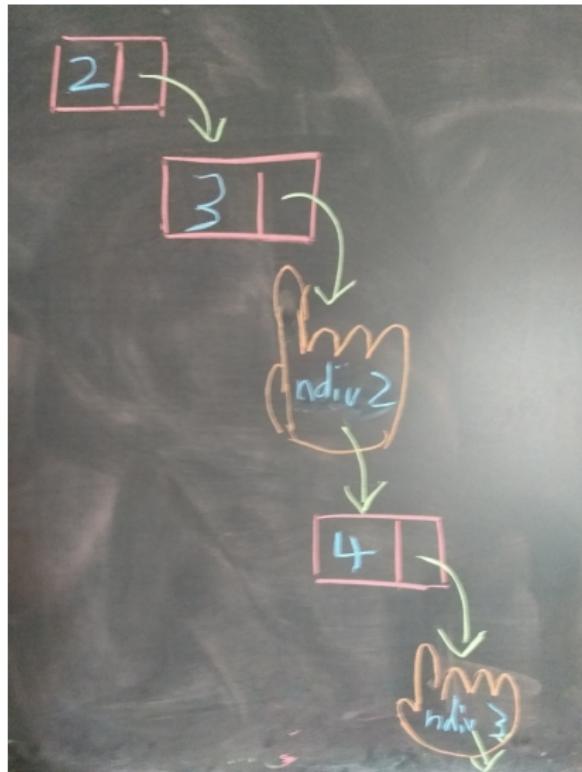
Generating prime numbers

```
primes :: [Int]
primes = from 2
where
    from k = k:(filter (ndiv k) (from (k+1)))
    ndiv k n = rem n k /= 0
-- take 4 primes == [2,3,5,7]
```

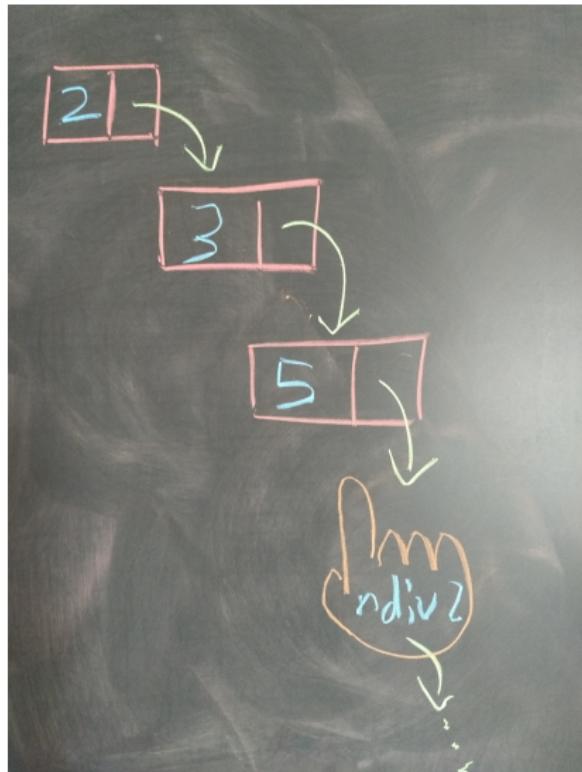
An illustration of primes



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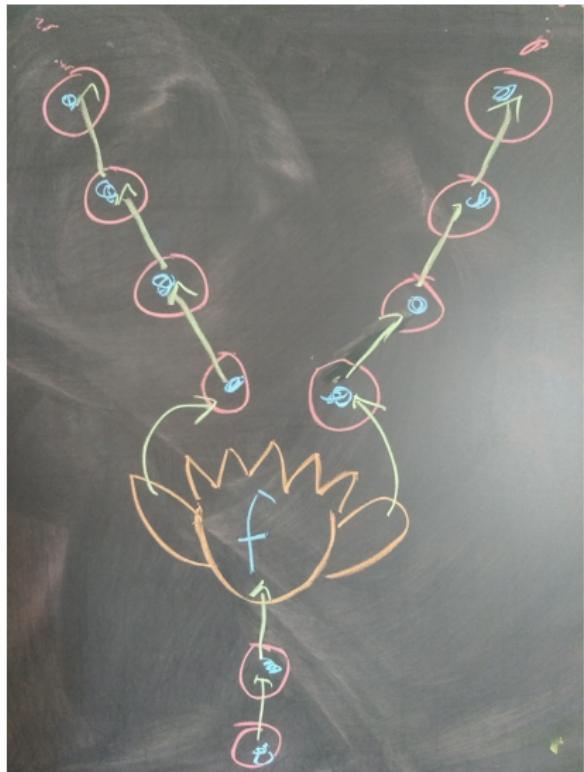
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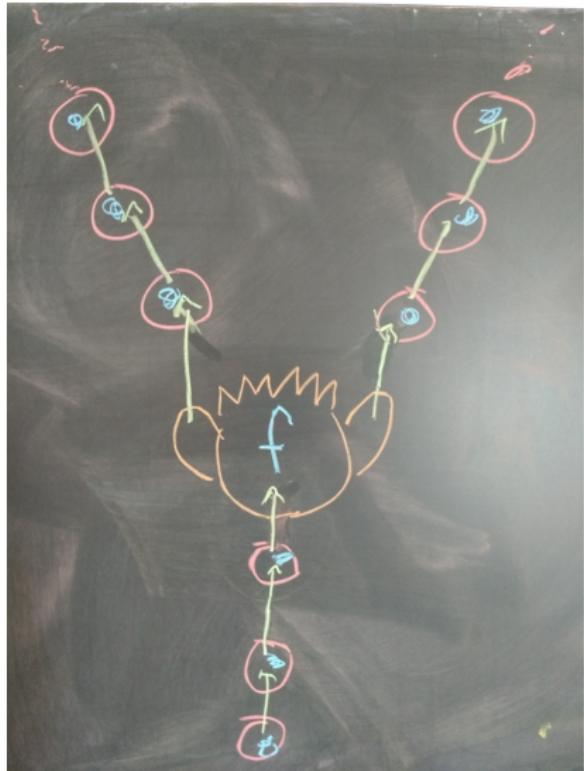
Zipping Lists

```
zipWith :: (a -> b -> c) -> [a] -> [b] -> [c]
zipWith _ [] _ = []
zipWith _ _ [] = []
zipWith f (x:xs) (y:ys) =
  (f x y) : (zipWith f xs ys)
```

The zipWith Monster!



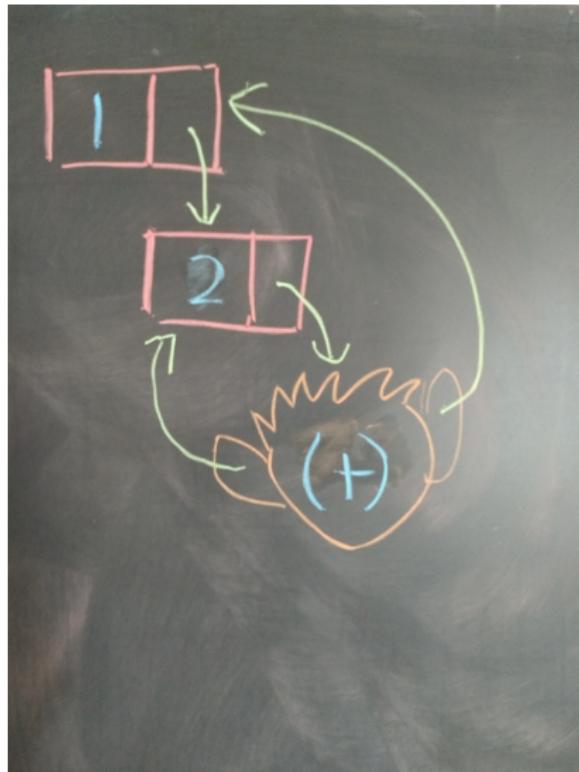
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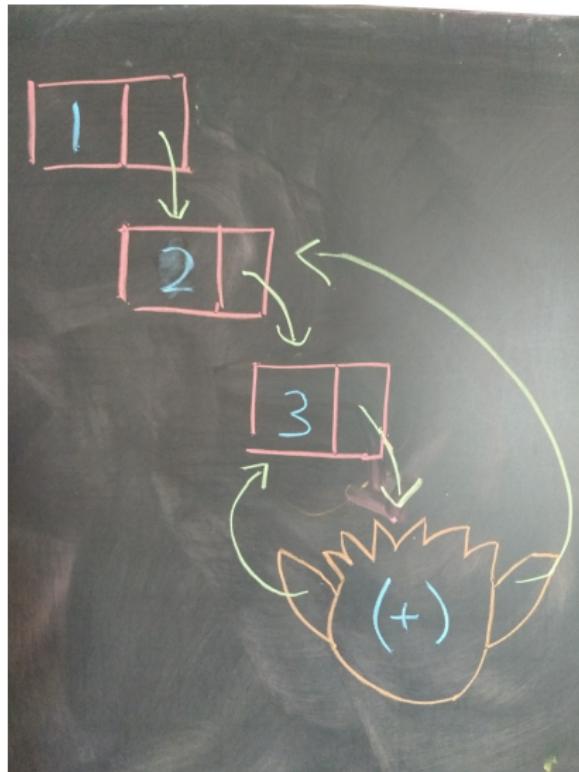
Fibonacci numbers

```
fibs :: [Int]
fibs = 1:2:(zipWith (+) fibs (tail fibs))
-- This one's a brainwister!
```

The Fibonacci zipWith Monster!



The Fibonacci zipWith Monster!



Lists as Monoids Revisited

```
newtype Stream a = S [a]
```

```
unS :: Stream a -> [a]  
unS (S xs) = xs
```

```
instance Monoid a => Monoid (Stream a) where  
    mempty = S []  
    (S []) <> (S ys) = S ys  
    (S xs) <> (S []) = S xs  
    (S (x:xs)) <> (S (y:ys)) = S ((x <> y):rest)  
        where (S rest) = (S xs) <> (S ys)
```

Conceptually, when the list ends, we treat the rest as an infinite stream of `mempty`s (this might make more sense in the context of the next slide)

Thoughts on Streams

`Stream Double` is a vector space, where `Double` is the type of real numbers (OK, floating point numbers) in Haskell.

```
scalarMult :: Double -> Stream Double -> Stream Double
scalarMult r (S xs) = S (map (r*) xs)
```

```
addV :: Stream Double -> Stream Double -> Stream Double
addV = (<>)
-- The monoid instance for Double uses addition
```

```
negV :: Stream Double -> Stream Double
negV = scalarMult (-1)
```

This is the same thing as the vector space of polynomials of one variable over \mathbb{R} .

$$[1, 0, \pi] \approx 1 + \pi x^2$$

FizzBuzz: The Final Showdown (Part 1)

```
spacer :: [Int] -> a -> [Maybe a]
spacer (n:ns) x = loop (n-1) (n:ns)
  where
    loop 0 (k1:k2:ns) =
      (Just x):(loop (k2-k1-1) (k2:ns))
    loop k ns = Nothing:(loop (k-1) ns)

-- spacer [1,3,4,7,...] 'x' ==
--   [Just 'x', Nothing, Just 'x', Just 'x', Nothing
--    Nothing, Just 'x', ...]
```

FizzBuzz: The Final Showdown (Part 2)

```
(.) :: (b -> c) -> (a -> b) -> (a -> c)
(f . g) x = f (g x)
-- We need the Monoid instance for a because we need
-- a monoid instance for Stream (Maybe a), which we
-- need because of mconcat
combine :: (Monoid a) => [[Int], a] -> [Maybe a]
combine = unS . mconcat . map ($ . uncurry spacer)
-- uncurry spacer :: ([Int], a) -> [Maybe a]

sol3 :: [String]
sol3 = zipWith fromMaybe (map show [1..100]) descs
  where descs = combine [(primes, "Fizz"), (fib, "Buzz")]
```

Reflecting on the Final Showdown

- ▶ What we liked

Reflecting on the Final Showdown

- ▶ What we liked
 - ▶ Really really extensible!

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 - ▶ Argument-free function definition!

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Reflecting on the Final Showdown

- ▶ What we liked
 - ▶ Really really extensible!
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 - ▶ Really hard to understand!
- ▶ There should always be a balance, no matter what your programming language is. The difference is, in Haskell you have many more choices about how you balance.

Resources

- ▶ Resources for learning haskell

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 - ▶ haskell.org, the center of all things Haskell
 - ▶ hoogle, a search engine for functions, data types, etc. (REALLY USEFUL)

Thank You

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Thank you all for coming and being curious!