What the hell are math nerds talking about?

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Oftentimes, it is rough trying understand what the nerds are talking about

Functional Programmers are often seen as nuts

Purpose for this presentation

> *Distill some of the more difficult terms in functional programming, show it in Haskell and on as many possible languages of the JVM*

Part 1 of this presentation

- Higher order functions
- Type classes
- Ad-hoc Polymorphism,
- Types vs. kinds
- Functors

All Hail from Haskell!

Haskell

- "Pure" Functional Language
- Simon Peyton Jones, Lennart Augustsson, Eric Meijer, Philip Wadler
- Designed in 1990
- **static**, **strong**, and **inferred**
- Cross Platform
- Compiled & Interpreted

Shall we start with Hello World? Hell No!

Haskell Basic Types

- `Int` - Bounded Integer
- `Integer` - Unbounded Integer
- `Float` - Floating Point
- `Double` - Double Precision
- `Bool` - Boolean
- `Char` - Character (String are list of chars)
- `Tuples` - Types surrounded by parenthesis

Basic Method in Haskell

```haskell
isOdd :: Int -> Int
isOdd x = (x `mod` 2) /= 0
```

What is `mod` with the backticks?

First off, here is the signature. What the hell is `a`?

```
mod :: Integral a => a -> a -> a
```

Take 2, and Returns 1

Look at mod a different way

```
(mod 5 2)
```

This would work and return `1`

Since it is a Take 2 and Return 1…

```
5 `mod` 2
```

Another Function!

Specifying the types before the method

```
sumThree :: Int -> Int -> Int -> Int
            |---- Take 3-----|
```

Combine with the implementation of `sumThree`

```
sumThree :: Int -> Int -> Int -> Int
sumThree x y z = x + y + z
```

To actually run `sumThree`

```
sumThree 1 2 3
```

Note: `x`, `y`, `z` is pattern matched

Currying

Another way to look at `sumThree` is through currying…

```
sumThree :: Int -> Int -> Int -> Int
sumThree x y z = x + y + z
```

I can partially apply `sumThree`

```
let f = sumThree 2 1
```

```
f(4) -- 7
```

Type Variables

```
myHead :: [a] -> a
myHead [] = error "empty list"
myHead [x] = x
myHead (x:xs) = x
```

This is analogous to in Java:

```
public A <A> myHead(List<A> list) {...}
```

Filtering with Haskell lambdas

```
filter (\x -> x `mod` 2 /= 0) [1,2,3,4]
```

Becomes:

```
[1,3]
```

Filtering with predefined functions

Remember this?

```
isOdd :: Int -> Int
isOdd x = (x `mod` 2) /= 0
```

We can apply it to as a function, since *it is* a function!

```
filter f [1,2,3,4]
```

Evaluates to…

```
[1,3]
```

Mapping with Haskell Lambdas

```
map (\x -> x * 3) [1,2,3,4]
```

Becomes:

```
[3,6,9,12]
```

Mapping with Haskell Postfix Lambdas

```
map (3*) [1,2,3,4]
```

Becomes:

```
[3,6,9,12]
```

Map is an interesting signature

```
map :: [a] -> (a -> b) -> [b]
```

This is a **higher order function**!

Note: `b` can represent another type

Looking at `map` again…

```
map (3*) [1,2,3,4]
```

Since `b` can be another type, therefore we can do…

```
map (\i -> "Hello " ++ show i) [1,2,3,4]
```

Evaluates to…

```
["Hello 1", "Hello 2", "Hello 3", "Hello 4"]
```

FYI: Show converts anything to String when it can.

Trying another higher order function

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

Simple Case:

```
myZipWith (+) [1,2,3] [4,5,6]
```

Evaluates To:

```
[5, 7, 9]
```

Higher Difficulty Case:

```
let a = [1,2,3,4,5,6]
let b = ["Rock", "Jazz", "Country", "Salsa", "Polka", "Hip Hop"]
putStrLn (show $ myZipWith (\i s -> s ++ " " ++ show i) a b)
```

What does using a higher function look like in Java?

Not really a higher order function but close a function into a method…

```
static <A,B,C> Stream<C> zip(Stream<? extends A> a, Stream<? extends B> b, BiFunction<? super A,? super B,?
extends C> zipper)
```

How do we use it?

```
let a = Arrays.asList(1,2,3,4,5,6);
let b = Arrays.asList("Rock", "Jazz", "Country", "Salsa", "Polka", "Hip Hop");
Streams.zip(a.stream(), b.stream(), (x, y) -> y + " " + x).collect(Collectors.toList())
```

Note: Using it wasn't bad, but if you had to create your own `zip`, rough

Higher Order Functions in Scala

```
val a = List(1,2,3,4,5,6)
val b = List("Rock", "Jazz", "Country", "Salsa", "Polka", "Hip Hop")
a.zip(b).map{case (i,s) => s + " " + i}
```

Higher Order Functions in Groovy

```
def a  = [1,2,3,4,5,6]
def b  = ["Rock","Jazz","Country","Salsa","Polka","Hip Hop"]
[a,b].transpose().collect{x -> x[1] + " " + x[0]}
```

Higher Order Functions in Clojure

```
(def a [1,2,3,4,5,6])
(def b ["Rock" "Jazz" "Country" "Salsa" "Polka" "Hip Hop"])
(map #(str %1 " " %2) a b)
```

Type Classes

Imagine…

That we can do this in Java

```
interface Eq <A> {
    public boolean equals (A a, A b);
    default public boolean notEquals (A a, A b) {
      return !equals(a,b)
    }
}
```

Lets Make an Instance for `Eq` and say for type `Cow`

```
package com.example.cowtypeclasses

public class CowEquivalenceByName implements Eq<Cow> {
    public boolean equals (Cow a, Cow b) {
       a.getName().equals(b.getName());
    }
}
```

Now lets say we can "bind" this in scope

In other words…

- By implementing an interface, we make this object available for anything that needs to use it.
- We have the power to `import` this `CowEquivalence` when ever we need to strategically use it.
- We can choose another implementation of Cow if we have another equivalence strategy
- Think of a Strategy Pattern that instead of setters we use imports!

Other ways to look at it

If we have the ability to create both classes in the same package (Java doesn't do this I know)

```
package com.example.cowtypeclasses
public class CowEquivalenceByName {...}
public class CowEquivalenceByWeight {...}
```

In some random method in some other package…I can do

```
public void foo(Cow a, Cow b) {
   import com.example.cowtypeclasses.CowEquivalenceByWeight
   a.equals(b); //true if equal weight!
}
```

That's a type class!

Coming back to Haskell

First off:

- There are no objects in Haskell. Get That?
- This is a functional language!
- Damn it! Listen to me I'm serious!

What Haskell has are "Algebraic Data Types"!

```
data GameResult = Win | Loss | Tie
```

What does the `Eq` type class look like?

This is already built into Haskell

```
class Eq a where
    (==) :: a -> a -> Bool
    (/=) :: a -> a -> Bool
    x == y = not (x /= y)
    x /= y = not (x == y)
```

Warning: `class` is not a Java `class`. It is a type class!

Now we will make an `instance` of the type class:

```
instance Eq GameResult where
    Win == Win = True
    Loss == Loss = True
    Tie == Tie = True
    _ == _ = False
```

Warning: By instance we don’t mean an object we mean "an implementation" of the type class

Using the type class

```
(Win == Win) -- True
(Loss == Win) -- False
```

Type Classes in Scala

```
trait Eq[a] {
  def eq(a1: a)(a2: a): Boolean
}
```

```
sealed abstract class GameResult
final case object Win extends GameResult
final case object Loss extends GameResult
final case object Tie extends GameResult
```

```
implicit class GameResult extends Eq[GameResult] {
   def eq(a1:GameResult, a2:GameResult) = (a1, a2) match {
       case (Win, Win) => true
       case (Loss, Loss) => true
       case (Tie, Tie) => true
       case _ => false
   }
}
```

```
def newIsEquals(x:GameResult, y:GameResult)(implicit val eq:Eq[GameResult]) = {
   eq(x)(y)
}
```

Type classes in Clojure

```
(defprotocol Eq
   (equal-to [x y])
   (not-equal-to [x y])
)

(extend-type clojure.lang.Keyword
   Eq
   (equal-to [x y] (= x y))
   (not-equal-to [x y] (not= x y))
)

(println (equal-to :Win :Win))
(println (equal-to :Loss :Loss))
(println (equal-to :Tie :Tie))
(println (equal-to :Win :Loss))
```

Ad Hoc Polymorphism

- Something badass you can tell your boss to get a raise
- It actually has to do with the ability of types
- Also known as "overloading"
- Definition that we can use the `Eq` type class for various types!

More about Ad Hoc Polymorphism

```
(1 == 4)
```

This works because there is an `instance` of `Eq Int`

```
("Hello" == "Hello")
```

This works because there is an `instance` of `Eq String`

```
(Win == Win)
```

This works because we said so and is an `instance` of `Eq GateResult`

Extending Type Classes

```
class  (Eq a) => Ord a  where
  (<), (<=), (>=), (>)  :: a -> a -> Bool
  max, min              :: a -> a -> a
```

Kinds Vs. Types

Types

- Type are what are classes in Java

```
Prelude> :t 4
4 :: Num a => a
```

```
Prelude> :t "What is love? Baby don't hurt me"
"What is love? Baby don't hurt me" :: [Char]
```

Kinds

Kinds are a description of the type

```
Prelude> :k Int
Int :: *
```

"In order to create a type Int, how many extra things do we need?"

Introduction to the `Maybe` Type

Algebraic Data Type of `Maybe`

```
data Maybe a = Nothing | Just a
```

```
Prelude> Just 3
Just 3

Prelude> Just "Blueberry Pancakes"
Just "Blueberry Pancakes"

Prelude> Nothing
Nothing

Prelude> Just 10 :: Maybe Double
Just 10.0
```

The Type of `Maybe`

```
Prelude> :t Just "Blueberry Pancakes"
Just "Blueberry Pancakes" :: Maybe [Char]
```

```
Prelude> :t Just 90
Just 90 :: Num a => Maybe a
```

The Kind of `Maybe`

First off, remember this signature…

```
data Maybe a = Nothing | Just a
```

```
Prelude> :k Maybe
Maybe :: * -> *
```

```
Prelude> :k Maybe Int
Maybe Int :: *
```

The `Either` type

```
data Either a b = Left a | Right b
```

```
Prelude> Left 10
Left 10
Prelude> :t Left 10
Left 10 :: Num a => Either a b
```

What do you think the unsatisfied kind is of `Either`?

The Kind of `Either`

```
Prelude> :k Either
Either :: * -> * -> *
```

```
Prelude> :k Either Int
Either Int :: * -> *
```

```
:k Either Int [Char]
Either Int [Char] :: *
```

The List Type

```
Prelude> :t []
[] :: [a]
```

```
Prelude> :t [1,2,3,4]
[1,2,3,4] :: Num t => [t]
```

What is the kind of `[]`?

Kind of `[]`

```
Prelude> :k []
[] :: * -> *
```

```
Prelude> :k [Int]
[Int] :: *
```

`Functor` Type Class

This is where things get "kind" of hard

```
class Functor f where
    fmap :: (a -> b) -> f a -> f b
```

`f` has a requirement, what kind does `f` have to be?

Discovering Kinds in `Functor`

```
class Functor f where
    fmap :: (a -> b) -> f a -> f b
```

`f a` means whatever `f` is it requires an `a` `f b` also means whatever `f` is, it requires a `b`

Because `f` requires one thing `*`, therefore we know that f is * -> *

Quick! It's up to us now to find a kind of * -> *!

Plugging in a `kind` of `Maybe`

Reminder #1:

```
data Maybe a = Nothing | Just a
```

Reminder #2:

```
class Functor f where
    fmap :: (a -> b) -> f a -> f b
```

Reminder #3:

```
Prelude> :k Maybe
Maybe :: * -> *
```

Well that's what we need a kind of `* → *`!

```
instance Functor Maybe where
   fmap f (Just x) = Just (f x)
   fmap f Nothing = Nothing
```

Using a `Maybe` `Functor`

```
fmap (\x -> x * 14) (Just 19)
```

Results in:

```
Just 266
```

I could’ve written it like this…

```
fmap (14*) (Just 19)
```

Now, trying with `Nothing`

```
fmap (22+) Nothing
```

Results in:

```
Nothing
```

It’s about find the right types and the right kinds

List Functor

Reminder of the kind of `[]`

```
Prelude> :k []
[] :: * -> *
```

It works! Therefore to make it a `Functor`:

```
instance Functor [] where
  fmap f xs = map f xs
```

or

```
instance Functor[] where
  fmap = map
```

Therefore `fmap` and `map` should work the same

```
Prelude> fmap (12*) [1,2,3,4,5]
[12,24,36,48,60]
Prelude> map (12*) [1,2,3,4,5]
[12,24,36,48,60]
```

Either Functor

Reminder of the Algebraic Data Type

```
data Either a b = Left a | Right b
```

The problem with `Either` is that it’s kind is..

```
Prelude> :k Either
Either :: * -> * -> *
```

and it is not * -> * like we need it to be, therefore we need satisfy one half of the kind pattern.

```
instance Functor (Either a) where
    fmap f (Right x) = Right (f x)
    fmap f (Left x) = Left x
```

Reminder:

```
class Functor f where
    fmap :: (a -> b) -> f a -> f b
```

Using the `Either` `Functor`

```
Prelude> fmap ("Nice " ++) (Right "Code")
Right "Nice Code"
Prelude> fmap (20*) (Left 30)
Left 30
```

Intermission

Part 2 of this presentation

- Some More Functors
- Applicatives
- Monoids
- Monads

What do Functors look like in Java?

Imagine...

...if we had the ability to do this in Java

```
public F<B> <A, B, F extends Functor> fmap(x:A, f:F<A>) {
   ....
}
```

But we can't. We cannot do F<B> because F is unknown, and java needs that. F is what is known as a **Higher Kinded Type**

Scala has Higher Kinded Types!

```
trait Functor[F[_]]  { self =>
  def map[A, B](fa: F[A])(f: A => B): F[B]
}

implicit object ListFunctor extends Functor[List] {
  override def map[A, B](fa: List[A])(f: (A) => B): List[B] = fa.map(f)
}

implicit object OptionFunctor extends Functor[Option] {
  override def map[A, B](fa: Option[A])(f: (A) => B): List[B] = fa match {
     case Some(x) => Some(f(x))
     case None => None
  }
}

/* Power play! I only need to declare once! Remember ad-hoc polymorphism! */
def fmap[A, B, C[_]](f:A => B)(coll:C[A])(implicit functor:Functor[C]) =
       functor.map(coll)(f)


fmap(x => x + 2)(List(1,2,3,4)) //List(3,4,5,6)
fmap(x => x + 2)(Some(100))     //Some(102)
fmap(x => x + 19)(None)         //None
```

Winner! Winner! Chicken Dinner!

Applicatives

- Beefed up functor
- Functors take one param
- Consider:

```
fmap (*) (Just 10)
```

Turns into:

```
(Just ((+) 10))
```

Which is the same as:

```
(Just (10+)
```

Where the type is:

```
:t Maybe(Int -> Int)
```

Other Partial Maps

```
fmap (+) [1,2,3,4,5]
```

Where the type is…

```
:t [Integer -> Integer]
```

or

```
fmap (\x y z -> x + y + z) [1,2,3,4,5]
```

Where the type is…

```
:t [Integer -> Integer -> Integer]
```

What if we wanted to do…

```
op Just(4*) Just(5)
```

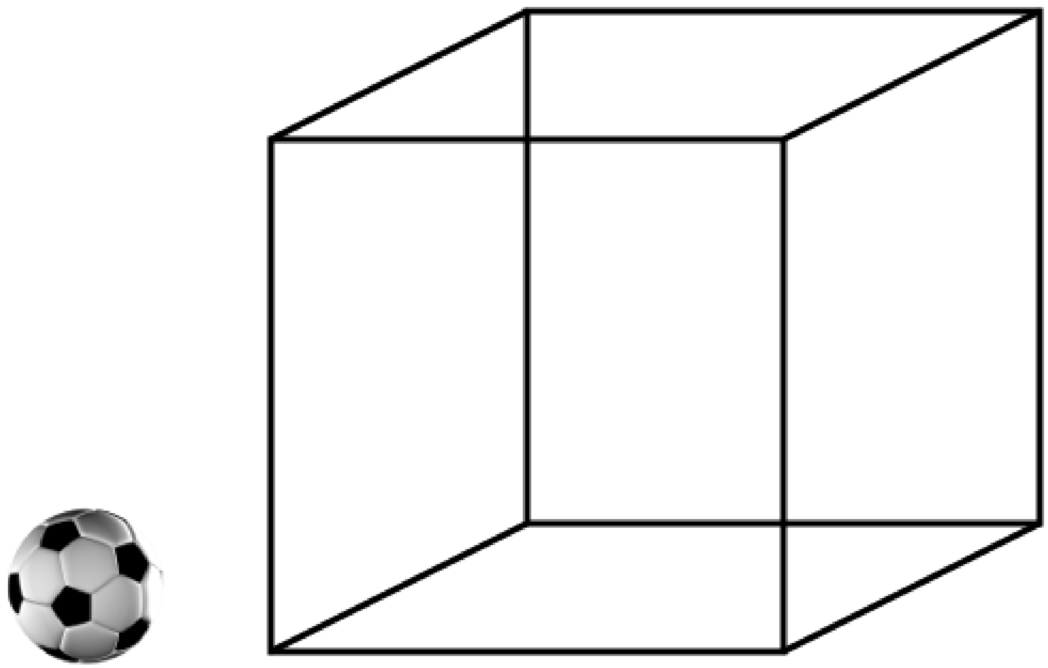
so we can get `Just(9)`?

Applicative Functors Definition

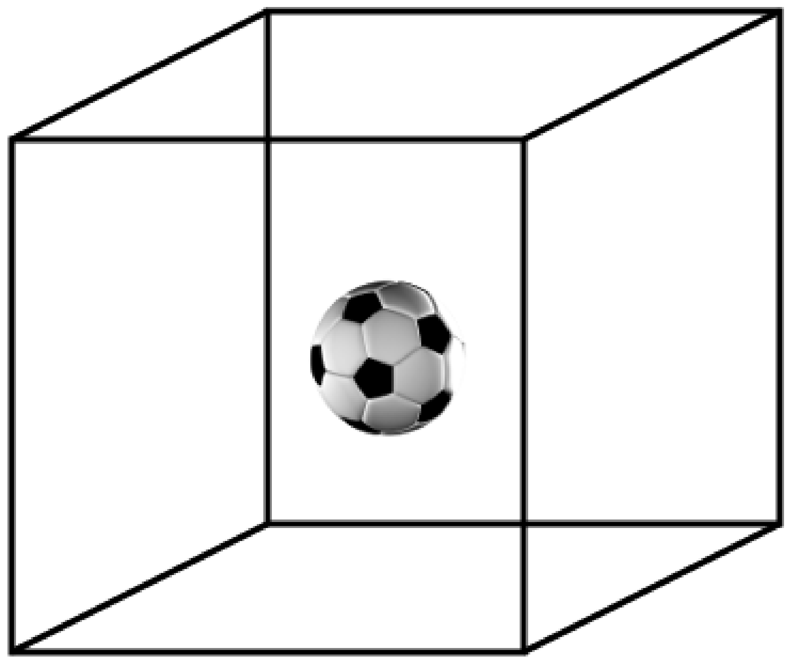
```
class (Functor f) => Applicative f where
    pure :: a -> f a
    (<*>) :: f (a -> b) -> f a -> f b
```

Note: Applicatives are Functors

It’s `pure` baby



It’s `pure` baby



```
pure 5 :: Maybe Int
```

More pure:

```
pure 3 :: Either String Int
```

Will return:

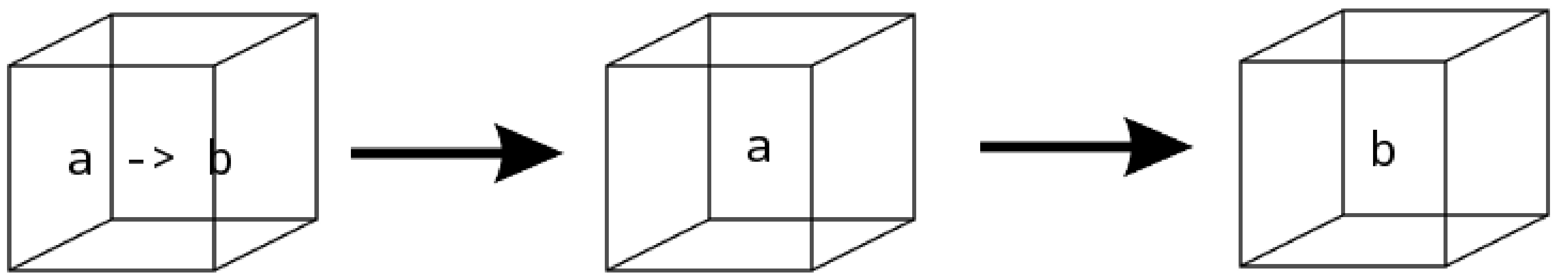
```
Right 3
```

Contrasting and Comparing `<*>` and `fmap`

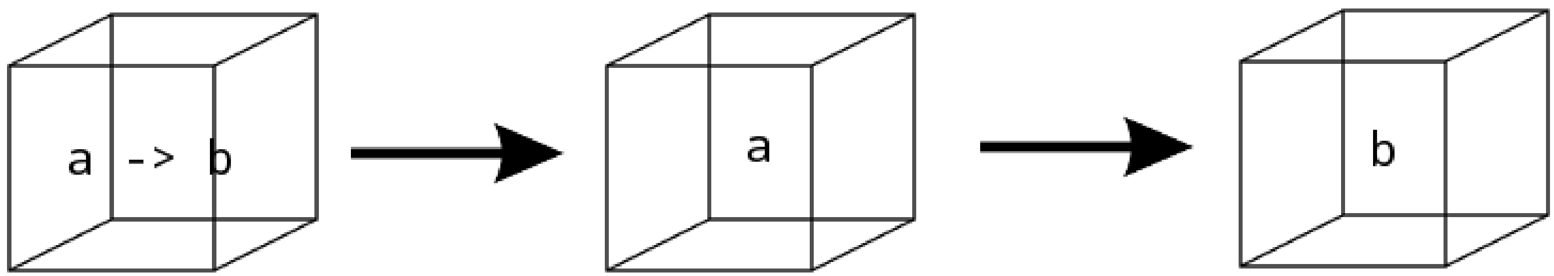
```
fmap :: (a -> b) -> f a -> f a
```

```
<*> :: f (a -> b) -> f a -> f b
```

Envisioning what `<*>` looks like

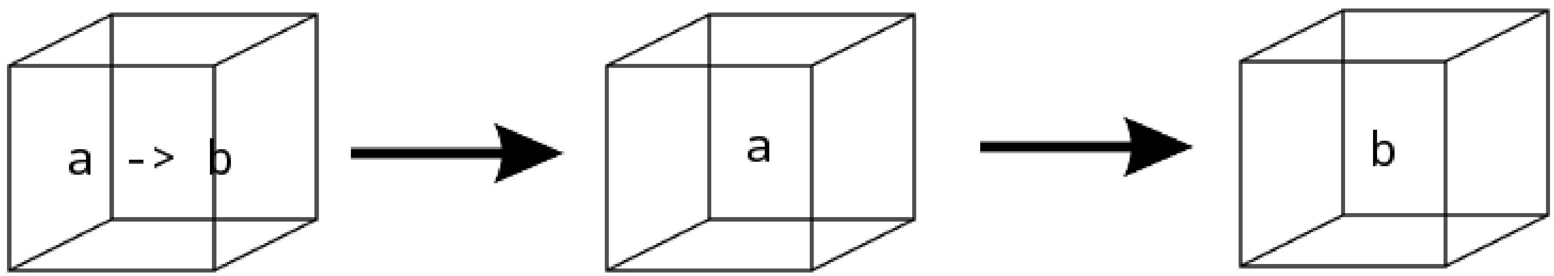

a -> b
a
b

Envisioning what `<*>` looks like



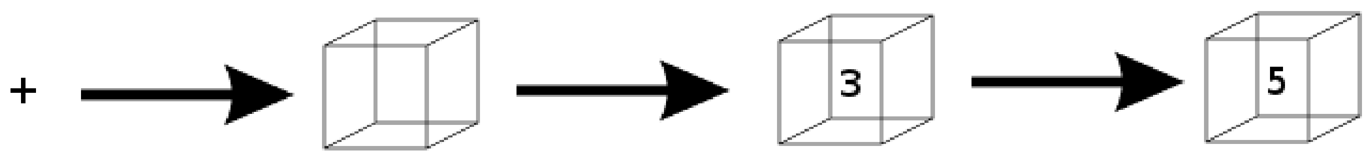

```
<*> Just(*3) Just 4
```

Envisioning what `<*>` looks like



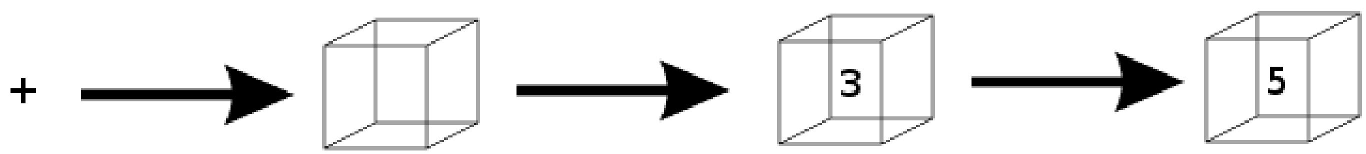

```
Just(*3) <*> Just 4
```

Building another applicative



```
pure (+) <*> Just 3 <*> Just 5
```

Building another applicative



```
pure (*) <*> Nothing <*> Just 9
```

List Applicatives

```
instance Applicative [] where
    pure x = [x]
    fs <*> xs = [f x | f <- fs, x <- xs]
```

Pure List Applicatives

```
pure 3 :: [Int]
```

Converts to:

```
[3]
```

```
pure "Dance" : [String]
```

Converts to:

```
["Dance"]
```

Note: `String` is an alias for `[Char]`

So how do we read List Applicative's `<*>` ?

The signature is

```
fs <*> xs = [f x | f <- fs, x <- xs]`
```

This is called a for comprehesion

```
[(1*), (2+)] <*> [3, 9]
```

```
[3, 9, 5, 11]
```

A slightly complicated Applicative chain

```
[(+), (*)] <*> [4,5] <*> [1,9]
```

Taking it in parts

```
[(+4), (+5), (*4), (*5)] <*> [1,9]
[5, 13, 6, 14, 4, 36, 5, 45]
```

What does Applicative look like in Scala?

```
trait Applicative[F[_]] {
   def pure[A](a:A):F[A]
   def apply[A, B](fa: F[A])(f:F[A=>B]):F[B]
}

implicit object ListApplicative extends Applicative[List] {
  override def pure[A] (a:A) = List(a)
  override def apply[A, B](xs: List[A])(fs: List[A => B]): List[B] =
    for (f <- fs;
         x <- xs) yield f(x)
}

implicit object OptionApplicative extends Applicative[Option] {
  override def pure[A] (a:A) = Some(a)
  override def apply[A, B](fa: Option[A])(f: Option[A => B]): Option[B] = (f, fa) match {
     case (None, _) => None
     case (Some(f), item) => fmap(f)(item)
  }
}

def applicate [A, B, C[_]](f:C[A => B])(coll: C[A])(implicit applicative:Applicative[C]) = {
       applicative.apply(coll)(f)
}

println(applicate(Some((x:Int) => x * 4):Option[Int => Int])(Some(5):Option[Int]))
println(applicate(List((x => x + 1), (x => x + 4)):List[Int => Int])(List(3, 9)))
```

Monoids

- Monoids combines things that are associative, regardless of order or parenthetical categorization:
- Examples

```
`3 * 4`
```

```
`2 + 10`
```

```
((r + s) + t) or (r + (s + t))
```

- A higher abstract to append one item to another, but in a type class way
- Functional Programmers are obsessive about using one method to work with many types

Monoid Definition

```
class Monoid m where
    mempty :: m
    mappend :: m -> m -> m
    mconcat :: [m] -> m
    mconcat = foldr mappend mempty
```

Monoid Rules

```
mempty `mappend` x = x
x `mappend` mempty = x
(x `mappend` y) `mappend` z = x `mappend` (y `mappend` z)
```

List Monoids

```
instance Monoid [a] where
    mempty = []
    mappend = (++)
```

```
Prelude> [1,2,3] `mappend` [4,5,6]
[1,2,3,4,5,6]
Prelude> "What's" `mappend` "cool"
What'scool
Prelude> mempty::[String]
[]
Prelude> mempty::[Int]
[]
Prelude> mempty::String
""
Prelude> mconcat [[1,2], [3,5,6,7,10], [12, 19]]
[1,2,3,5,6,7,10,12,19]
```

`foldr`?

```
Prelude> let g = foldr (+) 0
Prelude> g [1,2,3,4,5]
15
```

Repeating from the previous slide

```
Prelude> mconcat [[1,2], [3,5,6,7,10], [12, 19]]
[1,2,3,5,6,7,10,12,19]
```

What does a monoid look like in Scala?

```
trait Monoid[A] {
   def op(a1: A, a2: A): A
   def zero: A
}

val stringMonoid= new Monoid[String] {
   def op(a1: String, a2: String) = a1 + a2
   val zero = ""
}

def listMonoid[A] = new Monoid[List[A]] {
 def op(a1: List[A], a2: List[A]) = a1 ++ a2
 val zero = Nil
}
```

So far we have discovered..

```
fmap :: (Functor f) => (a -> b) -> f a -> f b
```

```
(<*>) :: (Applicative f) => f (a -> b) -> f a -> f b
```

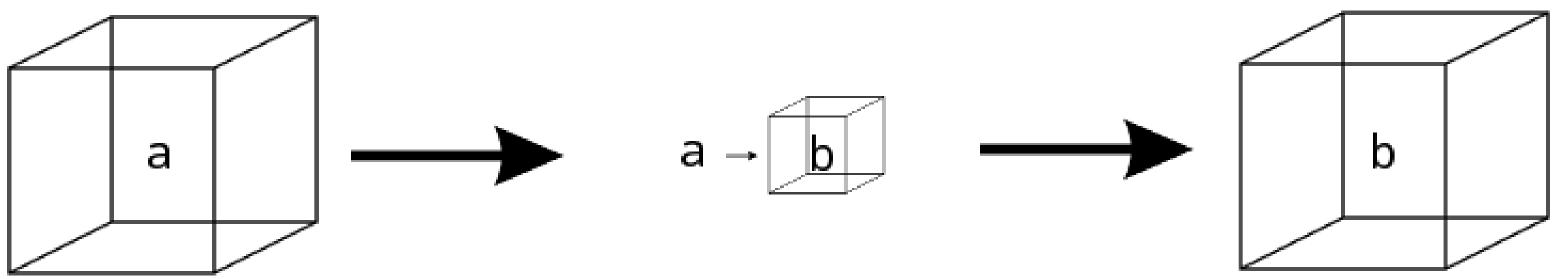
..and now Monads!

```
fmap :: (Functor f) => (a -> b) -> f a -> f b
```

```
(<*>) :: (Applicative f) => f (a -> b) -> f a -> f b
```

```
(>>=) :: (Monad m) => m a -> (a -> m b) -> m b
```

Monads in Visual Form



```
(>>=) :: (Monad m) => m a -> (a -> m b) -> m b
```

The complete Monad typeclass

```
class Monad m where
    return :: a -> m a

    (>>=) :: m a -> (a -> m b) -> m b

    (>>) :: m a -> m b -> m b
    x >> y = x >>= \_ -> y

    fail :: String -> m a
    fail msg = error msg
```

`return`?

- Same is `pure` in Applicative, take an item and put into a context or container

```
return 4 :: Maybe Int
```

Evaluates To…

```
Just 4
```

```
return 4 :: [Int]
```

Evaluates To..

```
[4]
```

Bind method

```
(>>=) :: m a -> (a -> m b) -> m b
```

How we will invoke as such:

```
ma >>= (a -> m b)
```

Bind will take one monad, and a function that will return a monad of another type, and provide some result

`fail`

- Monads provide an option for failure as a monad.
- Whereas `return` will provide a Monad of it’s simplest form
- `fail` will return a monad representing failure

The "move-along" function

- `(>>)` will take two monads, and determine with one to pass on down.
- By default will accept a the two monads, and return the second one.

The signature is:

```
(>>) :: m a -> m b -> m b
x >> y = x >>= \_ -> y
```

Maybe Monad

```
instance Monad Maybe where
    return x = Just x
    Nothing >>= f = Nothing
    Just x >>= f  = f x
    fail _ = Nothing
```

```
Prelude> Just 4 >>= \x -> return (3*x)
12
Prelude> Nothing >>= \x -> return(x + 100)
Nothing
Prelude> fail "Help" :: Maybe Int
Nothing
```

What is the point?

```
Prelude> Just 10 >>= (\x -> Just (show x ++ "!"))
Just "10!"
```

```
Prelude> Just 10 >>= (\x -> Just "!" >>= (\y -> Just (show x ++ y)))
Just "10!"
```

Both of the above, are longer than…

```
Prelude> let x = 3; y = "!" in show x ++ y
```

Monads have built in short circuit error handling

```
Prelude> Nothing >>= (\x -> Just "!" >>= (\y -> Just (show x ++ y)))
Nothing
Prelude> Just 3 >>= (\x -> Nothing >>= (\y -> Just (show x ++ y)))
Nothing
Prelude> Just 3 >>= (\x -> Just "!" >>= (\y -> Nothing))
Nothing
```

Because Haskell and other programming languages rely on monads...

We are able to convert this…

```
monadStack :: Maybe String
monadStack = Just 3 >>= (\x ->
             Just "!" >>= (\y ->
             Just (show x ++ y)))
```

to this…

```
monadStackWithDo :: Maybe String
monadStackWithDo = do
                     x <- Just 3
                     y <- Just "!"
                     Just (show x ++ y)
```

This is called "Monad Comprehension"

We can even do pattern matching as a Monad Comprehension

```
firstChar :: Maybe Char
firstChar = do
              (x:xs) <- Just "hello"
              return x
```

List Monads

Here is the definition of a list monad..

```
instance Monad [] where
    return x = [x]
    xs >>= f = concat (map f xs)
    fail _ = []
```

And here is how we use it…

```
[3,4,5] >>= \x -> [x,-x]
[3,-3,4,-4,5,-5]
```

Failure in List Monads

Should be very similar to the Maybe Monad

```
Prelude> [] >>= \x -> [1,2,3]
[]
Prelude> [1,2,3] >>= \x -> []
[]
```

As a list monad, does this operation look familiar?

```
Prelude> [10,11,12] >>= (\x -> [x + 1, x + 2, x + 3])
[11,12,13,12,13,14,13,14,15]
```

Flat Map!

Here is Flat Map in Java 8!

```
Arrays.asList(10, 11, 12).stream().flatMap(x -> Arrays.asList(x + 1, x + 2, x +
3).stream()).collect(Collectors.toList());
```

```
[11, 12, 13, 12, 13, 14, 13, 14, 15]
```

Flat Map in Scala!

```
List(10, 11, 12).flatMap(x => List(x + 1, x + 2, x + 3))
```

```
[11, 12, 13, 12, 13, 14, 13, 14, 15]
```

Flat Map in Scala is used for a variety of things

Like a Maybe Monad

```
Some(4).flatMap(x => Some(3 + x))
```

```
Some(7)
```

IO Monad?

```
main = do
         x <- return("Hello ")
         y <- return("World")
         putStrLn (x ++ y)
```

is the same as

```
main = do
          return("Hello ") >>= \x ->
             return("World") >>= \y ->
               putStrLn(x ++ y)
```

Note: This is perhaps the single reason why Haskell is always so hard to get started!

Futures Monad in Scala

```
val future1 = Future {
  Thread.sleep(3000)
  180 / 2
}

val future2 = Future {
  Thread.sleep(3000)
  90 / 3
}

val result = future1.flatMap {
  x =>
    future2.map {
      y =>
        x + y
    }
}
```

Rube Goldbergs and XMonad

Thank you!

Sources:

- Learn you a Haskell for A Greater Good - http://learnyouahaskell.com/
- Functional Programming in Scala - http://www.manning.com/bjarnason/
- Math World Wolfram Alpha - http://mathworld.wolfram.com
- Wikipedia - http://www.wikipedia.org

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