Applicatives

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Agenda

- Recap of Functors

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- Applicative

Functor[1,2]

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

Functors Laws

- Must preserve identity

```haskell
fmap id = id
```

```haskell
fmap (f . g)  ==  fmap f . fmap g
```

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    fmap :: (a -> b) -> f a -> f b
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Functors Laws

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fmap id = id
```

- Must preserve composition of morphism

```
fmap (f . g)  ==  fmap f . fmap g
```

[1] Category Design Pattern
[2] Functor Design Pattern

Higher order kinds[3]

- For something to be a functor, it has to be a first order kind.

[3] Haskell's Kind System

Applicative

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

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

fmap f x = pure f <*> x
```

Examples

```
pure (+1) <*> [1..3]
[2, 3, 4]

[(*2), (*3)] <*> [4, 5]
[8,10,12,15]

("Woo", (+1)) <*> (" Hoo!", 0)
("Woo Hoo!", 1)

(Sum 2, (+1)) <*> (Sum 0, 0)
(Sum {getSum = 2}, 1)

(Product 3, (+9)) <*> (Product 2, 8)
(Product {getProduct = 6}, 17)

(,) <$> [1, 2] <*> [3, 4]
[(1,3),(1,4),(2,3),(2,4)]
```

Lifting

- Seeing Functor as unary lifting and Applicative as n-ary lifting

```
liftA0 :: Applicative f => (a)                     -> (f a)
liftA1 :: Functor     f => (a -> b)                -> (f a -> f b)
liftA2 :: Applicative f => (a -> b -> c)           -> (f a -> f b -> f c)
liftA3 :: Applicative f => (a -> b -> c -> d) -> (f a -> f b -> f c -> f d)
liftA4 :: Applicative f => ..
```

Where `liftA0 = pure` and `liftA1 = fmap`.

Monoidal functors

– Remember Monoid?

```
class Monoid m where
  mempty :: m
  mappend :: m -> m -> m

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


mappend ::     f          f      f
($) ::       (a -> b) ->   a ->   b
<*> ::     f (a -> b) -> f a -> f b


instance Monoid a => Applicative ((,) a) where
  pure x = (mempty, x)
  (u, f) <*> (v, x) = (u `mappend` v, f x)
```

Function apply

- Applying a function to an `effectful` argument

```
(<$>) :: Functor m       =>   (a -> b)   -> m a -> m b
(<*>) :: Applicative m => m (a -> b)   -> m a -> m b
(=<<) :: Monad m         =>   (a -> m b) -> m a -> m b
```

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- Result of `f a` can't possibly influence the behaviour of `f b`
- That needs something like `a -> f b`

Applicative laws

```haskell
-- Identity
pure id <*> v = v

-- Composition
pure (.) <*> u <*> v <*> w = u <*> (v <*> w)

-- Homomorphism
pure f <*> pure x = pure (f x)

-- Interchange
u <*> pure y = pure ($ y) <*> u
```

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    - Branching on previous results

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- Weaker than monads but thus also more common
- Lends itself to optimisation (See Facebook's Haxl project)
- Always opt for the least powerful mechanism to get things done
- No dependency issues or branching? just use applicative

Questions

- Reach out on

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