Applicative Methods (3B)

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The definition of Applicative

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

f (a -> b) :: a **function** wrapped in f

f a :: a **value** wrapped in f

The class has a two methods :

pure brings arbitrary values into the functor

(<*>) takes a **function** wrapped in a functor f
and a **value** wrapped in a functor f
and returns the result of the application
which is also wrapped in a functor f

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

The Maybe instance of Applicative

```
instance Applicative Maybe where
  pure                  = Just
  (Just f) <*> (Just x) = Just (f x)
  _        <*> _        = Nothing
```

pure wraps the value with **Just**;

(<*>) applies

the function wrapped in **Just**

to the value wrapped in **Just** if both exist,

and results in **Nothing** otherwise.

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

An Instance of the Applicative Typeclass

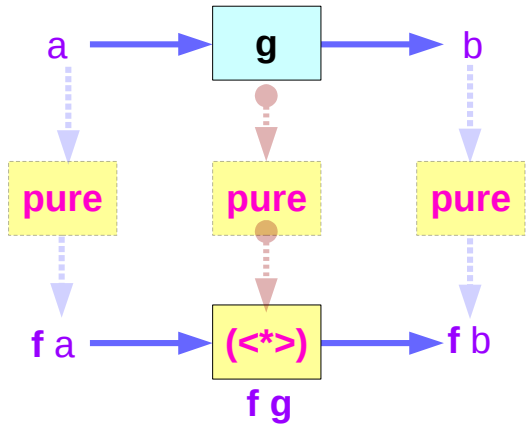
```
class (Functor f) => Applicative f where
    pure :: a -> f a
    (<*>) :: f (a -> b) -> f a -> f b
```

f : Functor, Applicative

(**Functor f**) => **Applicative f**

```
instance Applicative Maybe where
    pure = Just
    Nothing <*> _ = Nothing
    (Just f) <*> something = fmap f something
```

f : function in a context



(**Functor f**) => **Applicative f**

http://learnyouahaskell.com/functors-applicative-functors-and-monoids

Left associative <*>, fmap, and <$>

```
pure g <*> x <*> y <*> z
```

```
fmap g x <*> y <*> z
```

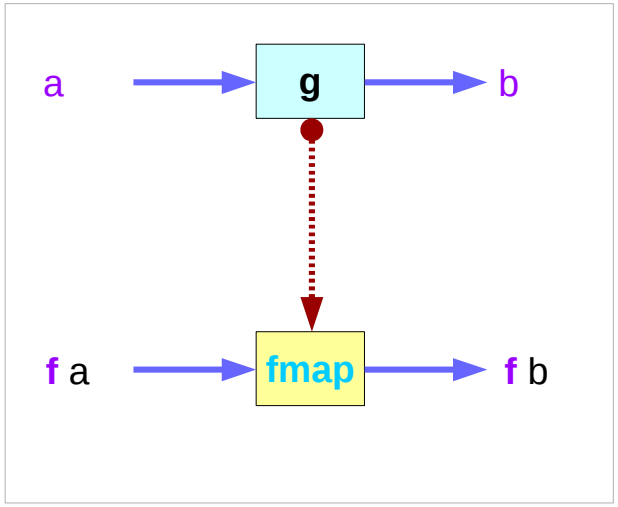
```
g <$> x <*> y <*> z
```

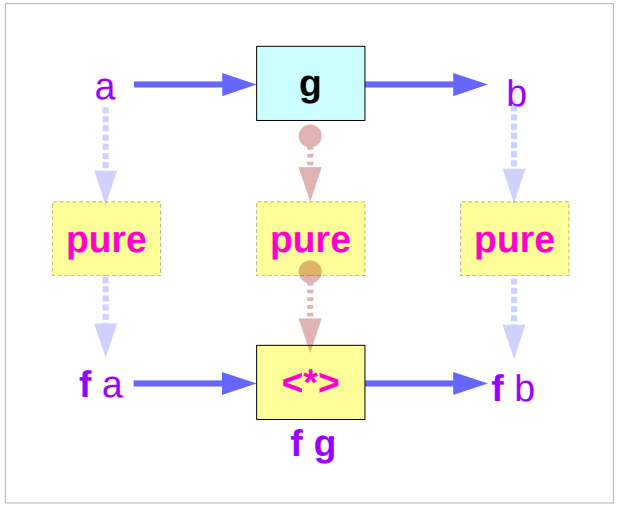
```
g :: f (a -> b -> c -> d)
x :: f a
y :: f b
z :: f c
```

infix operator <$>

http://learnyouahaskell.com/functors-applicative-functors-and-monoids

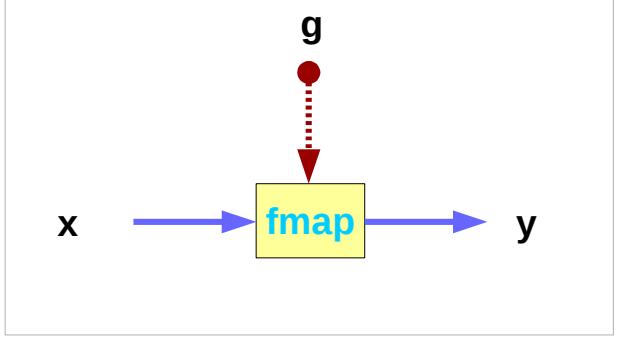
fmap g x = (pure g) <*> x





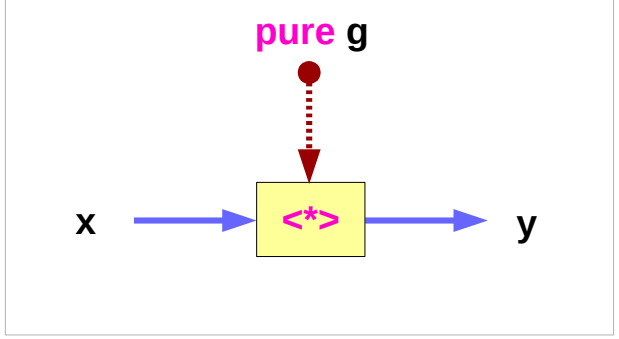
pure = f

fmap g x



x :: f a
y :: f b

(pure g) <*> x



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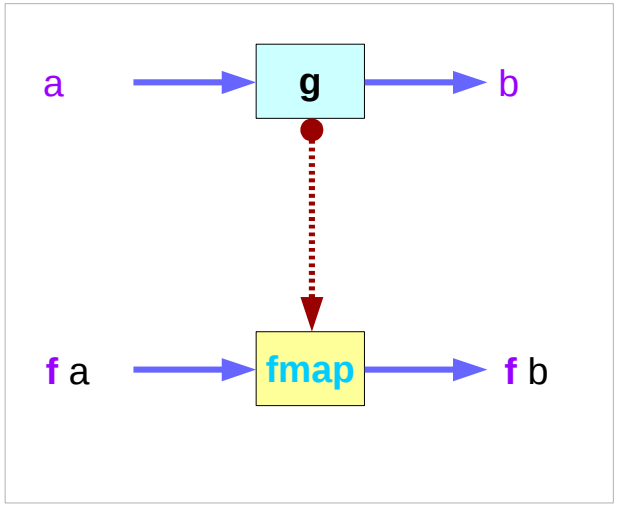
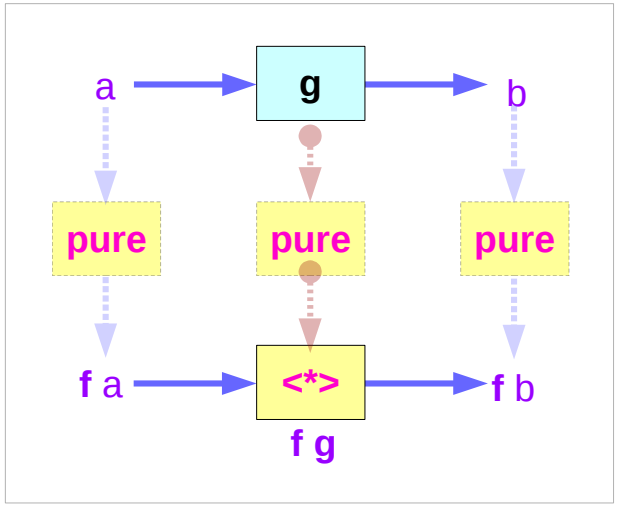
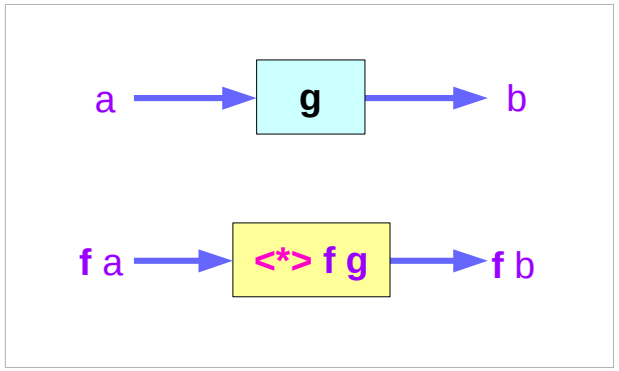
f a <*> f g





pure = f



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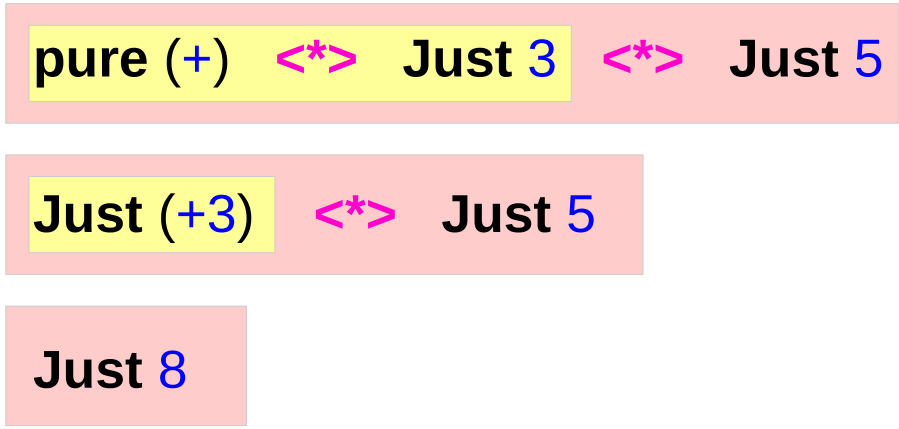
Left associative <*> examples

```
ghci> pure (+) <*> Just 3 <*> Just 5
Just 8
```




```
ghci> pure (+) <*> Just 3 <*> Nothing
Nothing
```

```
ghci> pure (+) <*> Nothing <*> Just 5
Nothing
```

http://learnyouahaskell.com/functors-applicative-functors-and-monoids

Infix Operators <*> vs <$> - a type view

```
h <*> x <*> y
```

```
h :: f (a -> b -> c)
x :: f a
y :: f b
```

```
h :: f (a -> b -> c)
x :: f a
h <*> x :: f (b -> c)
```

```
h :: f (a -> b -> c)
x :: f a
h <*> x :: f (b -> c)
y :: f b
h <*> x <*> y :: f c
```

```
g <$> x <*> y
```

```
g :: (a -> b -> c)
x :: f a
y :: f b
```

```
g :: (a -> b -> c)
x :: f a
g <$> x :: f (b -> c)
```

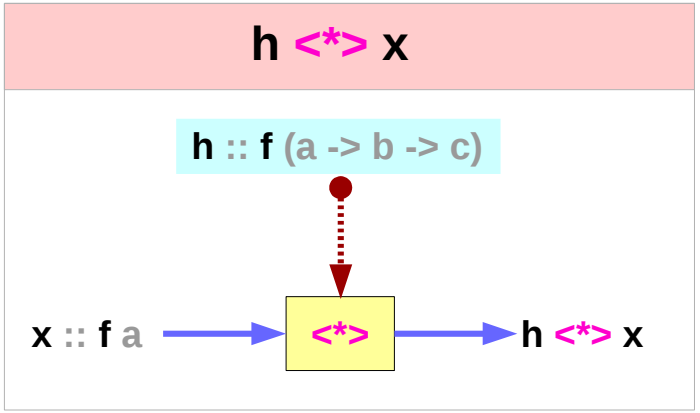
```
g :: (a -> b -> c)
x :: f a
g <$> x :: f (b -> c)
y :: f b
g <$> x <*> y :: f c
```

http://learnyouahaskell.com/functors-applicative-functors-and-monoids

Infix Operators <*> vs <$> - a curried function view

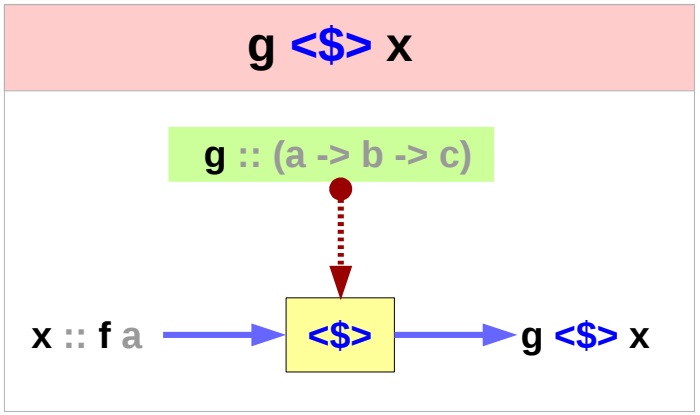
```
h <*> x <*> y
```

```
h :: f (a -> b -> c)
x :: f a
y :: f b
```




```
g <$> x <*> y
```

```
g :: (a -> b -> c)
x :: f a
y :: f b
```



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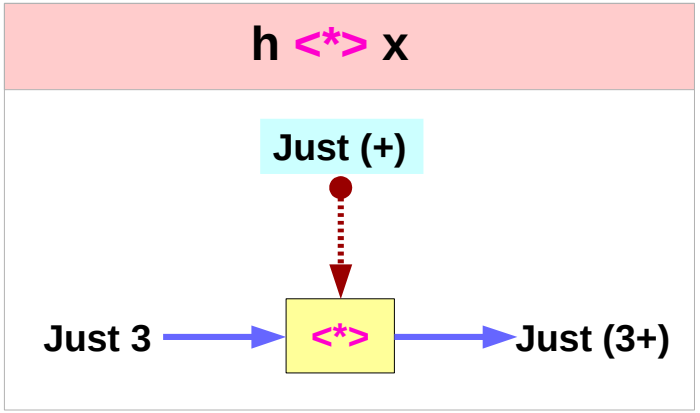
Infix Operators <*> vs <$> examples

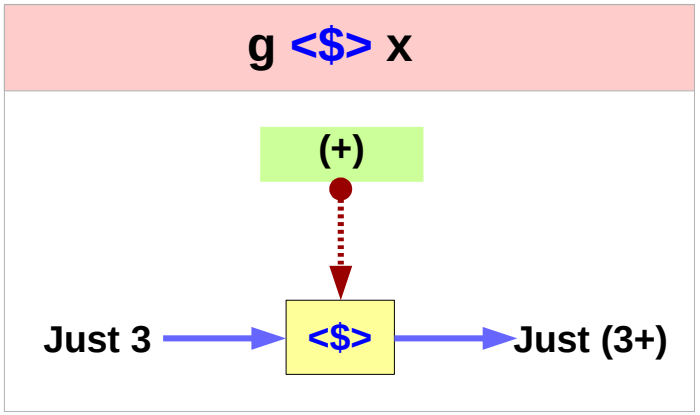
```
h <*> x <*> y
```

```
Just (+) <*> Just 3 <*> Just 2
Just (+3) <*> Just 2
Just 5
```




```
g <$> x <*> y
```

```
(+) <$> Just 3 <*> Just 2
Just (+3) <*> Just 2
Just 5
```



http://learnyouahaskell.com/functors-applicative-functors-and-monoids

the minimal complete definition

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

the minimal complete definition

```
(<$>) :: (Functor f) => (a -> b) -> f a -> f b
g <$> x = fmap g x
```

Not in the minimal complete definition

g :: a -> b, x :: f a

```
instance Applicative Maybe where
    pure = Just
    Nothing <*> _ = Nothing
    (Just g) <*> something = fmap g something
```

http://learnyouahaskell.com/functors-applicative-functors-and-monoids

The Applicative Typeclass

Applicative is a superclass of **Monad**.

every **Monad** is also a **Functor** and an **Applicative**

fmap, **pure**, **(<*>)** can all be used with **monad**s.

a **Monad** instance

requires **Functor** and **Applicative** instances.

defines the types and roles of **return** and **(>>)**

fmap : defined in **Functors**

pure, (**<*>**) : defined in **Applicatives**

return, (**>>**) : defined in **Monads**

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

(<$>) vs ($)

(<$>) infix operator

```
(<$>) :: (Functor f) => (a -> b) -> f a -> f b
g <$> x = fmap g x
```

The $ operator is for avoiding parentheses

```
putStrLn (show (1 + 1))
putStrLn $ show (1 + 1)
putStrLn $ show $ 1 + 1          – right associative
```

($) calls the function which is its left-hand argument of $

on the value which is its right-hand argument of $

The Applicative Laws

The identity law:	**pure id <*> v = v**	**id :: a -> a**	**v :: f a**
Homomorphism:	**pure g <*> pure x = pure (g x)**	**g :: a -> b**	**x :: a**
Interchange:	**u <*> pure y = pure ($ y) <*> u**	**u :: f (a -> b)**	**y :: a**
Composition:	**u <*> (v <*> w) = pure (.) <*> u <*> v <*> w**	**w :: f a**	**v :: f (a -> b)** **u :: f (b -> c)**

Left associative **u <*> v <*> w = (u <*> v) <*> w**

u :: f (c -> b -> a)
v :: f c
u <*> v :: f (b -> a)
w :: f b
u <*> v <*> w = f a

The Identity Law

The identity law **pure id <*> v = v** **id :: a -> a** **v :: f a**

pure to inject values into the functor
in a *default*, *featureless* way,
so that the result is as close as possible
to the plain value.

applying the **pure id** morphism does nothing,
exactly like with the plain **id** function.

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

The Homomorphism Law

The homomorphism law `pure g <*> pure x = pure (g x)` `g :: a -> b` `x :: a`

applying a "**pure**" function to a "**pure**" value is the same as
applying the function to the value in the *ordinary way*
and then using **pure** on the result.
means **pure** preserves function application.

applying a non-effectful function **g**
to a non-effectful argument **x** in an effectful context **pure**
is the same as just **applying** the function **g** to the argument **x**
and then injecting the result **(f x)**
into the effectual context with **pure**.

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

The Interchange Law

The interchange law **u <*> pure y = pure ($ y) <*> u** **u :: f (a -> b)** **y :: a**

($ **y**) is the *function* that supplies **y**
as argument to another function
– a higher order function

Function $ Argument
$ y
(**y**) as a single argument

applying a morphism **u** to a "**pure**" value **pure y**
is the same as applying **pure** (**$ y**) to the morphism **u**

Just (+3) <*> Just 2
Just ($ 2) <*> Just (+3)

when evaluating the application of
an effectful function (**u)** to a pure argument (**pure y**),
the order doesn't matter – commutative.

u :: f (a -> b) **y :: a**
u <*> pure y :: f b **pure y :: f a**
pure ($ y) <*> u :: f b **pure ($ y) :: f (a)**

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

The Composition Law

The composition law `pure (.) <*> u <*> v <*> w = u <*> (v <*> w)` `w :: f a` `v :: f (a -> b)` `u :: f (b -> c)`

pure (.) composes morphisms similarly

to how **(.)** composes functions:

```
w :: f a          -- value
v :: f (a -> b)   -- func1
u : f (b -> c)    -- func2
```

applying the composed mourphism

pure (.) <*> u <*> v *to* **w**

gives the same result **(u <*> (v <*> w))**

as applying **u** *to* the result **(v <*> w)**

of applying **v** to **w**

```
v <*> w :: f b
u <*> (v <*> w) :: f c
```

it is expressing a sort of associativity property of **(<*>)**.

```
pure (.) <*> u <*> v :: f (a -> c )
pure (.) <*> u <*> v <*> w :: f  c
```

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

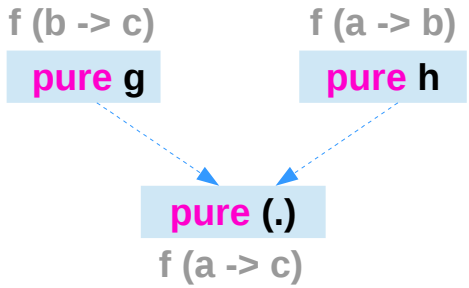
The Composition Law and Left Associativity

The composition law `pure (.) <*> u <*> v <*> w = u <*> (v <*> w)` `w :: f a  v :: f (a -> b)  u :: f (b -> c)`

`pure (.) <*> pure g <*> pure h <*> pure x` `(g . h) x`

`((pure (.) <*> pure g) <*> pure h) <*> pure x`

`= pure g <*> (pure h <*> pure x)` `g (h x)`



`u = pure g :: f (b -> c)` `g :: (b -> c)`
`v = pure h :: f (a -> b)` `h :: (a -> b)`
`w = pure x :: f a` `x :: a`

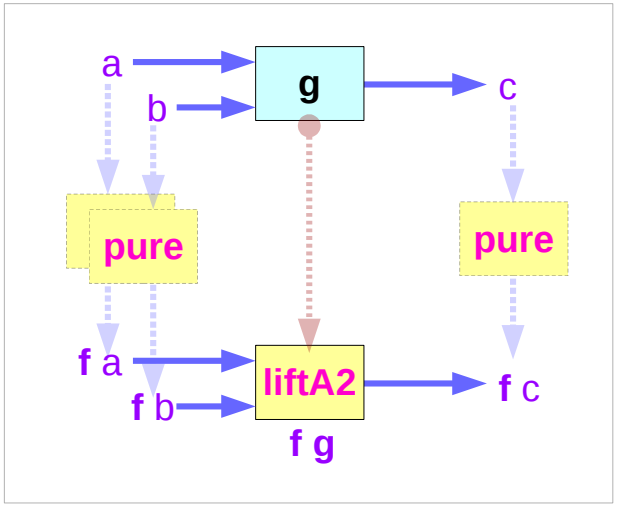
Left associative `u <*> v <*> w = (u <*> v) <*> w` `u :: f (c -> b -> a)  v :: f c  w :: f b`

`u :: f (c -> b -> a)`
`v :: f c`
`u <*> v :: f (b -> a)`
`w :: f b`
`u <*> v <*> w = f a`

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

liftA2

liftA2 :: (a -> b -> c) -> f a -> f b -> f c

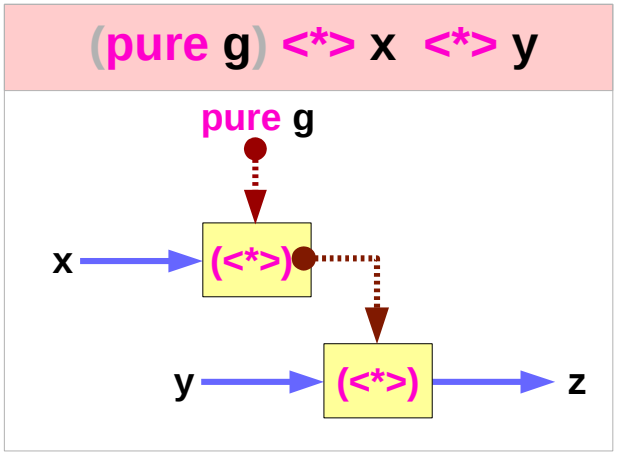


lift a binary function (**a->b->c**) to actions.

Some functors support an implementation of **liftA2**
that is more efficient than the default one.

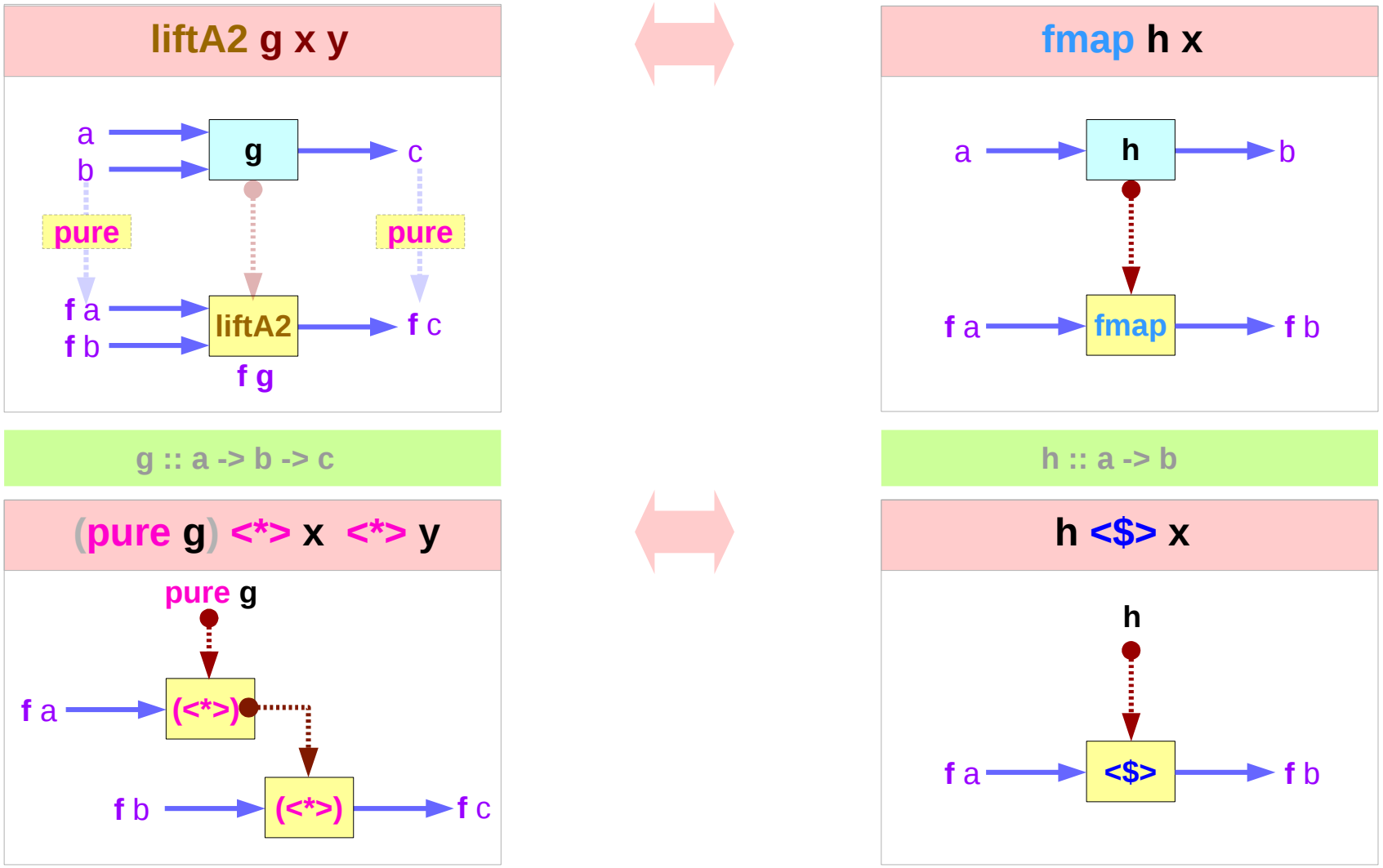
liftA2 may have an efficient implementation
whereas **fmap** is an expensive operation,

sometimes better to use **liftA2** than
to use **fmap** over the structure and then use **<*>**.

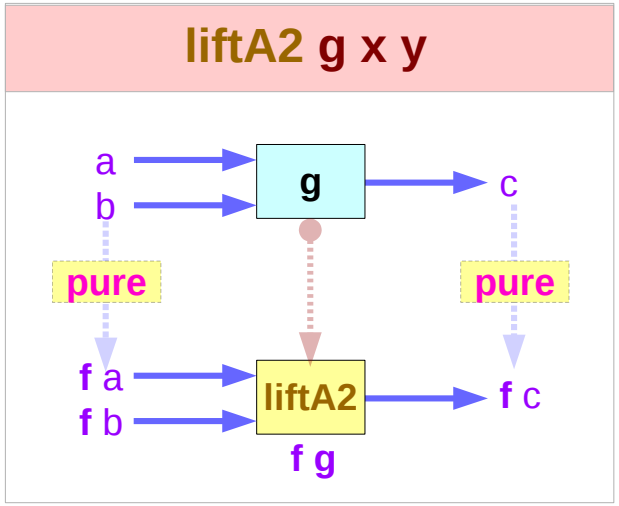


http://hackage.haskell.org/package/base-4.10.1.0/docs/Control-Applicative.html#v:liftA2

liftA2, <*>, fmap, <$>

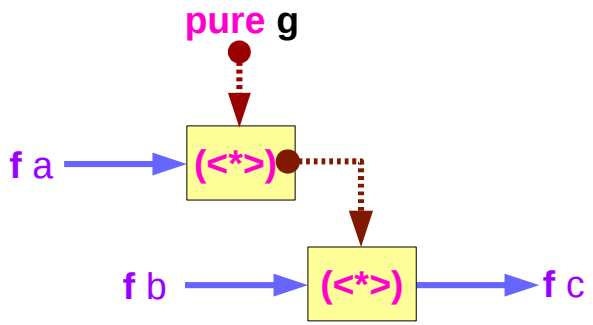

liftA2 g x y
a
b
g
c
pure
pure
f a
f b
liftA2
f c
f g
fmap h x
a
h
b
f a
fmap
f b
g :: a -> b -> c
h :: a -> b
(pure g) <*> x <*> y
pure g
f a
(<*>)
f b
(<*>)
f c
h <$> x
h
f a
<$>
f b

pure g <*> x <*> y equivalent



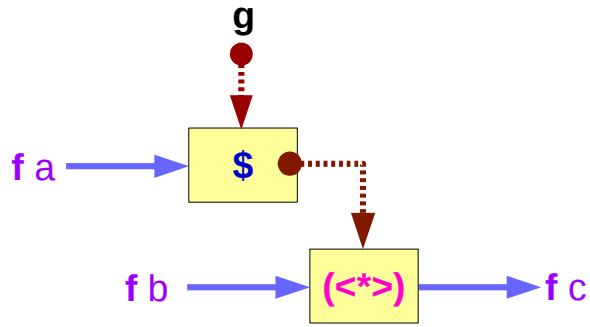
g :: a -> b -> c

(pure g) <*> x <*> y



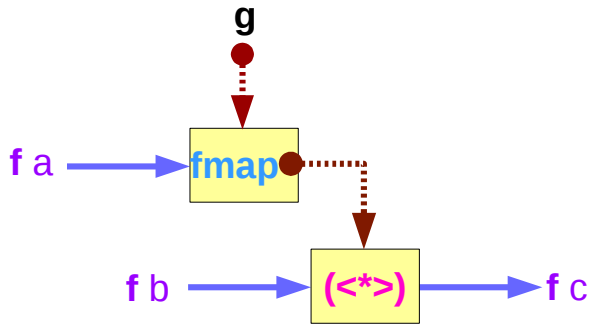
g :: a -> b -> c

(g $ x) <*> y



g :: a -> b -> c

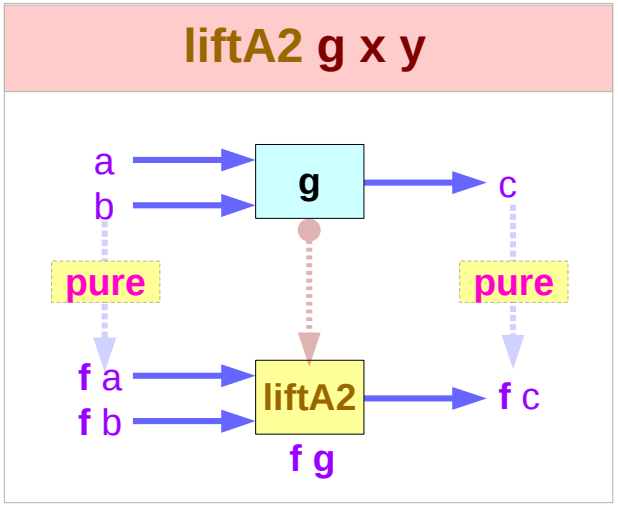
(fmap g x) <*> y



liftA2

```
liftA2 g x y

liftA2 :: (a -> b -> c) -> f a -> f b -> f c
g :: a -> b -> c
x :: f a
y :: f b
liftA2 g x y :: f c
```




```
pure g <*> x <*> y

g :: a -> b -> c
x :: f a
y :: f b
z :: f c
pure g <*> x <*> y :: f c
```

https://wiki.haskell.org/Applicative_functor

Limitations of Functors

(a -> b -> c) -> (f a -> f b -> f c) – let fmap2 Functor as an extension of fmap

fmap :: (a -> b) -> (f a -> f b)
fmap2 :: Functor f => (a -> b -> c) -> (f a -> f b -> f c)

fmap2 h fa fb = undefined
h :: a -> b -> c
fa :: f a
fb :: f b

h :: a -> (b -> c)
fmap h :: f a -> f (b -> c)
fmap h fa :: f (b -> c) – now **f (b -> c)** must be applied to **f b**

fmap gives us a way to apply functions (**a -> b**) to values (**f a**) inside a Functor context,
but **fmap** cannot be used to apply a functions **f (b -> c)**
which are themselves in a Functor context to values **f b** in a Functor context.

http://www.openhaskell.com/lectures/applicative.html

pure, fmap, and liftA2

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

```
pure    :: a -> f a                    – fmap0 → pure
fmap    :: (a -> b) -> f a -> f b      – fmap1 → fmap
fmap2   :: (a -> b -> c) -> f a -> f b -> f c    – fmap2 → liftA2
```

```
liftA2 :: Applicative f => (a -> b -> c) -> f a -> f b -> f c
liftA2 h fa fb = (h `fmap` fa) <*> fb
liftA2 h fa fb = h <$> fa <*> fb
```

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

```
liftA2 :: Applicative f => (a -> b -> c -> d) -> f a -> f b -> f c -> f d
liftA3 h fa fb fc = ((h <$> fa) <*> fb) <*> fc
```

http://www.openhaskell.com/lectures/applicative.html

liftA2 examples

```
liftA2 :: Applicative f => (a -> b -> c) -> f a -> f b -> f c
```

```
liftA2 (+) (Just 5) (Just 6) = Just 11
```

```
liftA2 h fa fb = (h `fmap` fa) <*> fb
liftA2 h fa fb = h <$> fa <*> fb
```

```
fmap (+) (Just 5) = Just (+5)
(+)  <$> (Just 5) = Just (+5)
```

```
<*> :: Applicative f => f (a -> b) -> f a -> f b
(Just (+5)) <*> (Just 6) = Just 11
```

```
let v1 = IO (Just (+5))
let v2 = IO (Just 6)

liftA2 (<*>) v1 v2 = IO (Just 11)
```

https://blog.ssanj.net/posts/2014-08-10-boosting-liftA2.html

<*> or liftA2 implementations

liftA2 :: (a -> b -> c) -> f a -> f b -> f c

A minimal complete definition :

either one of the two

1) pure and **<*>**

2) pure and **liftA2**

1) pure g <*> x <*> y

2) liftA2 g x y

If it defines both, then they must behave the same

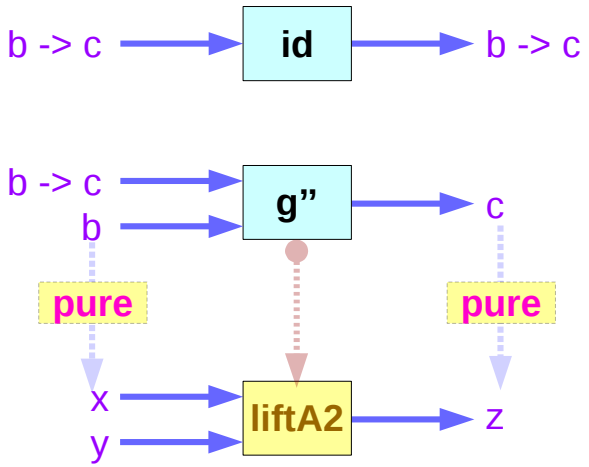
as their default definitions:

http://hackage.haskell.org/package/base-4.10.1.0/docs/Control-Applicative.html#v:liftA2

(<*>) = liftA2 id

liftA2 id x y = id <$> x <*> y = x <*> y

liftA2 id x y = x <*> y

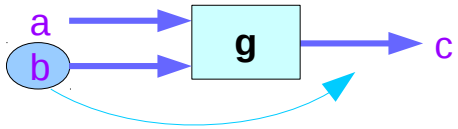


liftA2 g x y = g <$> x <*> y	g :: a -> b -> c	x :: f a	y :: f b
liftA2 g” x y = g” <$> x <*> y	g” :: (b -> c) -> b -> c	x :: f (b -> c)	y :: f b
liftA2 id x y = id <$> x <*> y = x <*> y	id :: (b -> c) -> (b -> c)	x :: f (b -> c)	y :: f b

(<*>) = liftA2 id

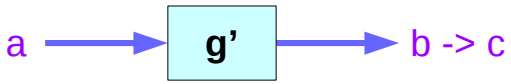
http://hackage.haskell.org/package/base-4.10.1.0/docs/Control-Applicative.html#v:liftA2

g'' :: (b->c) -> b->c



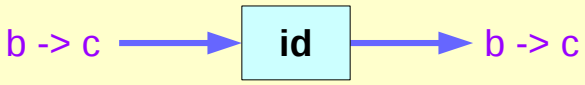
g :: a -> b -> c

view the function
as having one input only



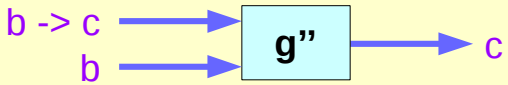
g' :: a -> (b -> c)

consider the case
when **a** is **(b -> c)**



id :: (b -> c) -> (b -> c)

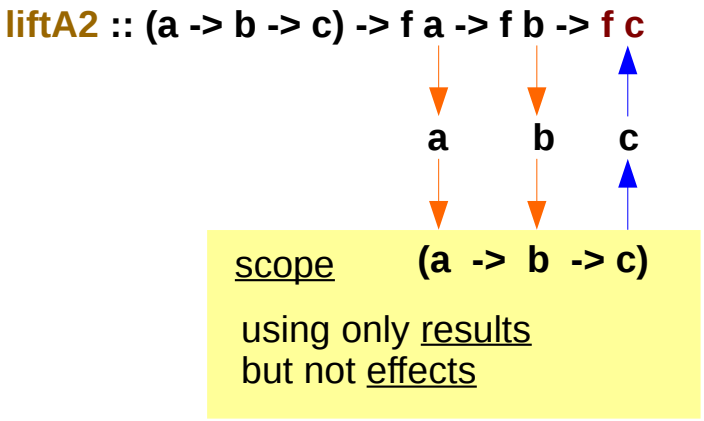
Then **g''** is the same as **id**



g'' :: (b -> c) -> (b -> c)

Results and effects in a scope

Actually, using the **liftA** commands
we can pull results of applicative functors
into a scope where we can talk
exclusively about functor results **c**
and not about effects. **f c**
Note that functor results can also be functions. **c**
This scope is simply a function,
which contains the code that we used in the non-functorial setting.



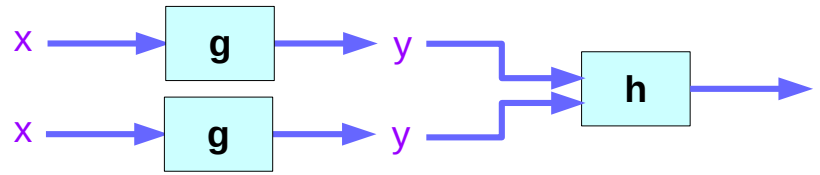
http://hackage.haskell.org/package/base-4.10.1.0/docs/Control-Applicative.html#v:liftA2

liftA3 – a non-functorial expression

Consider the non-functorial expression:

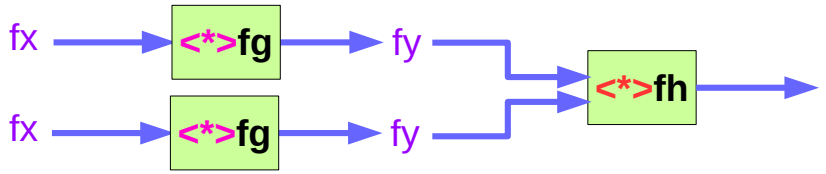
x :: x
g :: x -> y
h :: y -> y -> z

let y = g x
in h y y



generalization

fx :: f x
fg :: f (x -> y)
fh :: f (y -> y -> z)

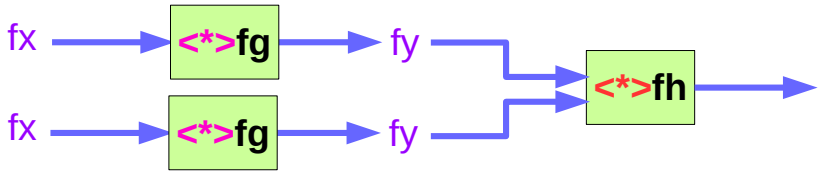


https://wiki.haskell.org/Applicative_functor

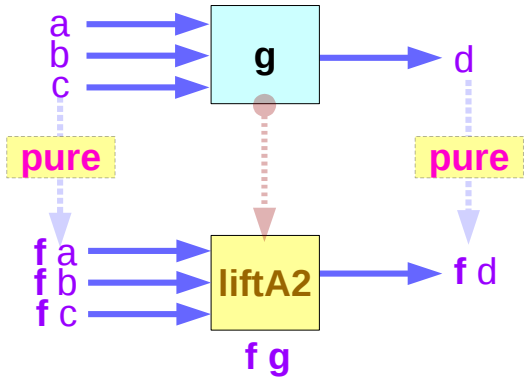
liftA3 – using <*> only

```
let fy = fg <*> fx
  in  fh <*> fy <*> fy
```

if **fy** writes something to the terminal
then **fh <*> fy <*> fy** writes twice.



this runs the effect of **fy** twice.
How the effect is run only once and the result is used twice?
→ utilize **liftA3**



https://wiki.haskell.org/Applicative_functor

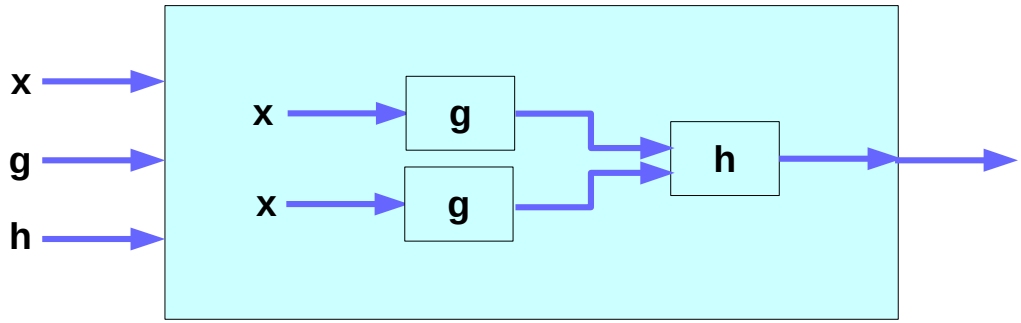
liftA3 – using three input function

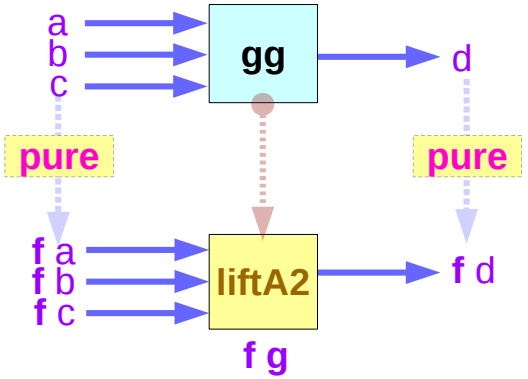
```
liftA3 :: Applicative f => (a -> b -> c -> d) -> f a -> f b -> f c -> f d
liftA3 h fa fb fc = ((h <$> fa) <*> fb) <*> fc
```

liftA3

```
(\x g h -> let y = g x in h y y)
```

fx fg fh





http://hackage.haskell.org/package/base-4.10.1.0/docs/Control-Applicative.html#v:liftA2

liftA3 – effects, results and scopes

Actually, using the **liftA** commands

we can pull results of applicative functors — **y** from **fy**

into a scope where we can talk — **y -> y -> z**

exclusively about functor results — **y**

and not about effects. — **fy**

Note that functor results can also be functions. — **y**

This scope is simply a function, — **y -> y -> z**

which contains the code that we used in the non-functorial setting.

liftA3

```
(\x g h -> let y = g x in h y y)
fx fg fh
```

The order of effects is entirely determined by the order of arguments to liftA3

https://wiki.haskell.org/Applicative_functor

liftA2 (<*>)

10

down vote

accepted

The wiki article says that **liftA2 (<*>)**
can be used to compose applicative functors.
It's easy to see how to use it from its type:

```
o :: (Applicative f, Applicative f1) =>
    f (f1 (a -> b)) -> f (f1 a) -> f (f1 b)
o = liftA2 (<*>)
```

https://stackoverflow.com/questions/12587195/examples-of-haskell-applicative-transformers

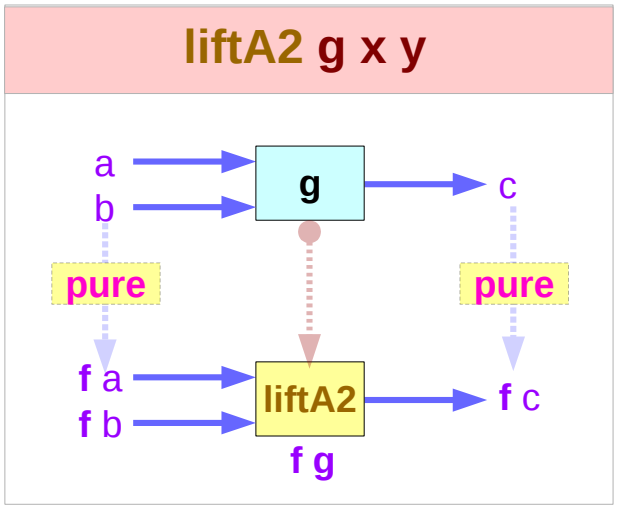
liftA2 (<*>) for composite applicative functors

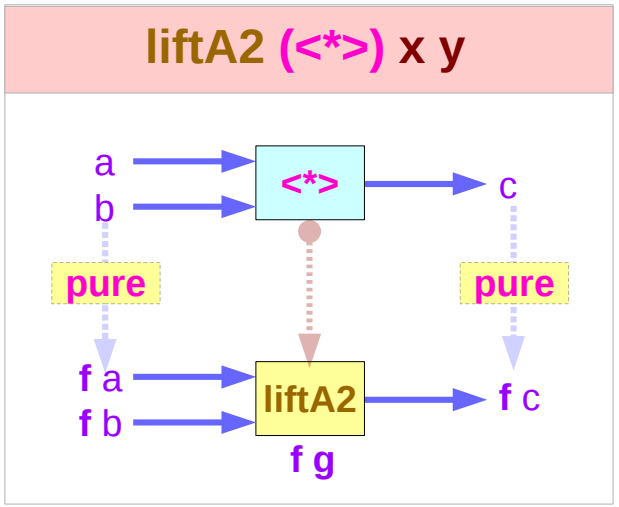
```
o :: (Applicative f, Applicative f1) =>
    f (f1 (a -> b)) -> f (f1 a) -> f (f1 b)

o = liftA2 (<*>)

    f1 (a -> b) <*> f1 a <*> f1 b
```

liftA2 (<*>) can be used to compose applicative functors.





https://stackoverflow.com/questions/12587195/examples-of-haskell-applicative-transformers

liftA2 (<*>) Examples (1)

if f is Maybe and f1 is [ ] we get:

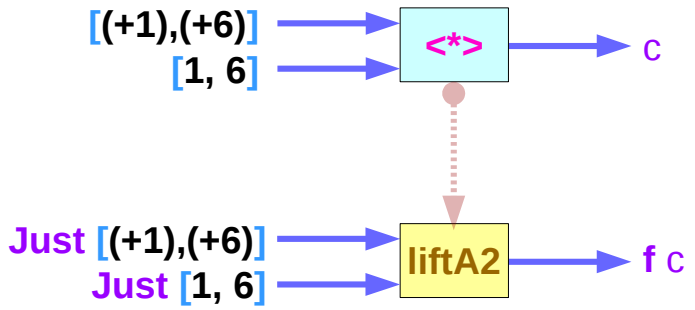
```
Just [(+1),(+6)] `o` Just [1, 6]
Just [2,7,7,12]
```

```
liftA2 (<*>)  Just [(+1),(+6)] Just [1, 6]
Just ( [(+1),(+6)] <*> [1, 6] )
Just   [2, 7, 7, 12] )
```

```
[(+1), (+6)]        [1, 6]

(+1)   [1, 6]
(+6)   [1, 6]
```

liftA2 (<*>) Just [(+1),(+6)] Just [1, 6]



https://stackoverflow.com/questions/12587195/examples-of-haskell-applicative-transformers

liftA2 (<*>) Examples (2)

if f is Maybe and f1 is [ ] we get:

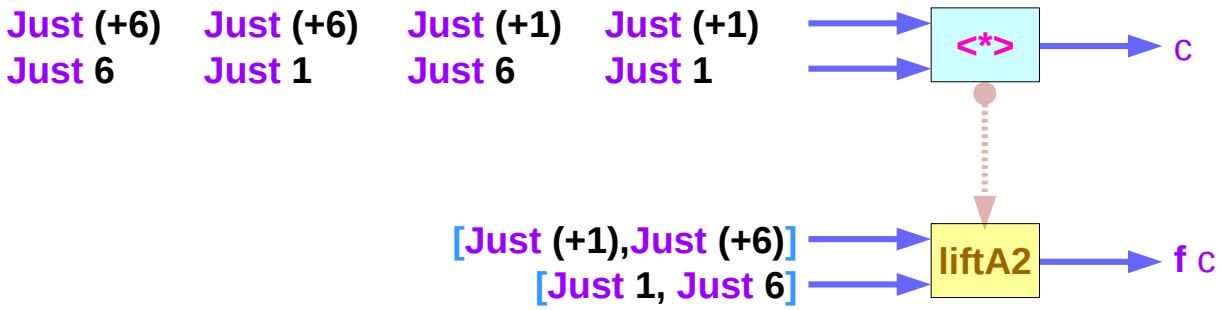
[Just (+1),Just (+6)] **[Just 1, Just 6]**

[Just (+1),Just (+6)] `o` [Just 1, Just 6]
[Just 2, Just 7, Just 7, Just 12]

Just (+1) [Just 1, Just 6]
Just (+6) [Just 1, Just 6]

liftA2 (<*>) [Just (+1),Just (+6)] [Just 1, Just 6]
[Just (+1) <*> Just 1, Just (+1) <*> Just 6, Just (+6) <*> Just 1, Just (+6) <*> Just 6]
[Just 2, Just 7, Just 7, Just 12]

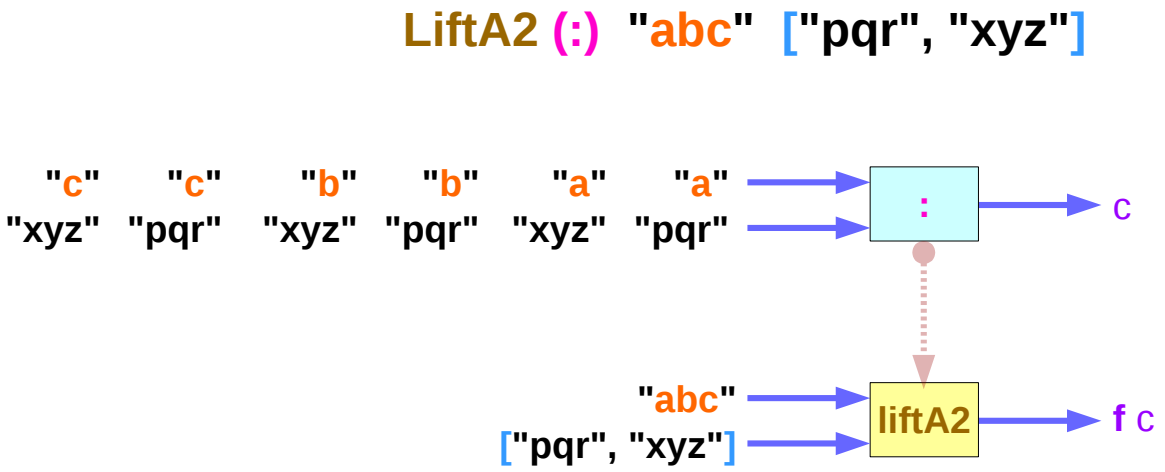
liftA2 (<*>) [Just (+1),Just (+6)] [Just 1, Just 6]



https://stackoverflow.com/questions/12587195/examples-of-haskell-applicative-transformers

liftA2 (:)

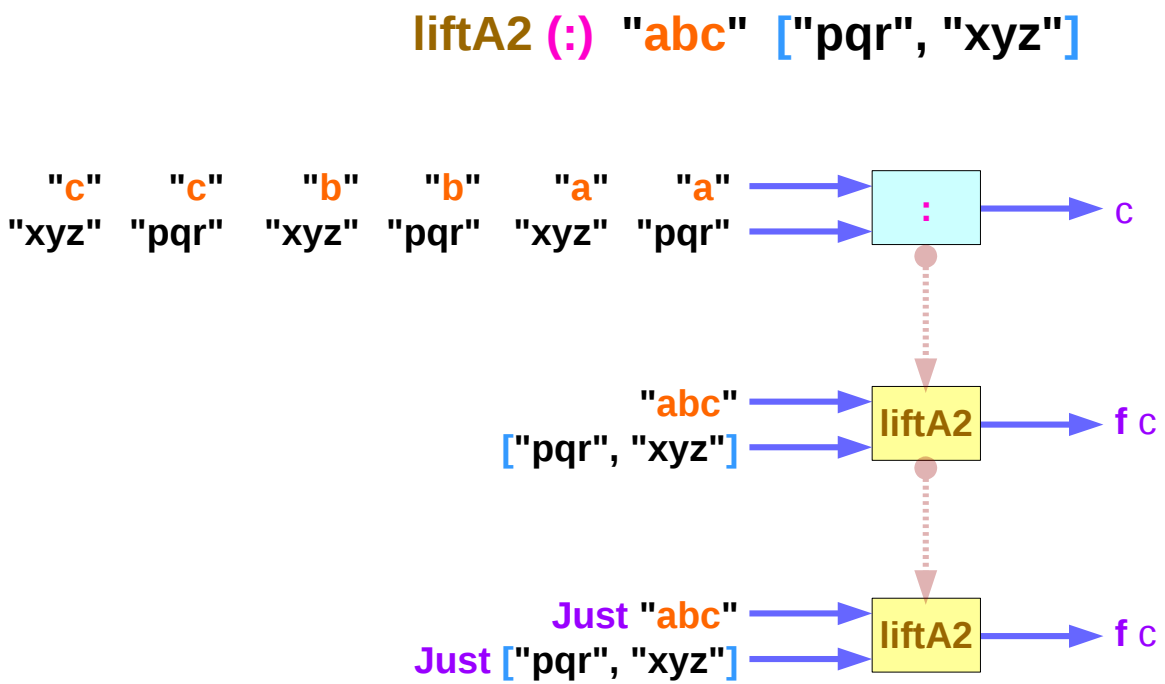
```
liftA2 (:) "abc" ["pqr", "xyz"]
["apqr","axyz","bpqr","bxyz","cpqr","cxyz"]
```



https://stackoverflow.com/questions/12587195/examples-of-haskell-applicative-transformers

liftA2 (:)

```
(liftA2 . liftA2) (:) (Just "abc") (Just ["pqr", "xyz"])
Just ["apqr","axyz","bpqr","bxyz","cpqr","cxyz"]
```



https://stackoverflow.com/questions/12587195/examples-of-haskell-applicative-transformers

liftA2 (:)

```
liftA2 (:) "abc" ["pqr", "xyz"]
["apqr","axyz","bpqr","bxyz","cpqr","cxyz"]
```

To use (:) with deeper applicative stack
you need multiple applications of **liftA2**:

```
(liftA2 . liftA2) (:) (Just "abc") (Just ["pqr", "xyz"])
Just ["apqr","axyz","bpqr","bxyz","cpqr","cxyz"]
```

However it only works when both operands are equally deep.
So besides double liftA2 you should use pure to fix the level:

```
(liftA2 . liftA2) (:) (pure "abc") (Just ["pqr", "xyz"])
Just ["apqr","axyz","bpqr","bxyz","cpqr","cxyz"]
```

https://stackoverflow.com/questions/12587195/examples-of-haskell-applicative-transformers

<$> related operators

Functor map <$>

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

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

($>) :: Functor f => f a -> b -> f b

The **<$>** operator is just a synonym

for the **fmap** function from the Functor typeclass.

This function generalizes the **map** function for lists

to many other data types, such as **Maybe**, **IO**, and **Map**.

https://haskell-lang.org/tutorial/operators

<$> examples

```
#!/usr/bin/env stack
-- stack --resolver ghc-7.10.3 runghc
import Data.Monoid ((<>))

main :: IO ()
main = do
    putStrLn "Enter your year of birth"
    year <- read <$> getLine
    let age :: Int
        age = 2020 - year
    putStrLn $ "Age in 2020: " <> show age
```

https://haskell-lang.org/tutorial/operators

<$, $> operators

In addition, there are two additional operators provided
which replace a value inside a Functor
instead of applying a function.
This can be both more convenient in some cases,
as well as for some Functors be more efficient.

value <$ functor = const value <$> functor
functor $> value = const value <$> functor

x <$ y = y $> x
x $> y = y <$ x

https://haskell-lang.org/tutorial/operators

<*> related operators

Applicative function application <*>

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

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

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

Commonly seen with **<$>**, **<*>** is an operator
that applies a wrapped function to a wrapped value.
It is part of the Applicative typeclass,
and is very often seen in code like the following:

foo <$> bar <*> baz

https://haskell-lang.org/tutorial/operators

<*> examples

For cases when you're dealing with a Monad, this is equivalent to:

```
do x <- bar
   y <- baz
   return (foo x y)
```

Other common examples including parsers and serialization libraries.

Here's an example you might see using the aeson package:

```
data Person = Person { name :: Text, age :: Int } deriving Show

-- We expect a JSON object, so we fail at any non-Object value.
instance FromJSON Person where
    parseJSON (Object v) = Person <$> v .: "name" <*> v .: "age"
    parseJSON _ = empty
```

https://haskell-lang.org/tutorial/operators

*> operator

To go along with this, we have two helper operators that are less frequently used:

***>** ignores the value from the first argument. It can be defined as:

```
a1 *> a2 = (id <$ a1) <*> a2
```

Or in do-notation:

```
a1 *> a2 = do
  _ <- a1
  a2
```

For Monads, this is completely equivalent to **>>**.

https://haskell-lang.org/tutorial/operators

<* operator

<* is the same thing in reverse: perform the first action then the second,

but only take the value from the first action.

Again, definitions in terms of **<*>** and do-notation:

```
(<*) = liftA2 const

a1 <* a2 = do
   res <- a1
   _ <- a2
   return res
```

https://haskell-lang.org/tutorial/operators

(*> v.s. >>) and (pure v.s. return)

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

pure ::    Applicative f  =>  a ->    f a
return ::  Monad m        =>  a ->    m a
```

the constraint changes from **Applicative** to **Monad**.

(*>) in **Applicative**	**(>>)** in **Monad**
pure in **Applicative**	**return** in **Monad**

https://en.wikibooks.org/wiki/Haskell/Applicative_functors

References

[1] ftp://ftp.geoinfo.tuwien.ac.at/navratil/HaskellTutorial.pdf
[2] https://www.umiacs.umd.edu/~hal/docs/daume02yaht.pdf