MonadReader Class (12A)

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This document was produced by using LibreOffice.

Based on

Haskell in 5 steps
https://wiki.haskell.org/Haskell_in_5_steps

MonadReader Class

Installing **mtl**

```
sudo apt-get install cabal-install

cabal update
cabal install mtl



ghci -package such-and-such
ghc-pkg list | grep such-and-such.
ghci -hide-package <package> flag on the command line
ghc-pkg hide <package> to hide the package by default
ghc-pkg --user hide <package> home directory packages
```

https://stackoverflow.com/questions/50321045/could-not-find-module-control-monad-state-after-updating-mtl
https://stackoverflow.com/questions/3102164/how-do-i-get-ghci-to-see-packages-i-installed-from-cabal

Auto-lifting in **mtl** MonadReader

Each **monad** in the **mtl** is defined in terms of a type class.

Reader is an instance of **MonadReader**,
ReaderT is also an instance of **MonadReader**

anything that wraps a **MonadReader** is
also set up to be a **MonadReader**

asks and **local** functions will work without any (manual) lifting.
Other **mtl monads** behave in a similar way.

https://wiki.haskell.org/Monad_Transformers_Explained

MonadReader Class Definition

```
class Monad m => MonadReader r m | m -> r where

(ask | reader), local

ask :: m r
ask = reader id

local :: (r -> r) -> m a  -> m a

reader :: (r -> a) -> m a
reader f = do
      r <- ask
      return (f r)

asks :: MonadReader r m => (r -> a)  -> m a
asks = reader
```

See examples in **Control.Monad.Reader**.

Note, the partially applied function type **(->) r** is a simple **reader** monad.

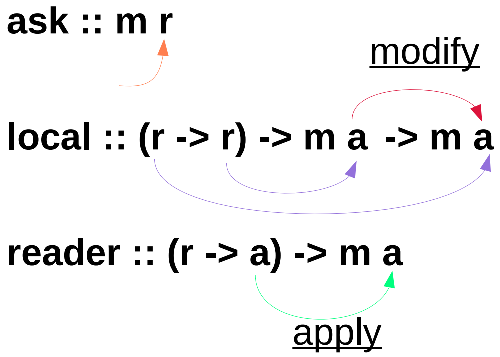
cf)

```
instance (Monad m) => Monad (ReaderT r m) where
```

http://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-Reader.html

MonadReader Class Methods

```
class Monad m => MonadReader r m | m -> r where



(ask | reader), local

ask :: m r          -- retrieves the monad environment.

local :: (r -> r)   -- the selector function to modify the environment.
         -> m a     -- reader to run in the modified environment.
         -> m a     -- executes a computation in a modified environment.

reader :: (r -> a)  -- the selector function to apply to the environment.
         -> m a     -- retrieves a function of the current environment.
```



ask :: m r

modify

local :: (r -> r) -> m a -> m a

reader :: (r -> a) -> m a

apply

http://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-Reader.html

ReaderT Monad Example

```
import Control.Monad.Reader

liftReaderT :: m a -> ReaderT r m a
liftReaderT m = ReaderT (const m)

eg2 :: ReaderT Int IO String
eg2 = do
            e <- ask :: ReaderT Int IO Int
            liftReaderT $ print $ "in eg2 the env  is: " ++ (show e)
            return $ "returned value: " ++ show e



*Main> runReaderT eg2 100
"in eg2 the env is: 100"
"returned value: 100"
```

https://gist.github.com/davidallsopp/9aaf8568349e6b8643d4

MonadReader – **ask**, **asks** methods

```
class Monad m => MonadReader r m | m -> r where

ask :: m r
ask = reader id

local :: (r -> r) -> m a  -> m a

reader :: (r -> a) -> m a
reader f = do
      r <- ask
      return (f r)

asks :: MonadReader r m => (r -> a)  -> m a
asks = reader
```

```
class Monad m =>  …
```

```
ask :: m r
```

retrieves the monad environment.

```
asks:: MonadReader r m =>
           (r -> a) -> m a
```

retrieves a function applied result of the current environment.

https://gist.github.com/davidallsopp/9aaf8568349e6b8643d4

Reader Monad Example – **ask**, **asks**

```haskell
import Control.Monad.Reader

stuff :: Reader Int String
stuff = do
  s <- ask
  return (show s ++ " green bottles")

stuff2 :: Reader Int String
stuff2 = asks $ \s -> (show s ++ " green bottles")

type IntRead = Reader Int

stuff3 :: IntRead String
stuff3 = asks show

stuff4 :: IntRead String
stuff4 = asks $ \s -> (show s ++ " green bottles")
```

```
*Main> print $ runReader stuff 99
"99 green bottles"

*Main> print $ runReader stuff2 99
"99 green bottles"

*Main> print $ runReader stuff3 99
"99"

*Main> print $ runReader stuff4 99
"99 green bottles"
```

https://gist.github.com/davidallsopp/9aaf8568349e6b8643d4

Reader Monad Example

The purpose of Reader, instead of passing the **parameters** to a function

Reader is used as a **global state**, for "**constants**" etc to avoid polluting every **function call** with **params** (a function might only pass these **params** to other functions, not even using them)

Modification of all these functions to use **Reader** is still necessary.

can use '**asks**' to avoid all the **do-block** boilerplate
can create an **alias** for the reader if it's used in lots of places

do-block boilerplate

```
stuff = do
  s <- ask
  return (show s ++ " green bottles")
```

alias for the reader

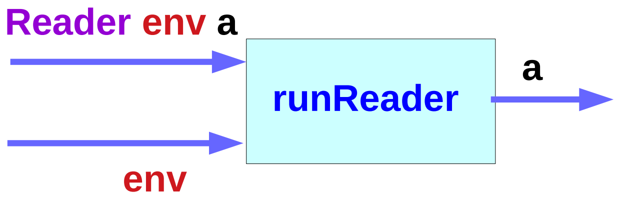
```
type IntRead = Reader Int

stuff3 :: IntRead String
stuff3 = asks show
```

-- See http://stackoverflow.com/questions/14178889/reader-monad-purpose

https://gist.github.com/davidallsopp/9aaf8568349e6b8643d4

Purpose of Reader Monad

```
data Reader env a = …

instance Monad (Reader env)                         -- Reader is a monad

                        copy
ask :: Reader env env                               -- get its environment

runReader :: Reader env a -> env -> a               -- to run the monad
```



https://stackoverflow.com/questions/14178889/what-is-the-purpose-of-the-reader-monad

Purpose of Reader Monad – configuration information

```
data Reader env a = …
instance Monad (Reader env)                  -- Reader is a monad
ask :: Reader env env                        -- get its environment
runReader :: Reader env a -> env -> a        -- to run the monad
```

the **reader monad** is useful in passing (implicit) **configuration information** through a **computation**.

a "**constant**" in a **computation** is accessed at various points
In order to perform the same **computation** with different **values**,
use a **reader monad**

https://stackoverflow.com/questions/14178889/what-is-the-purpose-of-the-reader-monad

Purpose of Reader Monad – ask, local

```
newtype Reader env a = Reader {runReader :: env -> a}


instance Functor (Reader env) where
   fmap f (Reader g) = Reader $ f . g


instance Monad (Reader env) where
   return x = Reader (\_ -> x)
   (Reader f) >>= g = Reader $ \x -> runReader (g (f x)) x


ask = Reader $ \x -> x

local f (Reader g) = Reader $ \x -> runReader g (f x)
```

Reader is just a fancy name for **functions**!

runReader extracts the inside function

every **Monad** is also a **Functor**:

https://stackoverflow.com/questions/14178889/what-is-the-purpose-of-the-reader-monad

Purpose of Reader Monad – reader Monad

Okay, so the **reader** monad is just a function.
Why have **Reader** at all? Good question. Actually, you don't need it!

```
instance Functor ((->) env) where
   fmap = (.)

instance Monad ((->) env) where
   return = const
   f >>= g = \x -> g (f x) x
```

These are even simpler.
What is more, **ask** is just **id** and
local is just function composition in the other order!

https://stackoverflow.com/questions/14178889/what-is-the-purpose-of-the-reader-monad

Purpose of Reader Monad –

```
newtype Reader r a = Reader { runReader :: r -> a }

instance Monad (Reader r) where
   return a = Reader $ \_ -> a
   m >>= k = Reader $ \r -> runReader (k $ runReader m r) r

asks :: (r -> a) -> Reader r a
asks f = Reader f

ask :: Reader a a
ask = Reader id
```

https://passy.svbtle.com/dont-fear-the-reader

Purpose of Reader Monad

Expression = a **Reader**
Free variables = uses of **ask**
Evaluation environment = **Reader** execution environment.
Binding constructs = **local**

https://stackoverflow.com/questions/14178889/what-is-the-purpose-of-the-reader-monad

Reader Monad – example

```
example :: String
example = runReader computation "Hello"
   where
      computation :: Reader String String
      computation = do
         g <- ask
         return $ g ++ ", Haskell"

main = putStrLn example

   Hello, Haskell
```

https://passy.svbtle.com/dont-fear-the-reader

Reader Monad – example1

```
example1 :: String -> String
example1 context = runReader (computation "Tom") context
   where
      computation :: String -> Reader String String
      computation name = do
         g <- ask
         return $ g ++ name

main :: IO ()
main = putStrLn example1 "Hello"

   Hello, Tom
```

https://passy.svbtle.com/dont-fear-the-reader

Reader Monad – example2

```
example2 :: String -> String
example2 context = runReader (greet “James” >>= end) context
    where
        greet :: String -> Reader String String
        greet name = do
            g <- ask
            return $ g ++ “, “ ++ name

           end :: String -> Reader String String
           end input = do
               isHello <- asks (== “Hello”)
               return $ input ++ if isHello then “!” else “.”

main :: IO ()
main = putStrLn example2 “Hello”

    Hello, James!
```

https://passy.svbtle.com/dont-fear-the-reader

Reader Monad – example

pricing an asset can do without any monads.
But to deal with multiple currencies,
on the fly conversion between currencies is needed.

```
type CurrencyDict = Map CurrencyName Dollars
currencyDict :: CurrencyDict
```

You can then call this dictionary in your code....but that won't work!
The currency dictionary is immutable and so has to be the same
not only for the life of your program, but from the time it gets compiled!

```
computePrice :: Reader CurrencyDict Dollars
computePrice
    = do currencyDict <- ask
        -- insert computation here
```

```
Reader env a
Reader r a
```

https://stackoverflow.com/questions/14178889/what-is-the-purpose-of-the-reader-monad

Reader Monad – example

```
type CurrencyDict = Map CurrencyName Dollars
currencyDict :: CurrencyDict
currencyDict :: Map CurrencyName Dollars              -- Map k e

computePrice :: Reader CurrencyDict Dollars
computePrice
   = do currencyDict <- ask
      -- insert computation here

(Ord k, Read k, Read e) => Read (Map k e)

computePrice :: Reader CurrencyDict Dollars
computePrice :: Reader Map CurrencyName Dollars Dollars
```

https://stackoverflow.com/questions/14178889/what-is-the-purpose-of-the-reader-monad

Data Map (dictionary) Example

```haskell
import Data.Map (Map, (!))
import qualified Data.Map as Map

main = do
   let m0  = Map.empty
   let m1  = Map.insert "k1" 7 m0
   let m   = Map.insert "k2" 13 m1
   putStrLn $ "map: " ++ show m

   let v1  = m ! "k1"
   putStrLn $ "v1: " ++ show v1
   putStrLn $ "len: " ++ show (Map.size m)
   let m'  = Map.delete "k2" m
   putStrLn $ "map: " ++ show m'
   let prs = Map.lookup "k2" m'
   putStrLn $ "prs: " ++ show prs
   let n   = Map.fromList [("foo", 1), ("bar", 2)]
   putStrLn $ "map: " ++ show n
```

```
$ runhaskell maps.hs
map: fromList [("k1",7),("k2",13)]
v1: 7
len: 2
map: fromList [("k1",7)]
prs: Nothing
map: fromList [("bar",2),("foo",1)]
```

https://lotz84.github.io/haskellbyexample/ex/maps

Data Map (dictionary) Example

```haskell
import Prelude hiding (lookup)
import Data.Map

employeeDept        = fromList([("John","Sales"), ("Bob","IT")])
deptCountry         = fromList([("IT","USA"), ("Sales","France")])
countryCurrency     = fromList([("USA", "Dollar"), ("France", "Euro")])

employeeCurrency :: String -> Maybe String
employeeCurrency name = do
    dept <- lookup name employeeDept
    country <- lookup dept deptCountry
    lookup country countryCurrency

main = do
    putStrLn $ "John's currency: " ++ (show (employeeCurrency "John"))
    putStrLn $ "Pete's currency: " ++ (show (employeeCurrency "Pete"))
```

```
John's currency: Just "Euro"
Pete's currency: Nothing
```

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

Simple Reader Usage (1)

```haskell
 type Bindings = Map String Int;

-- Returns True if the "count" variable contains correct bindings size.
isCountCorrect :: Bindings -> Bool
isCountCorrect bindings = runReader calc_isCountCorrect bindings

-- The Reader monad, which implements this complicated check.
calc_isCountCorrect :: Reader Bindings Bool
calc_isCountCorrect = do
    count <- asks (lookupVar "count")
    bindings <- ask
    return (count == (Map.size bindings))
```

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

Simple Reader Usage (2)

```
-- The selector function to  use with 'asks'.
-- Returns value of the variable with specified name.
lookupVar :: String -> Bindings -> Int
lookupVar name bindings = maybe 0 id (Map.lookup name bindings)

sampleBindings = Map.fromList [("count",3), ("1",1), ("b",2)]

main = do
    putStr $ "Count is correct for bindings " ++ (show sampleBindings) ++ ": ";
    putStrLn $ show (isCountCorrect sampleBindings);




calc_isCountCorrect :: Reader Bindings Bool
calc_isCountCorrect = do
    count <- asks (lookupVar "count")
```

```
lookupVar name(=”count”) bindings(=Bindings)
maybe 0 id (Map.lookup ”count” Bindings)
```

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

Data.Maybe

data Maybe a

The Maybe type encapsulates an optional value.
A value of type Maybe a
either contains a value of type a (represented as Just a),
or it is empty (represented as Nothing).
Using Maybe is a good way to deal with errors or exceptional cases
without resorting to drastic measures such as error.

The Maybe type is also a monad.
It is a simple kind of error monad,
where all errors are represented by Nothing.
A richer error monad can be built using the Either type.

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

Data.Maybe – maybe method (1)

maybe :: b -> (a -> b) -> Maybe a -> b

The **maybe function** takes

- a default **value** (**b**),
- a **function** (**a->b**), and
- a **Maybe value** (**Maybe a**).

If the Maybe value is **Nothing**, the **function** returns the default **value**.
Otherwise, it applies the **function** to the **value** inside the **Just**
and returns the **result**.

```
>>> maybe False odd (Just 3)
True
```

```
>>> maybe False odd Nothing
False
```

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

Data.Maybe – maybe method (2)

```
maybe :: b -> (a -> b) -> Maybe a -> b
```

Read an integer from a string using **readMaybe**.
If we succeed, return twice the integer; that is, apply **(*2)** to it.
If instead we fail to parse an integer, return **0** by default:

```
>>> import Text.Read ( readMaybe )

>>> maybe 0 (*2) (readMaybe "5")
10
>>> maybe 0 (*2) (readMaybe "")
0
```

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

Data.Maybe – maybe method (3)

```
maybe :: b -> (a -> b) -> Maybe a -> b
```

Apply **show** to a **Maybe Int**.
If we have **Just n**, we want to show the underlying **Int n**.
But if we have **Nothing**, we return the **empty string**
instead of (for example) "Nothing":

```
>>> maybe "" show (Just 5)
"5"
>>> maybe "" show Nothing
""
```

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

Modifying Reader Content with local

```haskell
calculateContentLen :: Reader String Int
calculateContentLen = do
    content <- ask
    return (length content);

-- Calls calculateContentLen after adding a prefix to the Reader content.
calculateModifiedContentLen :: Reader String Int
calculateModifiedContentLen = local ("Prefix " ++) calculateContentLen

main = do
    let s = "12345";
    let modifiedLen = runReader calculateModifiedContentLen s
    let len = runReader calculateContentLen s
    putStrLn $ "Modified 's' length: " ++ (show modifiedLen)
    putStrLn $ "Original 's' length: " ++ (show len)
```

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

ReaderT Monad Transformer

```haskell
-- The Reader/IO combined monad, where Reader stores a string.
printReaderContent :: ReaderT String IO ()
printReaderContent = do
    content <- ask
    liftIO $ putStrLn ("The Reader Content: " ++ content)

main = do
    runReaderT printReaderContent "Some Content"
```

https://hackage.haskell.org/package/containers-0.4.2.0/docs/Data-Map.html

References

[1] ftp://ftp.geoinfo.tuwien.ac.at/navratil/HaskellTutorial.pdf

[2] https://www.umiacs.umd.edu/~hal/docs/daume02yaht.pdf