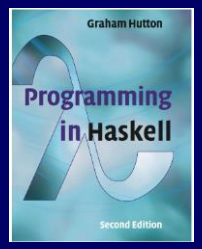
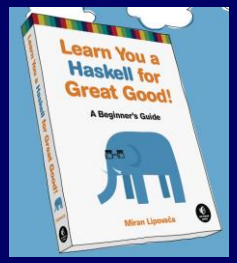
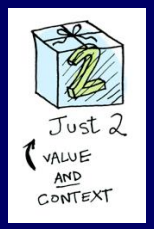
State Monads

Monads







Based on lecture notes by Graham Hutton, the book "Learn You a Haskell for Great Good", pictures from Aditya Bhargava, and https://wiki.haskell.org/State_Monad

Monads

We have seen how Monads work.

There is a nice introduction to Writer, Reader and State Monads here (Aditya Bhargava)

We will look at the State Monad most closely.

State Monad

```
import Control.Monad.State
--will include
newtype State s a = State { runState :: (s -> (a,s)) }
```

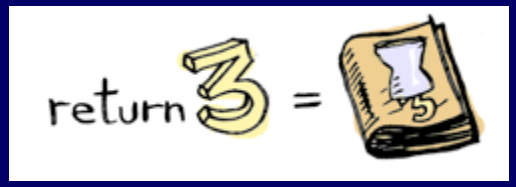
There are a few things going on here

- *newtype* is a lot like *data*, except for some details
- what's "in" our data type? It's a function! And we're implicitly defining a function to extract our inner function from the data type: that function is called runState
- It's type is *s -> (a,s)*. Essentially, it's a type for any function that takes some initial state and then returns a tuple of *(regular return value, new state)*.

State Monad – primitives return, runState

```
> runState (return 'X') 1
('X', 1)
```

return --set the result value but leave the state unchanged.




```
return a = State $ \s -> (a, s)
```

State Monad - put

put -- set the result value to () and set the state value.

```
-- ie: (put 5) 1 -> ((),5)
put :: s -> State s
put x s = ( () ,x)
```

State Monad - get

get - set the result value to the state and leave the state unchanged

```
>runState get 1
(1, 1)
```

State Monad - helpers

evalState and **execState** just select one of the two values returned by runState.
EvalState returns the final result while execState returns the final state:

```
evalState :: State s a -> s -> a
evalState act = fst . runState act

execState :: State s a -> s -> s
execState act = snd . runState act
```

State Monad –simple example

```
import Control.Monad.State

greeter :: State String String
greeter = do
        name <- get
        put "Some State"
        return ("hello, " ++ name ++ "!")


>runState greeter “Mairead”
("hello, Mairead!","Some State")
```

State Monad - parse example

```
import Control.Monad.State
-- Example use of State monad
- Passes a string of dictionary {a,b,c}
-- Game is to produce a number from the string.
-- By default the game is off, a c toggles the
-- game on and off. A 'a' gives +1 and a b gives -1.
-- E.g -- 'ab' = 0 -- 'ca' = 1 -- 'cabca' = 0
-- State = game is on or off & current score
--       = (Bool, Int)
```

State Monad - parse example

```
type GameValue = Int
type GameState = (Bool, Int)
playGame :: String -> State GameState GameValue
playGame [] = do
      (_, score) <- get
        return score
playGame (x:xs) = do
        (on, score) <- get
        case x of
                'a' | on -> put (on, score + 1)
                'b' | on -> put (on, score - 1)
                'c' -> put (not on, score)
                _ -> put (on, score)
        playGame xs
startState = (False, 0)
main = print $ evalState (playGame "abcaaacbbcabbab") startState
```

State Monad – stack example

```
import Control.Monad.State
type Stack = []

pop :: State Stack Int
pop = state $ \(x:xs) -> (x, xs)

push :: Int -> State Stack ()
push a = state $ \xs -> ((), a:xs)
```

State Monad – stack example

```
stackManip :: State Stack Int
stackManip = do
        push 3
        a <- pop
        pop
```

Run as

```
>runState stackManip [1,2,3]
(1,[2,3])
```

State Monad – stack example

```
stackStuff :: State Stack ()
stackStuff = do
        a <- pop
        if a == 5
                then push 5
                else do
                        push 3
                        push 8
```

Run as

```
>runState stackStuff [9,0,2,1,0]
((),[8,3,0,2,1,0])
```

State Monad – simple state

```
-- a concrete and simple example of using the State monad
import Control.Monad.State
-- the State is an integer.
-- the value will always be the negative of the state
type MyState = Int

valFromState :: MyState -> Int
valFromState s = -s
nextState :: MyState->MyState
nextState x = 1+x
```

State Monad – simple state

```
MyStateMonad = State MyState -- this is it, the State transformation. Add 1 to the state, return -1*the state as the computed value.


getNext :: MyStateMonad Int
getNext = state (\st -> let st' = nextState(st) in
                                  (valFromState(st'),st') )


-- advance the state three times.
inc3::MyStateMonad Int
inc3 =  getNext >>= \x ->
        getNext >>= \y ->
        getNext >>= \z ->

        return z
```

State Monad – simple state

```
-- advance the state three times with do sugar
 inc3Sugared::MyStateMonad Int
inc3Sugared = do
                x <- getNext
                y <- getNext
                z <- getNext
                return z
```

State Monad – simple state

```
-- advance the state three times without inspecting computed values
inc3DiscardedValues::MyStateMonad Int
inc3DiscardedValues = getNext >> getNext >> getNext


-- advance the state three times without inspecting computed values with do sugar
inc3DiscardedValuesSugared::MyStateMonad Int
inc3DiscardedValuesSugared = do
                                getNext
                                getNext
                                getNext
```

State Monad – simple state

```
-- advance state 3 times, compute the square of the state
inc3AlternateResult:: MyStateMonad Int
inc3AlternateResult = do   getNext
                           getNext
                           getNext
                           s<-get
                           return (s*s)
```

State Monad – simple state

```
-- advance state 3 times, ignoring computed value, and
--then once more
inc4::MyStateMonad Int
inc4 = do inc3AlternateResult
          getNext

main = do print (evalState inc3 0) -- -3
          print (evalState inc3Sugared 0) -- -3
          print (evalState inc3DiscardedValues 0) -- -3
          print (evalState inc3DiscardedValuesSugared 0) -- -3
          print (evalState inc3AlternateResult 0) -- 9
          print (evalState inc4 0) -- -4
```