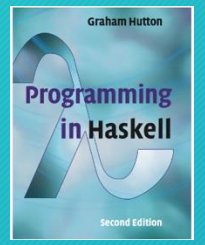
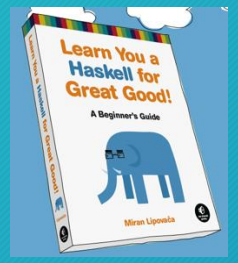
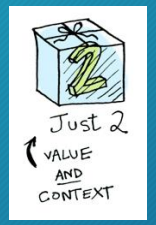
PROGRAMMING IN HASKELL

State 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

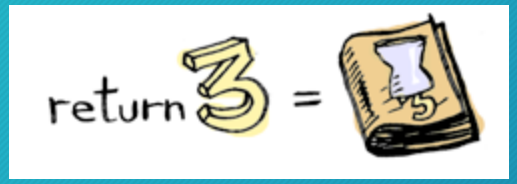

```haskell
import Control.Monad.State
--will include
newtype State s a = State { runState :: (s -> (a,s)) }
```

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 - state


```
state :: (s -> (a, s)) -> m a
-- embed a simple state action into a monad
-- both returns a value and updates state
```

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)
```

*This code is from https://wiki.haskell.org/State_Monad

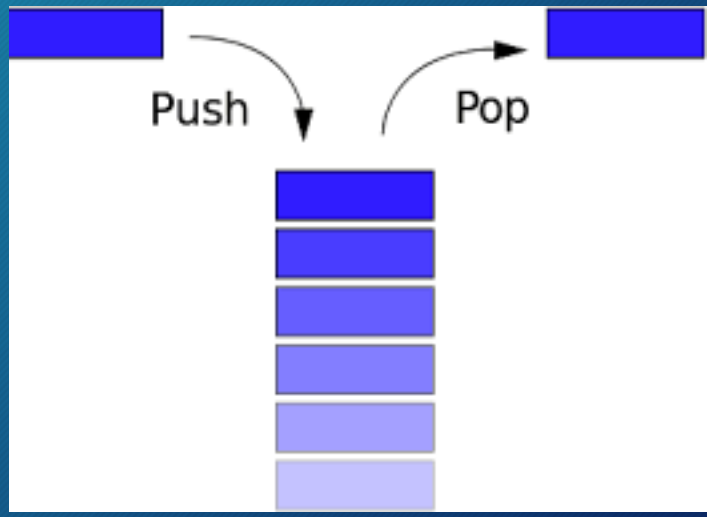
State Monad - parse example

```haskell
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
```

Call by running main

State Monad – stack example


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

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


```haskell
-- 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 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


```haskell
-- 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


```haskell
-- 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
```


ANY
QUESTIONS?