State Monad – Methods (6B)

Please send corrections (or suggestions) to youngwlim@hotmail.com.

This document was produced by using LibreOffice.

Based on

Haskell in 5 steps

https://wiki.haskell.org/Haskell_in_5_steps

put changes the current state

put :: s **->** **State** s a

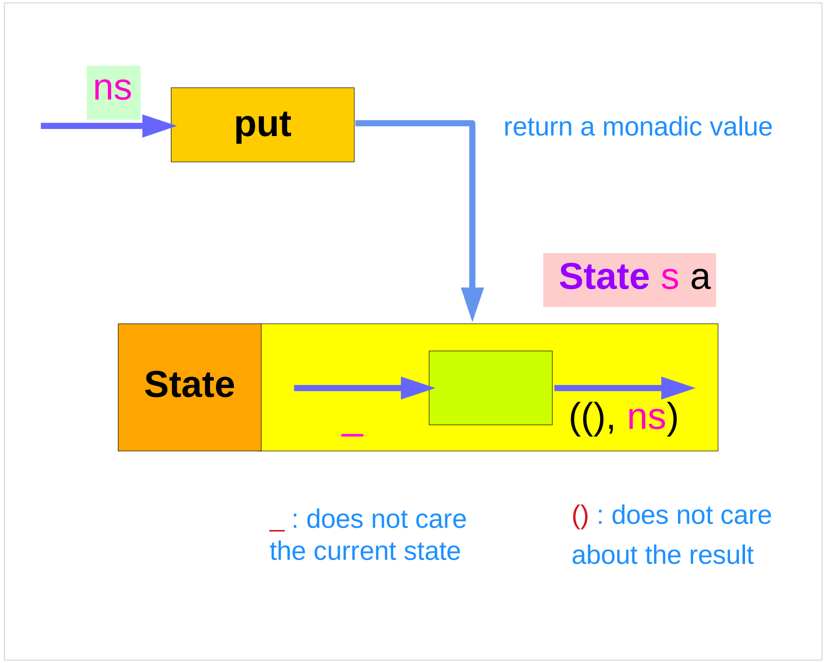
put ns = **state $** _ -> ((), ns)

Given a wanted state new State (ns),

put generates a **state processor**

- ignores whatever the state it receives,
- updates the state to ns
- doesn't care about the result of this processor

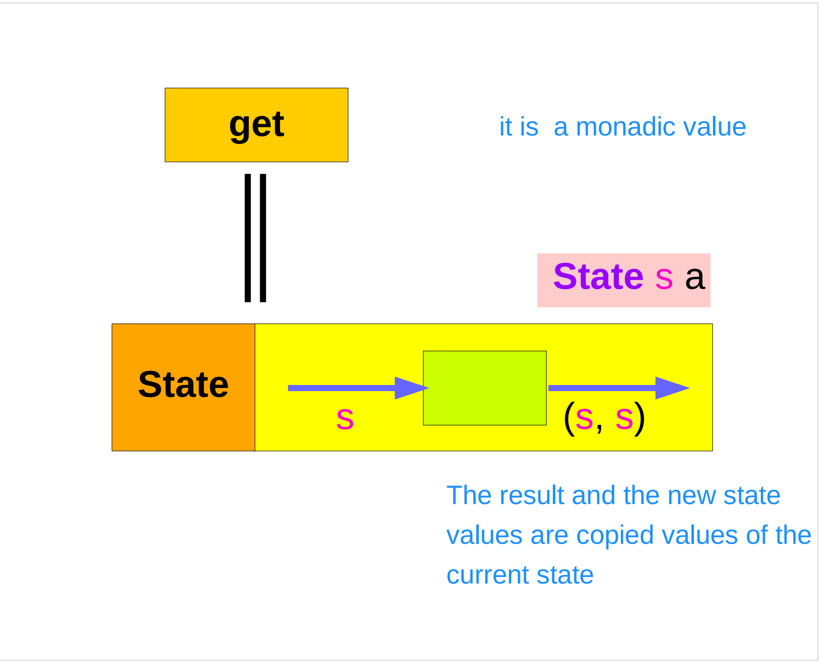
- all we want to do is to change the state
- the tuple will be ((), ns)
- () : the **universal placeholder value**.



https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

get gives the current state :

```
get :: State s s
get = state $ \s -> (s, s)
```



get generates a **state processor**

- gives back the state s0
- as a result and as an updated state – (s0, s0)

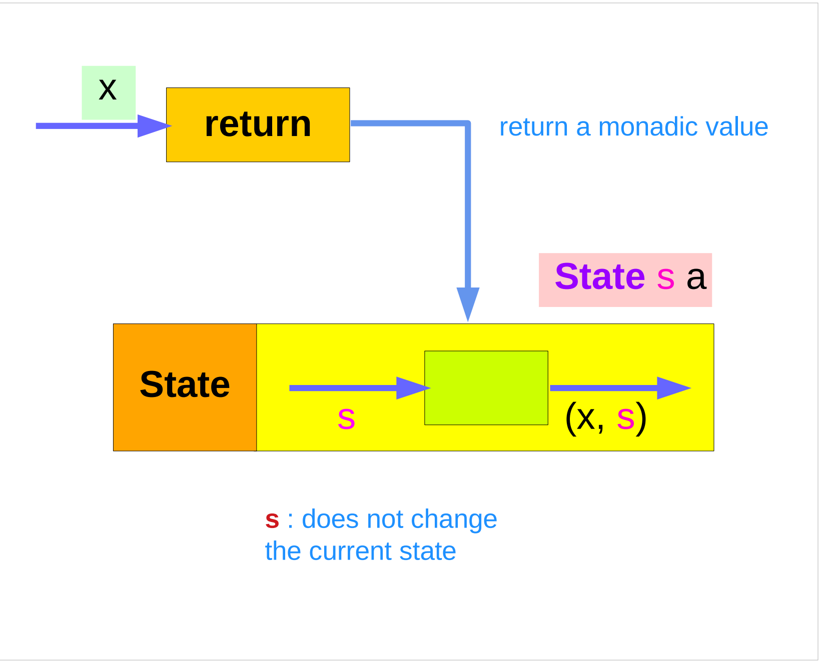
- the state will remain unchanged
- a copy of the state will be made available through the result returned

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

return method

return :: a -> State s a

return x = state (\s -> (x, s))



giving a value (x) to **return**

results in a **state processor** function

which takes a state (s) and

returns it unchanged (s),

together with the value x

finally, the function is wrapped up by **state**.

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

put returns a monadic value by state

put :: s **->** **State** s a

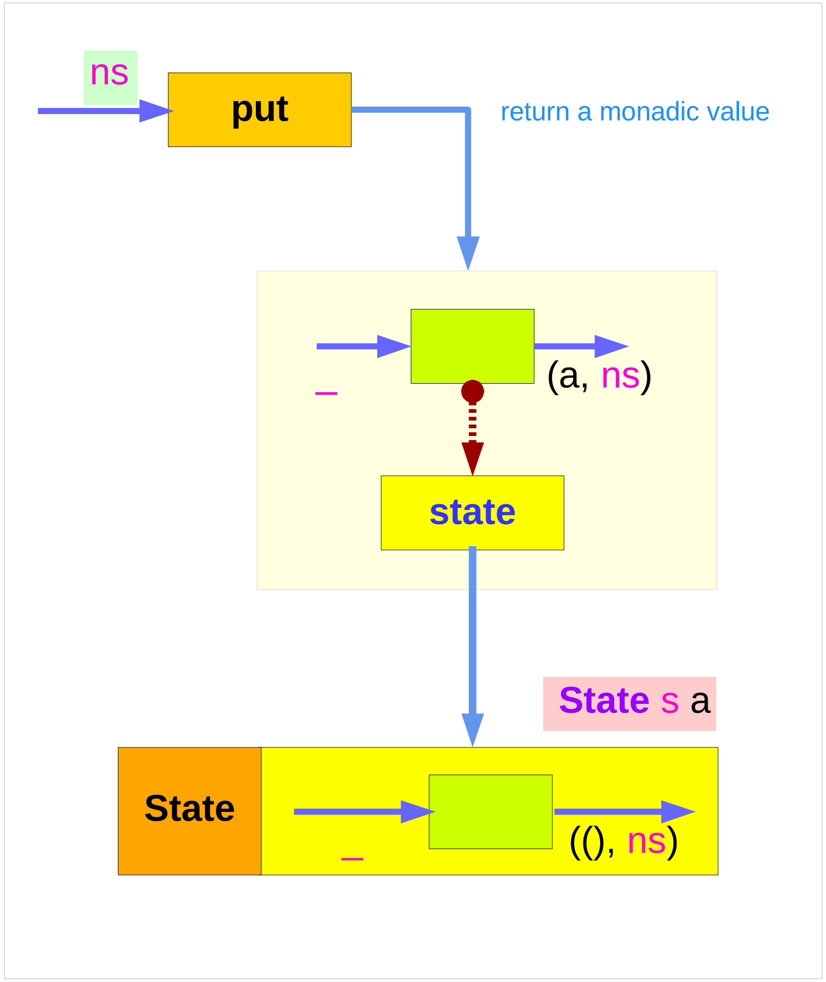
put s **::** **State** s a

put newState = **state $** _ -> ((), newState)

-- setting a state to newState

-- regardless of the old state

-- setting the result to ()



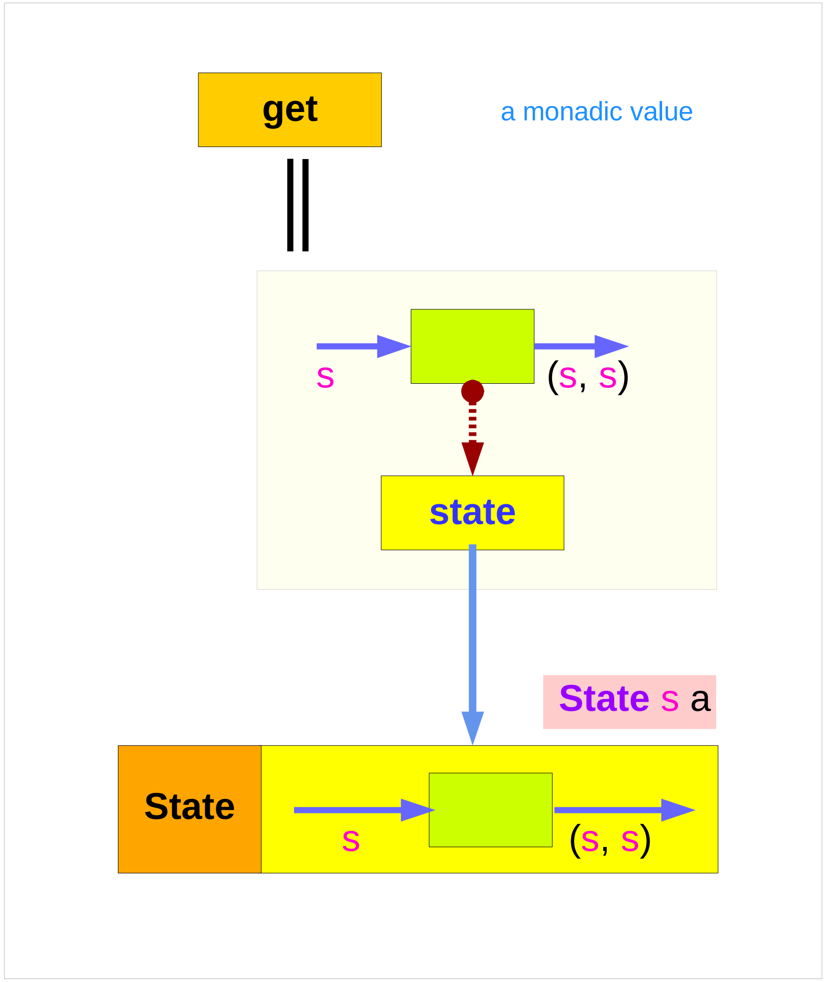
https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

get is a monadic value by **state**

```
get :: State s s

get = state $ \s -> (s, s)

-- getting the current state s
-- also setting the result to s
```



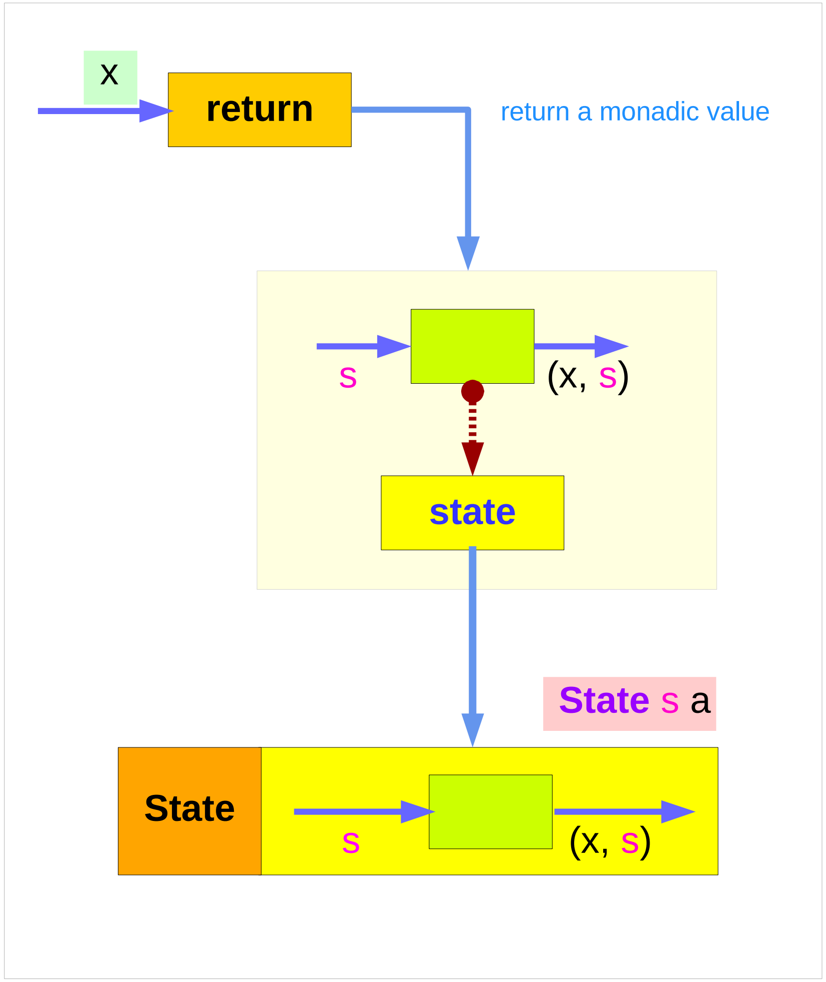
https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

return returns a monadic value by **state**

```
return :: s -> State s a
return s ::  State s a

return x = state $ \_ -> (x, s)

-- do not change a state s
-- setting the result to x
```



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Running **put**

put :: s **->** **State** s a

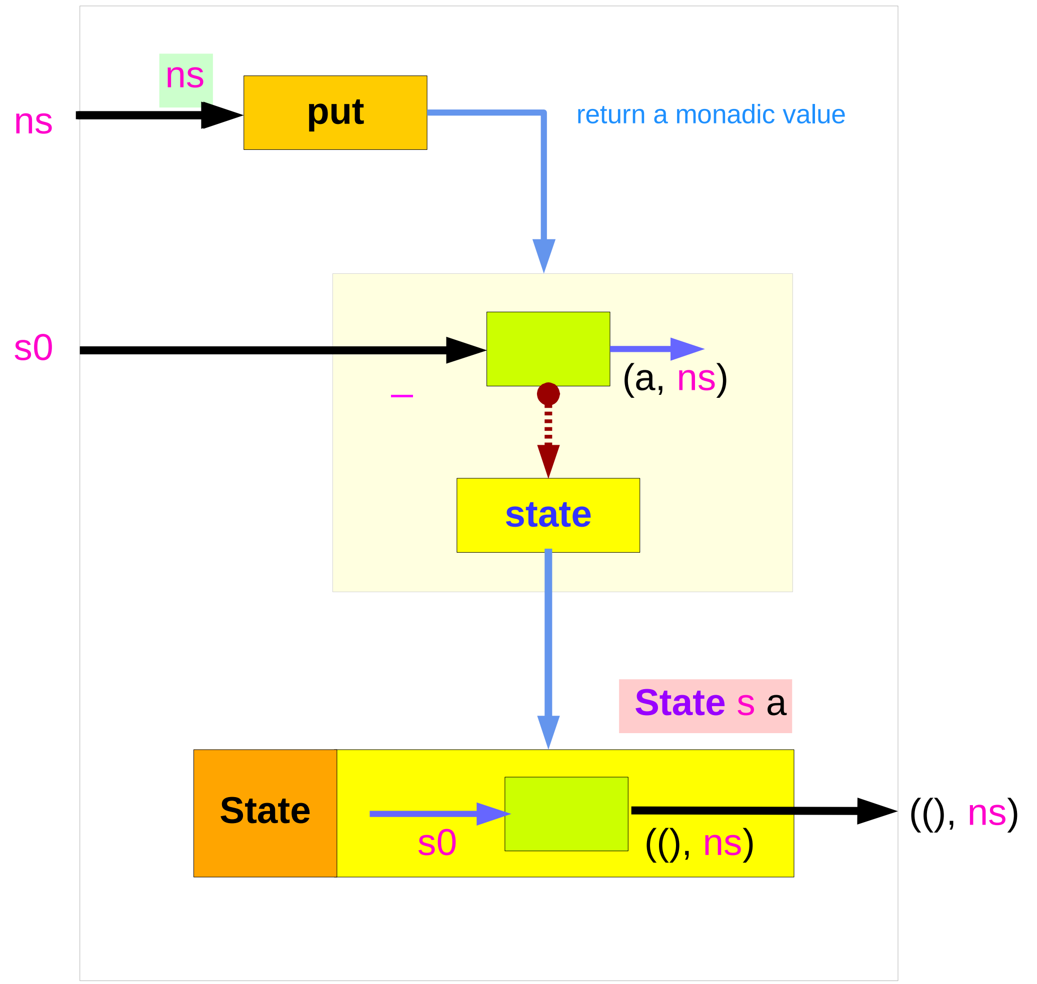
put s **::** **State** s a

put newState = **state $** _ -> ((), newState)

runState **(put** ns**)** s0

runState **(put 5)** 1

((),5)



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Running **get**

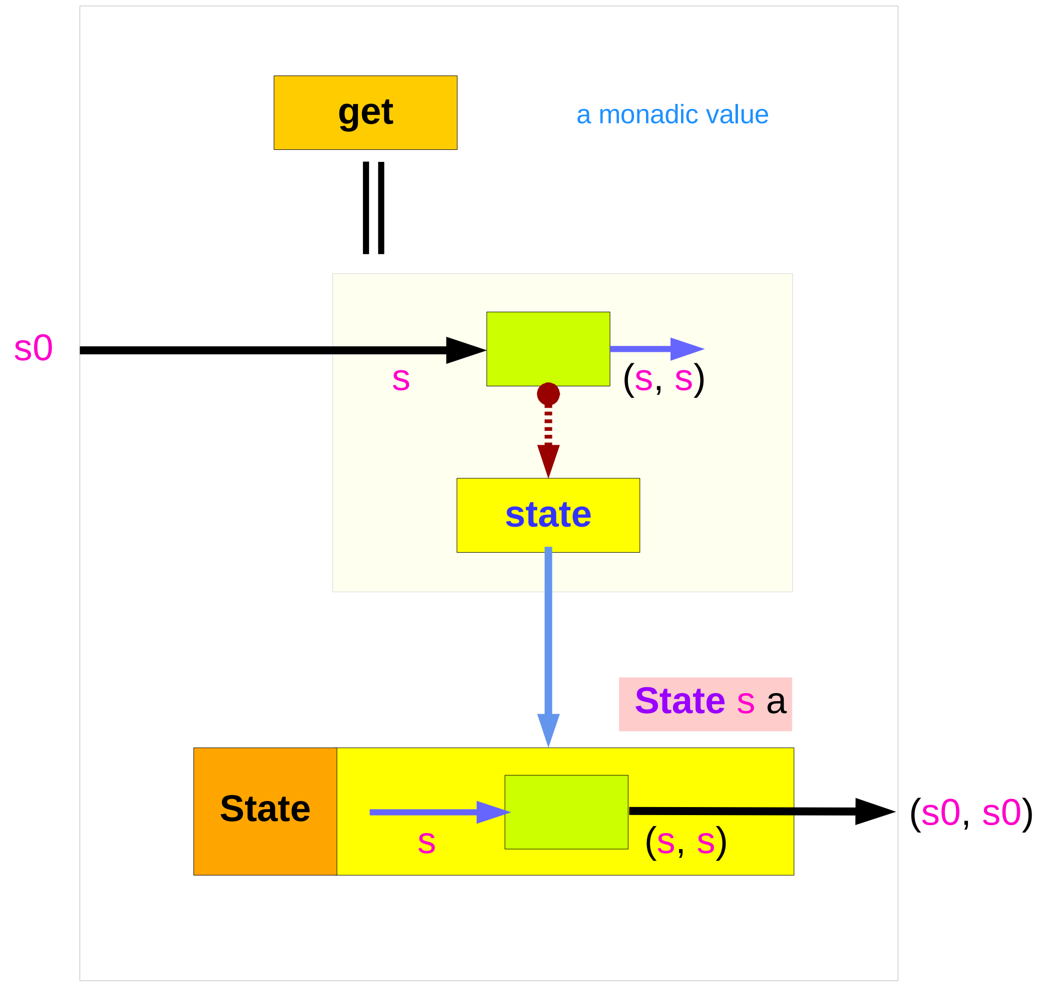
get :: **State** s s

get = **state** **$** \s -> (s, s)

runState **(get)** **s0**

runState **(get)** **1**

(1,1)



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Running **return**

return :: s **->** **State** s a

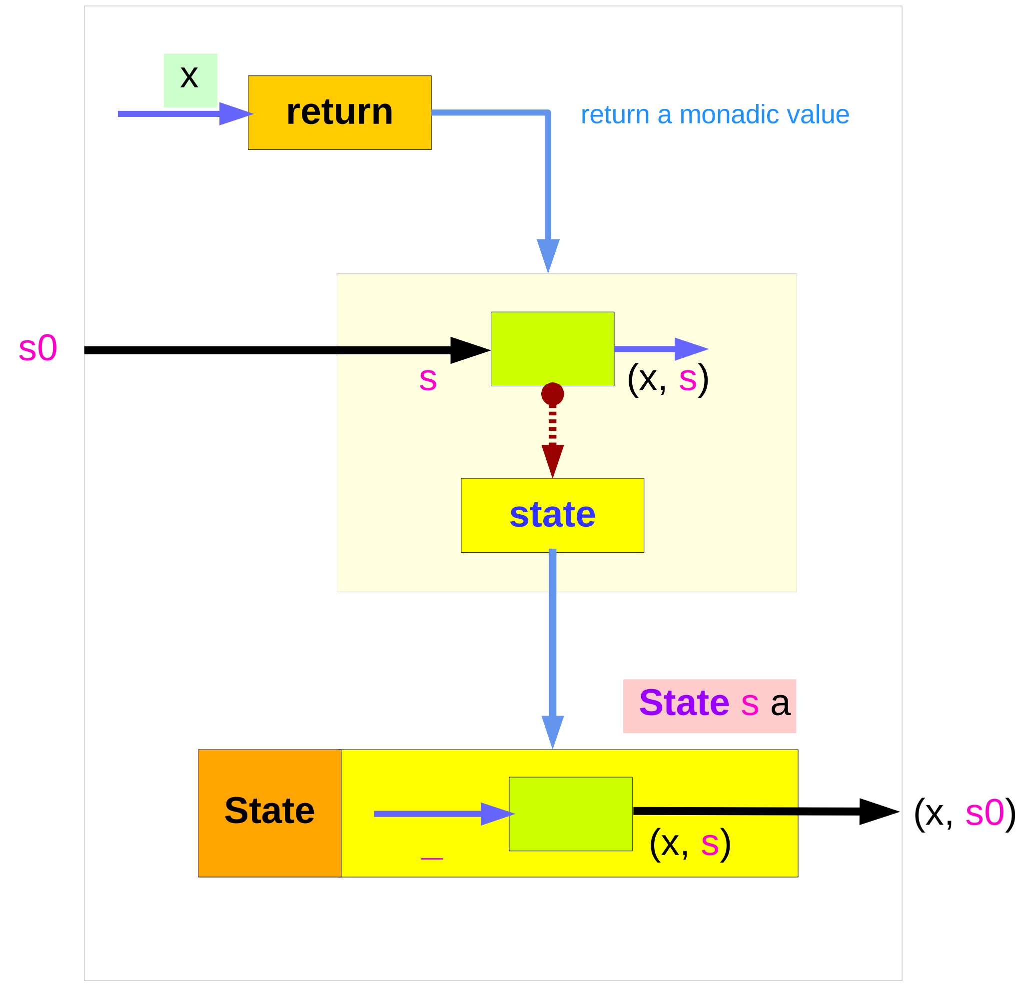
return s **::** **State** s a

return x = **state** **$** _ -> (x, s)

runState **(return x)** **s0**

runState **(return 3)** **1**

(3,1)



https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

Example codes (1)

```
import Control.Monad.Trans.State

runState get 1
(1,1)
runState (return 'X') 1
('X',1)
runState get 1
(1,1)
runState (put 5) 1
((),5)
```

```
runState (put 1 >> get >> put 2 >> get ) 0
(2,2)
runState (get >>= \n -> put (n+1) >> return n) 0
(0,1)

inc = get >>= \n -> put (n+1) >> return n

runState inc 0
(0,1)
runState (inc >> inc)  0
(1,2)
runState (inc >> inc >> inc)  0
(2,3)
```

https://wiki.haskell.org/State_Monad

Example codes (2)

```
import Control.Monad.Trans.State

let postincrement = do { x <- get; put (x+1); return x }
runState postincrement 1
(1,2)

let predecrement = do { x <- get; put (x-1); get }
 runState predecrement 1
(0,0)
```

```
runState (modify (+1)) 1
((),2)
runState (gets (+1)) 1
(2,1)
evalState (gets (+1)) 1
2
execState (gets (+1)) 1
1
```

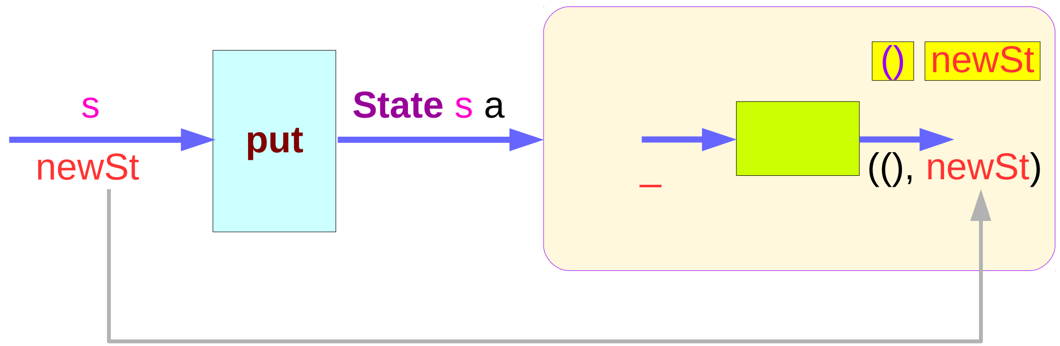
https://wiki.haskell.org/State_Monad

Simple representation of **put** and **get**

put :: s **->** **State** s a

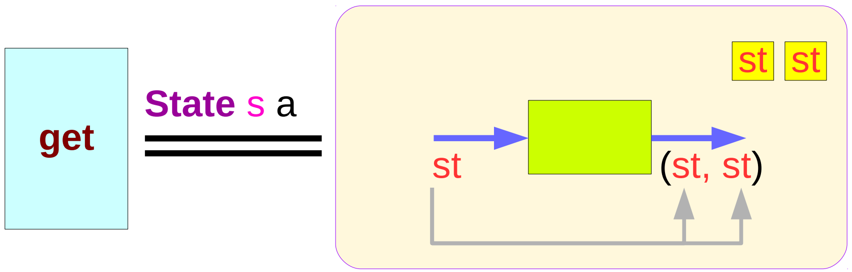
put s **::** **State** s a

put newSt = **state $** _ -> ((), newSt)



get :: **State** s s

get = **state $** \s -> (s, s)



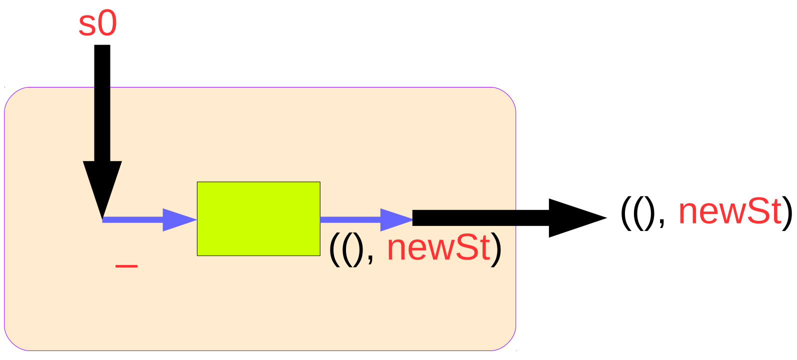
https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

Executing the state processor

put :: s **->** **State** s a

put newSt = **state $** _ -> ((), newSt)

runState (**put** newSt) s0 ➡ ((), newSt)

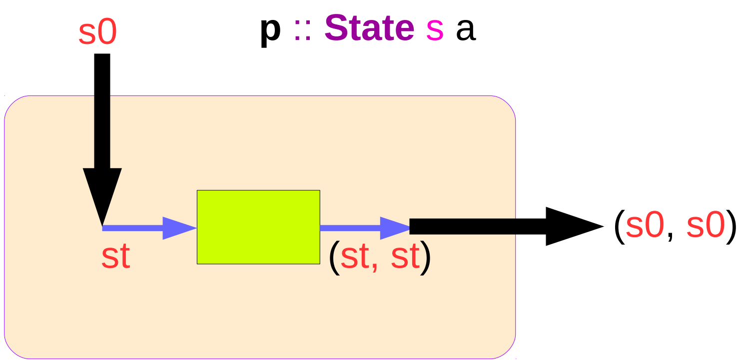


applying the function

get :: **State** s s

get = **state $** \s -> (s, s)

runState (**get**) s0 ➡ (s0, s0)



applying the function

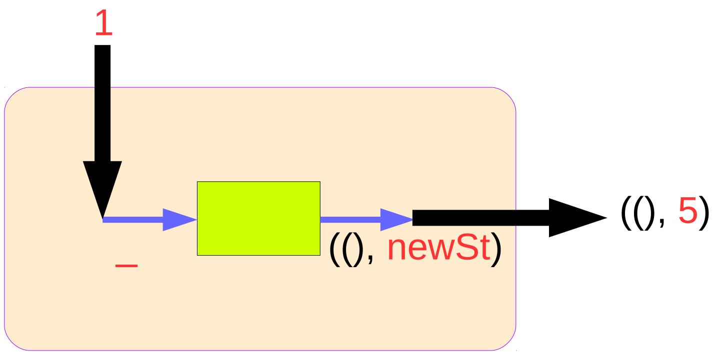
https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

State Monad Examples – **put**

runState (**put** 5) 1

((),5)

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



put 5 :: **State** Int ()

runState (**put** 5) :: Int -> ((),Int)

initial state = 1 :: Int

final value = () :: ()

final state = 5 :: Int

put :: s -> State s a

put newState = **state $** _ -> ((), newState)

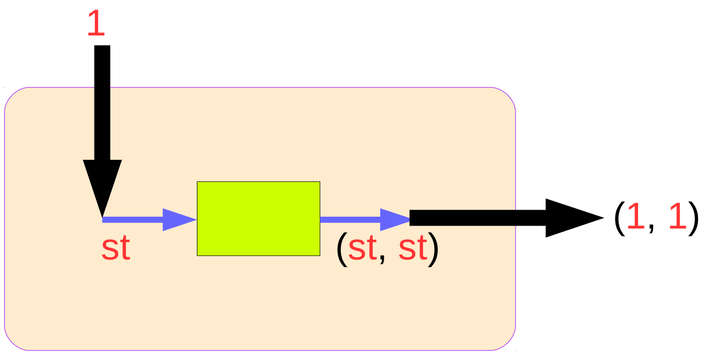
https://wiki.haskell.org/State_Monad

State Monad Examples – **get**

runState get 1

(1,1)

set the result value to the state and leave the state unchanged.



get :: **State** Int Int

runState get :: Int -> (Int, Int)

initial state = 1 :: Int

final value = 1 :: Int

final state = 1 :: Int

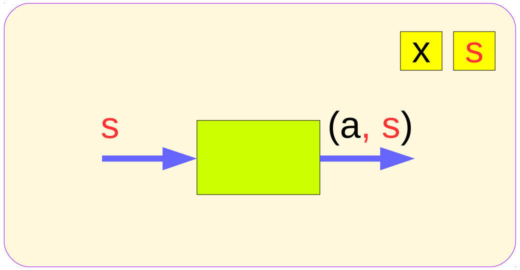
get :: State s s

get = **state $** \s -> (s, s)

https://wiki.haskell.org/State_Monad

Think an unwrapped state processor

(**return** 5)	1 -> (5,1)	-- a way of thinking	Think an **unwrapped** state processor
get	1 -> (1,1)	-- a way of thinking	
(**put** 5)	1 -> ((),5)	-- a way of thinking	



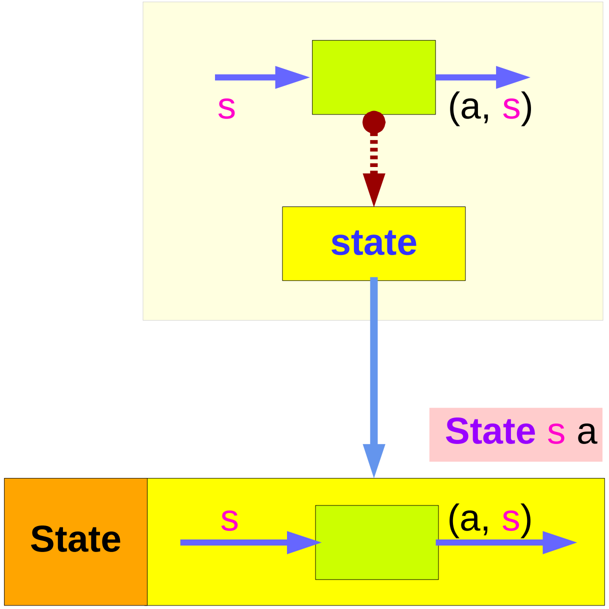
a value of type (**State** s a) is

a **function** from initial state s

to final value a and final state s: (a,s).

these are usually wrapped,

but shown here unwrapped for simplicity.



(**return** 5)	**state**(1 -> (5,1))	-- an actual impl	**wrapping** the state processor
get	**state**(1 -> (1,1))	-- an actual impl	
(**put** 5)	**state**(1 -> ((),5))	-- an actual implementation	

https://wiki.haskell.org/State_Monad

State Monad Examples – return, get, and put

Return leaves the state unchanged and sets the result:

-- ie: (**return** 5) ⇨ 1 -> (5,1) -- a way of thinking

runState (**return** 5) 1 ⇨ (5,1)

Get leaves state unchanged and sets the result to the state:

-- ie: **get** ⇨ 1 -> (1,1) -- a way of thinking

runState **get** 1 ⇨ (1,1)

Put sets the result to () and sets the state:

-- ie: (**put** 5) ⇨ 1 -> ((),5) -- a way of thinking

runState (**put** 5) 1 ⇨ ((),5)

https://wiki.haskell.org/State_Monad

State Monad Examples – modify and gets

runState (modify (+1)) 1 ⇨	((),2)
(+1) 1 → 2 :: s	
runState (gets (+1)) 1 ⇨	(2,1)
(+1) 1 → 2 :: a	

evalState (modify (+1)) 1 ⇨		( )
→ s :: state	**fst** ((), 2)	
execState (modify (+1)) 1 ⇨		2
→ a :: result	**snd** ((), 2)	

evalState (gets (+1)) 1		2
→ s :: state	**fst** (2, 1)	
execState (gets (+1)) 1		1
→ a :: result	**snd** (2, 1)	

https://wiki.haskell.org/State_Monad

modify state	**(–, f x)**
get state	**(f x, s)**
evalState	**(a, s)**
execState	**(a, s)**

(a , s)
(eval, exec)
(get, modify)

Unwrapped Implementation Examples

```
return :: a -> State s a
return x s = (x,s)

get :: State s s
get s = (s,s)

put :: s -> State s ()
put x s = ((),x)

modify :: (s -> s) -> State s ()
modify f = do { x <- get; put (f x) }

gets :: (s -> a) -> State s a
gets f = do { x <- get; return (f x) }
```

(x,s)

(s,s)

((),x)

- inside a monad instance
- unwrapped implementations of **return**, **get**, and **put**

x <- **get**; **put** (**f** **x**) - state

x <- **get**; **return** (**f** **x**) - result

- inside a monad instance
- unwrapped implementations of **modify** and **gets**

https://wiki.haskell.org/State_Monad

State Monad Examples – put, get, modify

`execState get 0`	⇨ 0
set the value of the counter using put:	
`execState (put 1) 0`	⇨ 1
set the state multiple times:	
`execState (do put 1; put 2) 0`	⇨ 2
modify the state based on its current value:	
`execState (do x <- get; put (x + 1)) 0`	⇨ 1
`execState (do modify (+ 1)) 0`	⇨ 1
`execState (do modify (+ 2); modify (* 5)) 0`	⇨ 10

https://stackoverflow.com/questions/25438575/states-put-and-get-functions

A Stateful Computation

a **stateful computation** is a **function** that

takes some **state** and

returns a **value** along with some **new state**.

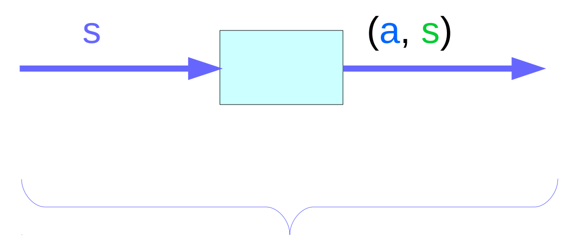
That function would have the following type:

s -> (a,s)

s is the type of the **state** and

a the **result** of the **stateful computation**.

s -> (a, s)



a function is an executable data

when executed, a result is produced

action, execution, result

s -> (a, s)

http://learnyouahaskell.com/for-a-few-monads-more

Stateful Computations inside the State Monad

inside a monad,

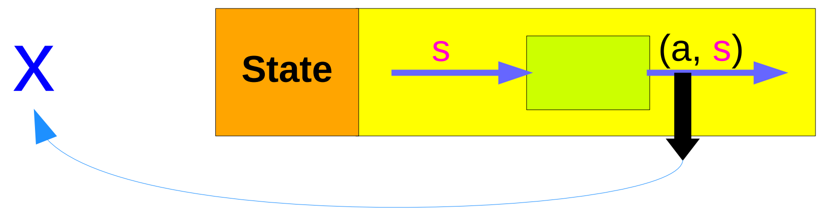
when **sc** is a stateful computation

then the **result** of the stateful computation **sc**

can be assigned to **x**

x <- sc

State s a



only the **result** is bound

x <- **sc**

sc :: State s a

x :: a   (the execution result of **sc**)

~~**x :: State** s a~~

s -> (a, s)

the **result** type

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

get inside the State Monad

inside the **State** monad,

get returns the current monad instance with the type of **State** s a

x <- get

the stateful computation is performed

over the current monad instance returned by **get**

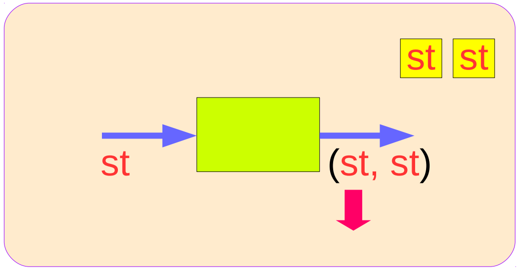
the result of the stateful computation of **get**

is **st**::s, thus **x** will get the st

this is like **evalState** is called with the current monad instance

- **get executed**
- **current monad instance**
- **stateful computation**
- **result :: s**

x :: a the execution result of **get**



https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

put and get inside State Monad

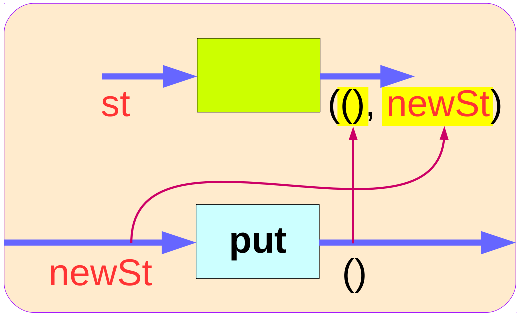
```
put :: s -> State s a
put newSt = state $ \_ -> ((), newSt)
```

put :: s -> ()

the result type :: ()

-- a way of thinking

stateful computation of **put**




```
get :: State s s
get = state $ \s -> (s, s)
```

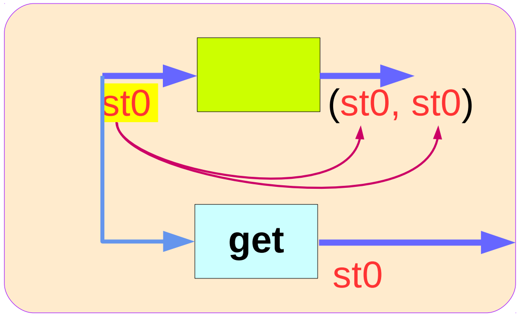
get :: s

the result type :: s

-- a way of thinking

-- no such a function

stateful computation of **get**



https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

run functions inside a Monad

Most monads have some "***run***" **functions**

such as **runState**, **execState**, and so forth.

frequent calling such functions *inside* the monad

indicates that the **functionality** of the monad does not fully exploited

```
s0 <- get                       -- read the state of the current instance
let (a,s1) = runState p s0      -- pass the state to p, get new state
put s1                          -- save new state
return a
```

let p = state (\y -> (y, y+1))

||

```
a <- p      -- the stateful computation p updates the state to s1
            -- the result of the state returned is assigned to a
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

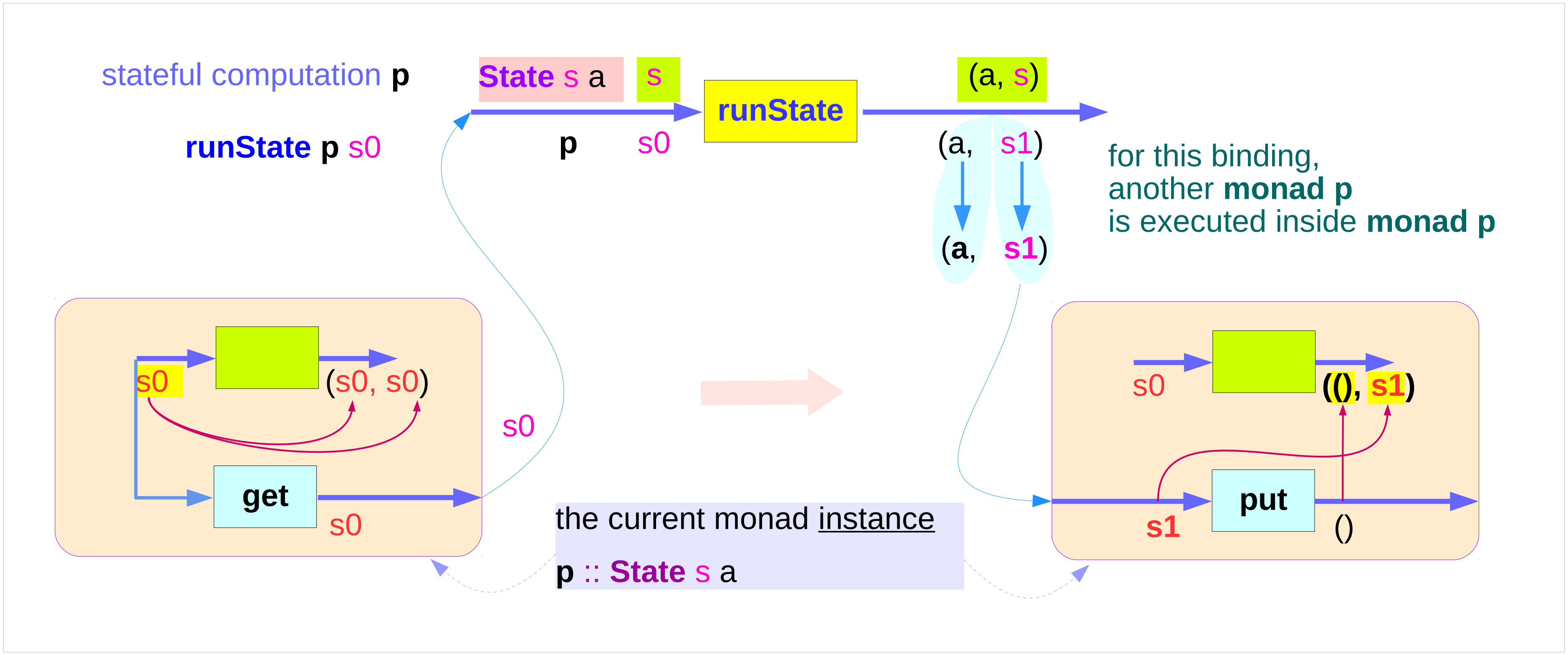
Redundant computation examples (1)

```
s0 <- get
let (a,s1) = runState p s0
put s1
```

the same binding variable **a**

the same state s1

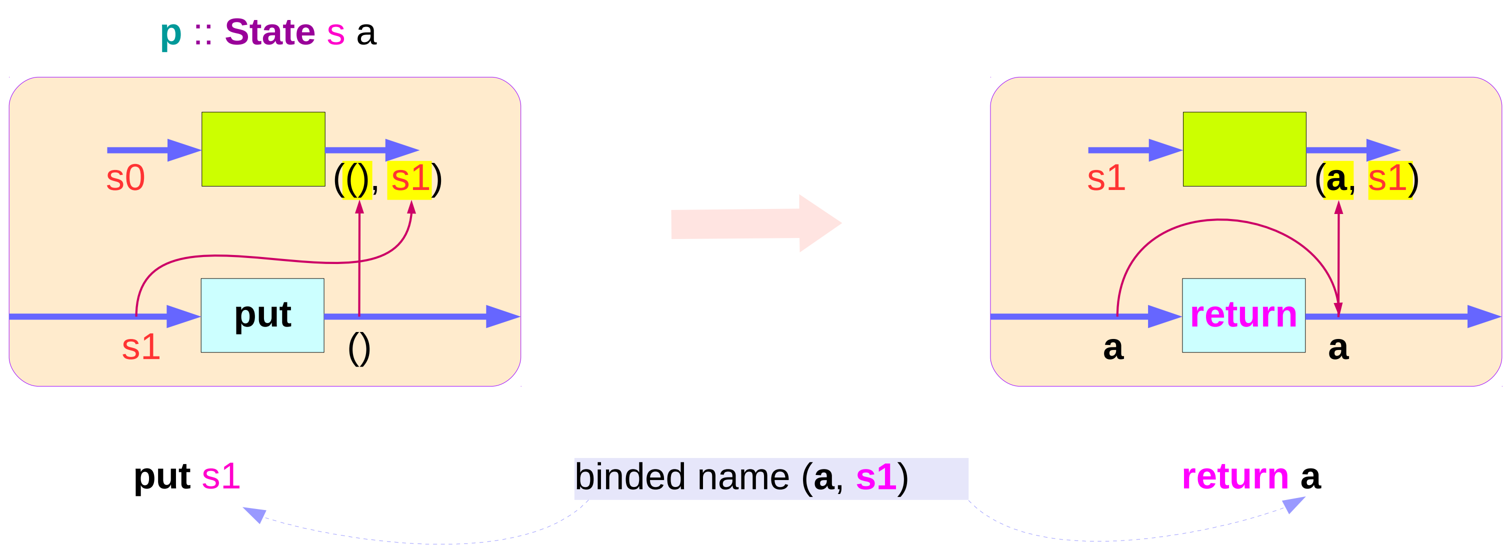
```
a <- p
```



https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Redundant computation examples (2)

```
s0 <- get
let (a,s1) = runState p s0
put s1
return a
```



https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

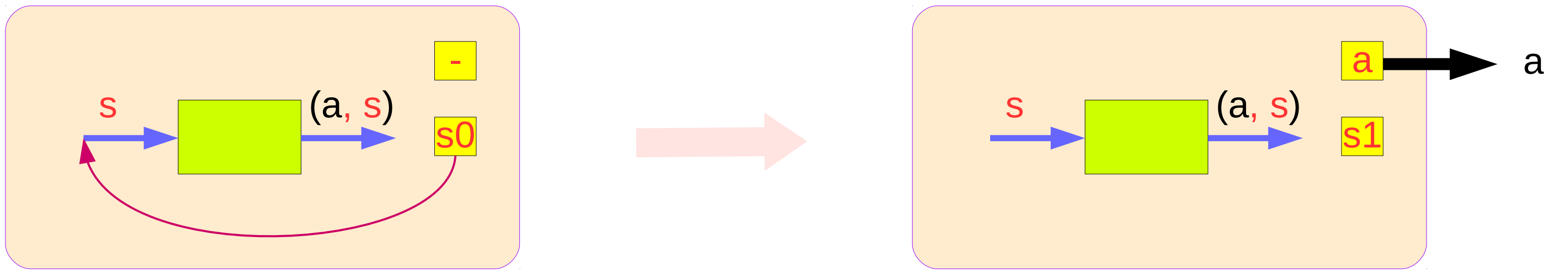
Redundant computation examples (3)

a <- p

-- the stateful computation p updates the state to s1

-- the result of the state returned is assigned to a

p :: **State** s a



stateful computation **p**

return the result a

runState p s0 ➡ (a, s1)

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Counter Example

```
import Control.Monad.State.Lazy

tick :: State Int Int
tick = do n <- get
          put (n+1)
          return n

plusOne :: Int -> Int
plusOne n = execState tick n

plus :: Int -> Int -> Int
plus n x = execState (sequence $ replicate n tick) x
```

A function to increment a counter.

tick :

- a monadic value itself

- ~~a function returning a monadic value~~

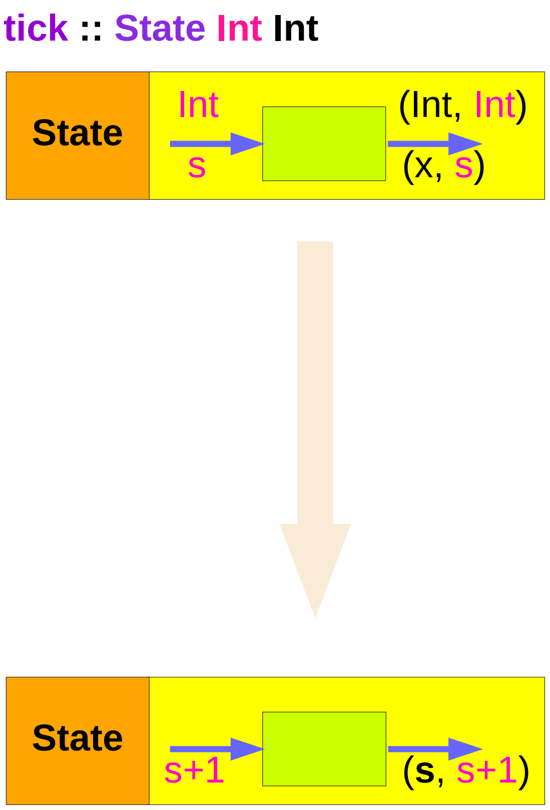
Add one to the given number using the state monad:

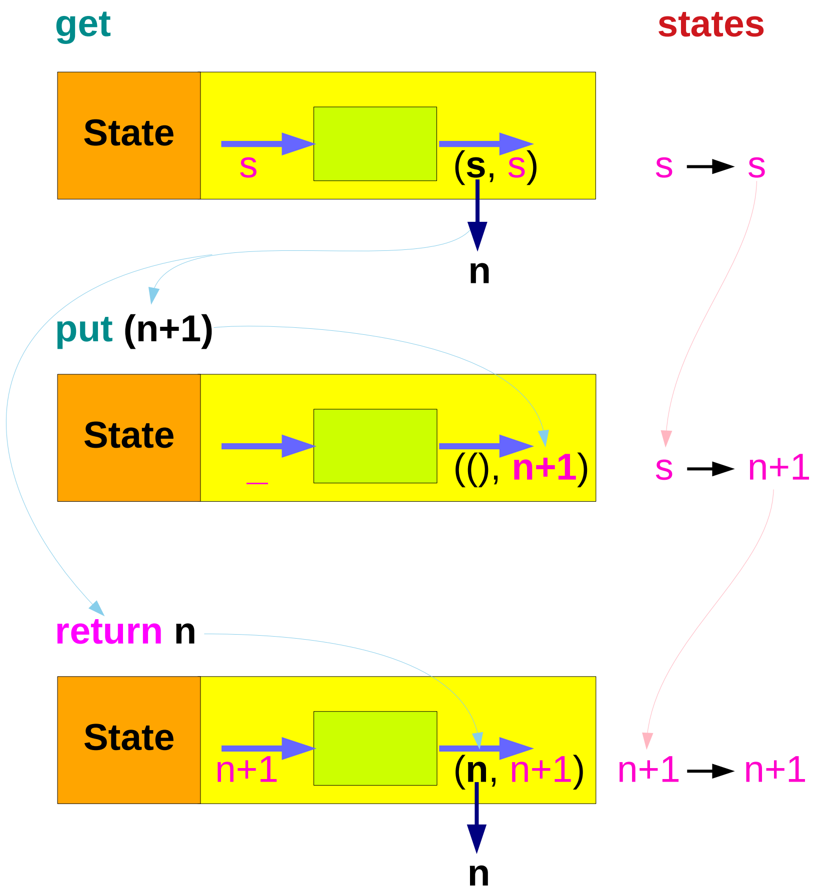
A contrived addition example. Works only with positive numbers:

https://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-State-Lazy.html

Counter Example – tick

```
tick :: State Int Int
tick = do n <- get
          put (n+1)
          execState n
```





https://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-State-Lazy.html

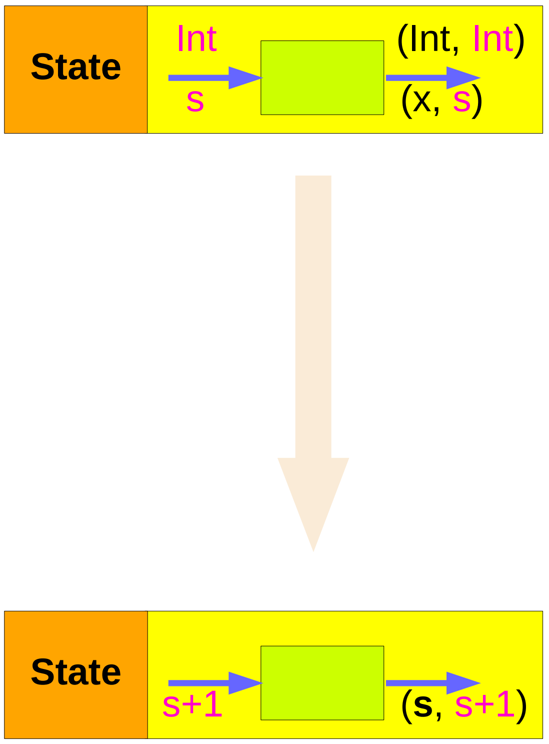
Counter Example – tick without **do**

```
tick :: State Int Int
tick = do n <- get
          put (n+1)
          return n
```

Int cannot receive **()**

```
tick = get >>= \n -> put (n+1) >> return n
```

tick :: State Int Int

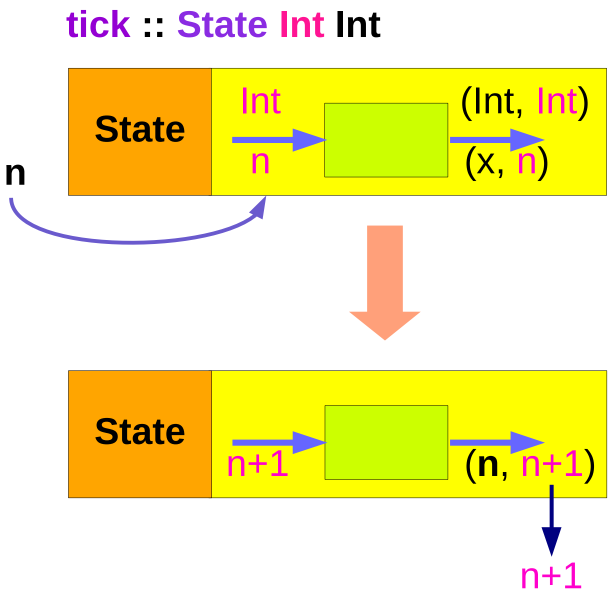


https://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-State-Lazy.html

Counter Example – incrementing

```
tick :: State Int Int
tick = do n <- get
          put (n+1)
          return n

plusOne :: Int -> Int
plusOne n = execState tick n
```



https://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-State-Lazy.html

Counter Example – using sequence

```
plus :: Int -> Int -> Int
plus n x = execState (sequence $ replicate n tick) x


                  1     2          n
sequence $ [tick, tick, … ,tick]


runState   (sequence $ [tick, tick]) 3          ➡ ([3,4],5)


runState   (sequence $ [tick, tick, tick]) 3    ➡ ([3,4,5],6)
execState  (sequence $ [tick, tick, tick]) 3    ➡ 6
evalState  (sequence $ [tick, tick, tick]) 3    ➡ [3,4,5]
```

https://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-State-Lazy.html

replicate

replicate :: Int -> a -> [a]

replicate n x is a list of length n with x the value of every element.

replicate 3 5

[5,5,5]

replicate 5 "aa"

["aa","aa","aa","aa","aa"]

replicate 5 'a'

"aaaaa"

http://zvon.org/other/haskell/Outputprelude/replicate_f.html

sequence

sequence :: Monad m => [m a] -> m [a]

evaluate **each action** in the sequence from left to right,

and collect the **results**.

runState (sequence [get, return 3, return 4]) 1

([1,3,4],1)

runState get 1 **(1,1)** **result: 1**

runState (return 3) 1 **(3,1)** **result: 3**

runState (return 4) 1 **(4,1)** **result: 4**

http://derekwyatt.org/2012/01/25/haskell-sequence-over-functions-explained/

Example of collecting returned values

```
collectUntil f comp = do
    st <- get                          -- Get the current state
    if f st  then return [ ]           -- If it satisfies predicate, return
             else do                   -- Otherwise...
                x  <- comp             -- Perform the computation s
                xs <- collectUntil f comp  -- Perform the rest of the computation
                return (x : xs)        -- Collect the results and return them
```

comp :: State s a

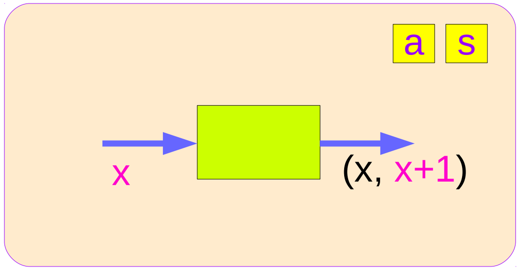
st :: s

x :: a

xs :: [a]

```
simpleState = state (\x -> (x,x+1))
```

simpleState :: State s a




```
*Main> evalState (collectUntil (>10) simpleState) 0
[0,1,2,3,4,5,6,7,8,9,10]
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Example of collecting – stateful computations

```
collectUntil f comp = do
    st <- get
    if f st  then return [ ]
             else do
               x  <- comp
               xs <- collectUntil f comp
               return (x : xs)
```

```
*Main> evalState (collectUntil (>10) simpleState) 0
[0,1,2,3,4,5,6,7,8,9,10]
```

```
simpleState = state (\x -> (x,x+1))
```

```
get = state (\s -> (s, s))
```

get	st ← 0	comp : 0 → (0, 1)	x ← 0
get	st ← 1	comp : 1 → (1, 2)	x ← 1
get	st ← 2	comp : 2 → (2, 3)	x ← 2
get	st ← 3	comp : 3 → (3, 4)	x ← 3
get	st ← 4	comp : 4 → (4, 5)	x ← 4
get	st ← 5	comp : 5 → (5, 6)	x ← 5
get	st ← 6	comp : 6 → (6, 7)	x ← 6
get	st ← 7	comp : 7 → (7, 8)	x ← 7
get	st ← 8	comp : 8 → (8, 9)	x ← 8
get	st ← 9	comp : 9 → (9, 10)	x ← 9
get	st ← 10	comp : 10 → (10, 11)	x ← 10

stateful computation

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Example of collecting – the return type

```
collectUntil f comp = do
    st <- get
    if f st  then return [ ]          ---------------------- return State t [a] type
             else do                                                          } return the same
                x  <- comp    -- stateful computation                           monadic type value
                xs <- collectUntil f comp
                return (x : xs)       ---------------------- return State t [a] type
```

x :: a

xs :: [a]

(x : xs) :: [a]

0: [1: [2: [3: [4: [5: [6: [7: [8: [9: [10: [ ]]]]]]]]]]]

nesting do statement

- is possible if they are within the same monad

- enables **branching** within one do block,

as long as both branches of the **if statement**

results in the same monadic type.

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Example of collecting – another stateful compuation

```
collectUntil f comp = do
    st <- get
    if f st  then return [ ]
             else do
               x  <- comp
               xs <- collectUntil f comp
               return (x : xs)
```

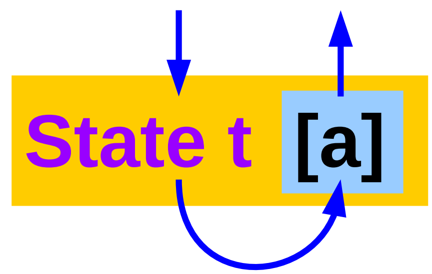
```
return :: State t [a] type
collectUntil f comp   :: State t [a]  type
xs <- collectUntil f comp -- stateful computation
xs :: [a]
```

```
*Main> evalState (collectUntil (>10) simpleState) 0
[0,1,2,3,4,5,6,7,8,9,10]
```

```
simpleState = state (\x -> (x,x+1))
```

t -> ([a], t)

the result type



https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Example of collecting – the function type

Inferred Function Type

collectUntil :: Monad State t m => (t -> Bool) -> m a -> m [a]

m ➡ State t

Specific Function Type

collectUntil :: (t -> Bool) -> State t a -> State t [a]

(>10) :: (t -> Bool)

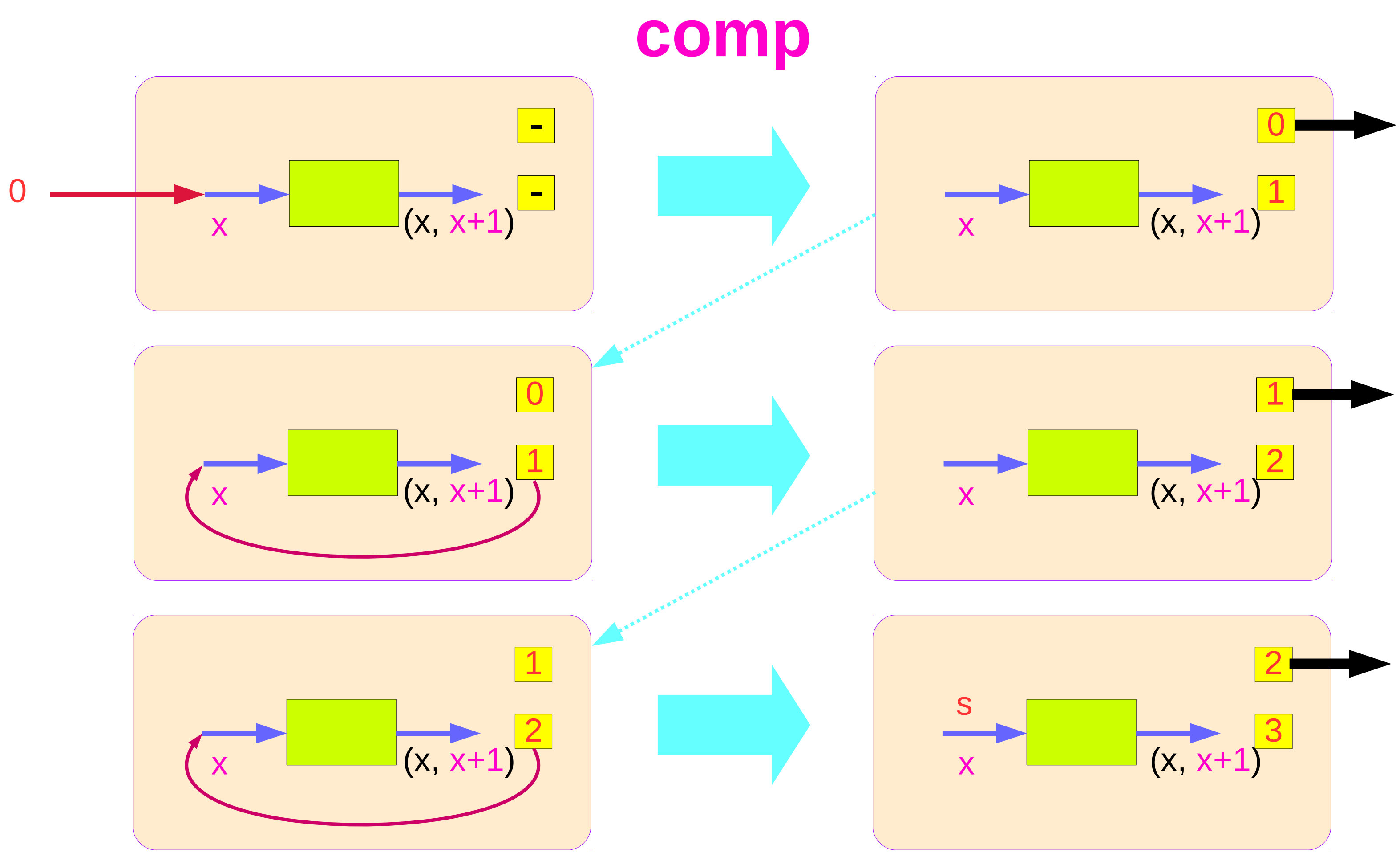
SimpleState :: State t a

***Main> evalState (collectUntil (>10) simpleState) 0**

simpleState = state (\x -> (x,x+1))

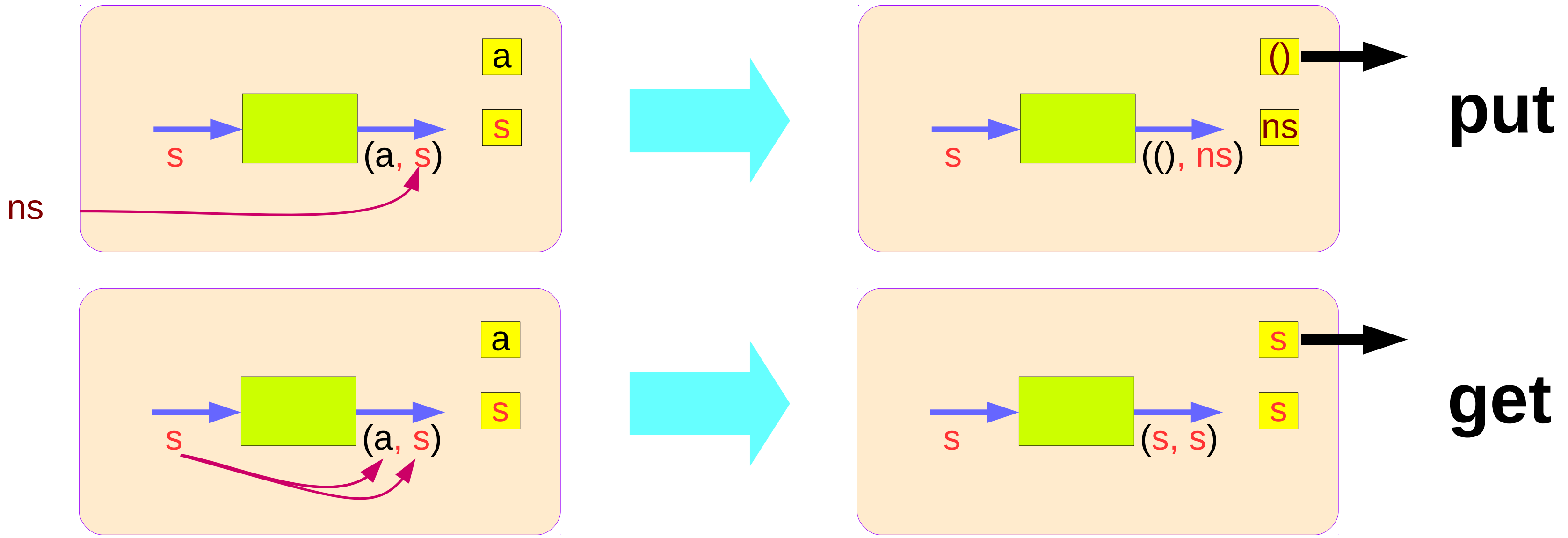
https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Stateful Computation of comp



https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Stateful Computations of **put** & **get**



https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting returned values

```
collectUntil :: (s -> Bool) -> State s a -> State s [a]
collectUntil f comp = step
  where
    step = do a <- comp                              -- updating stateful computation
              liftM (a : ) continue
    continue = do b <- get                           -- current state getting stateful computation
                  if f b then return []
                  else step
```

```
*Main> evalState (collectUntil (>10) simpleState) 0
[0,1,2,3,4,5,6,7,8,9,10]


simpleState = state (\x -> (x,x+1))
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – other representation

```
collectUntil :: (s -> Bool) -> State s a -> State s [a]
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return []
                  else step
```

-

```
step = do a <- comp
          liftM (a : ) do b <- get
                          if f b then return []
                          else step
```

-

```
if f b then return []  else step
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – the return type

```
collectUntil :: (s -> Bool) -> State s a -> State s [a]
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return [] else step
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – liftM to merge

```
collectUntil :: (s -> Bool) -> State s a -> State s [a]
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return []  else step
```

```
return :: State t [a] type
collectUntil f comp  :: State t [a]  type
continue  :: State t [a]  type
```

```
(:) :: a -> [a] -> [a]
(++) :: [a] -> [a] -> [a]
```

```
a :: a
continue :: State s [a]
liftM (a :) continue
```

```
      (:)    :: a ->          [a] ->          [a]
liftM (:)    :: a -> State s  [a] -> State s  [a]
```

```
      (a :)  ::         [a] ->          [a]
liftM (a :)  :: State s [a] -> State s  [a]
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – stateful computations

```
collectUntil :: (s -> Bool) -> State s a -> State s [a]
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return []  else step
```

a <- comp

b <- get

return []

comp : 0 → (0, 1)	a ← 0	get	b ← 1
comp : 1 → (1, 2)	a ← 1	get	b ← 2
comp : 2 → (2, 3)	a ← 2	get	b ← 3
comp : 3 → (3, 4)	a ← 3	get	b ← 4
comp : 4 → (4, 5)	a ← 4	get	b ← 5
comp : 5 → (5, 6)	a ← 5	get	b ← 6
comp : 6 → (6, 7)	a ← 6	get	b ← 7
comp : 7 → (7, 8)	a ← 7	get	b ← 8
comp : 8 → (8, 9)	a ← 8	get	b ← 9
comp : 9 → (9, 10)	a ← 9	get	b ← 10
comp : 10 → (10, 11)	a ← 10	get	b ← 11

stateful computation

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – **comp**, **get**, **return**

a <- comp

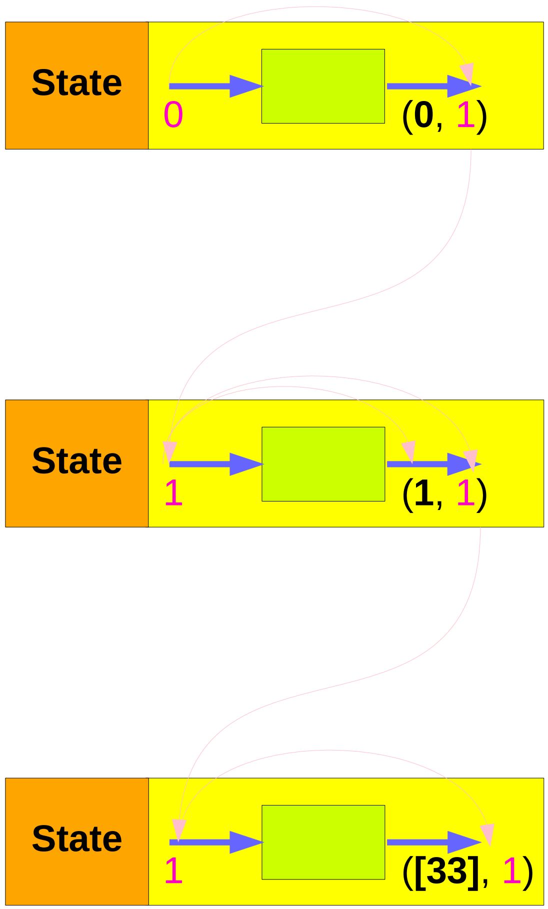
a=0

b <- get

b=1

return [33]

[33]

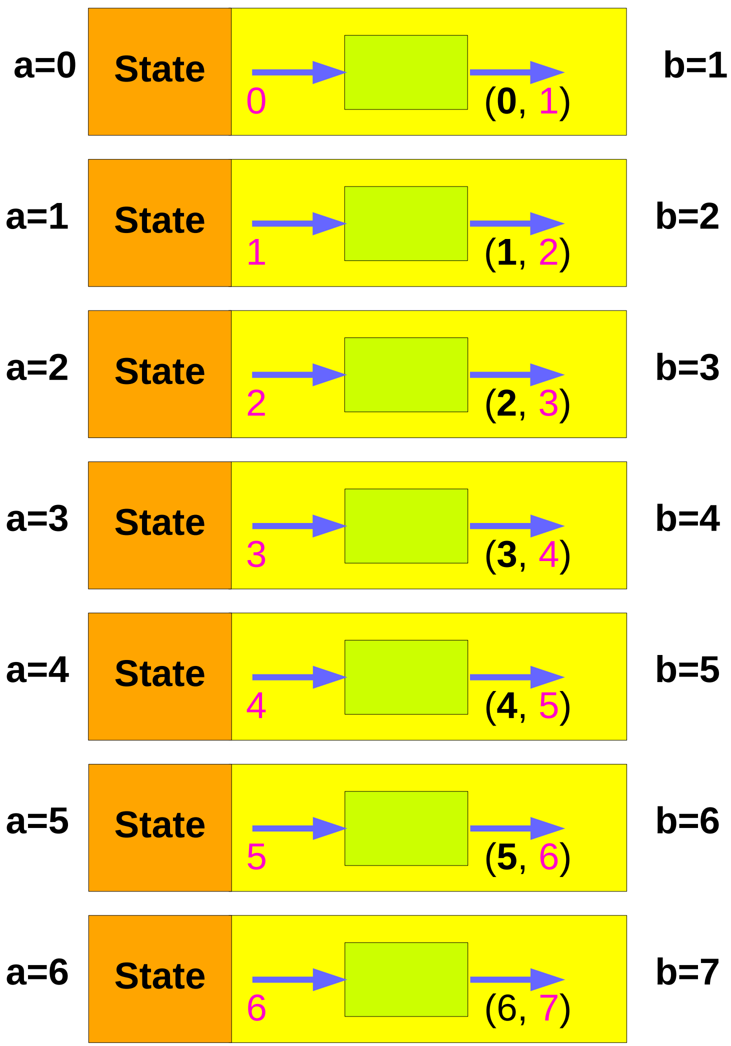


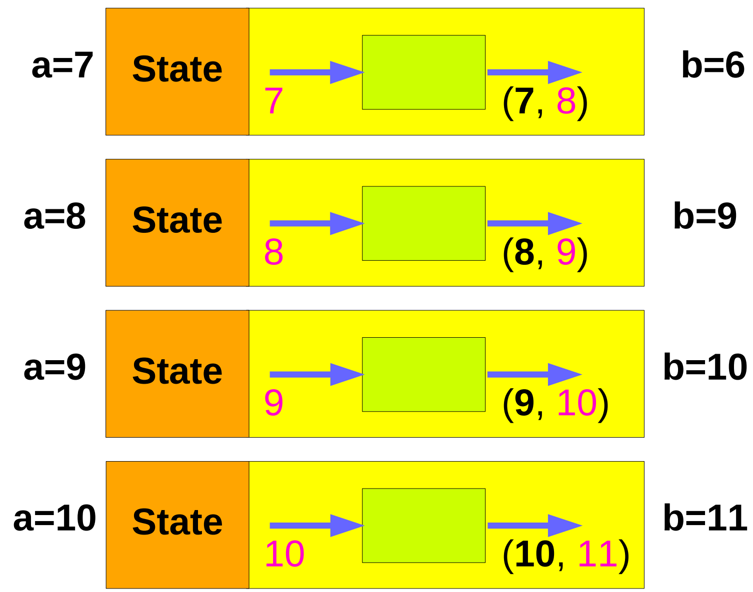
state (\x -> (x,x+1))

```
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return []
                         else step
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – **a<-comp**, **b<-get**

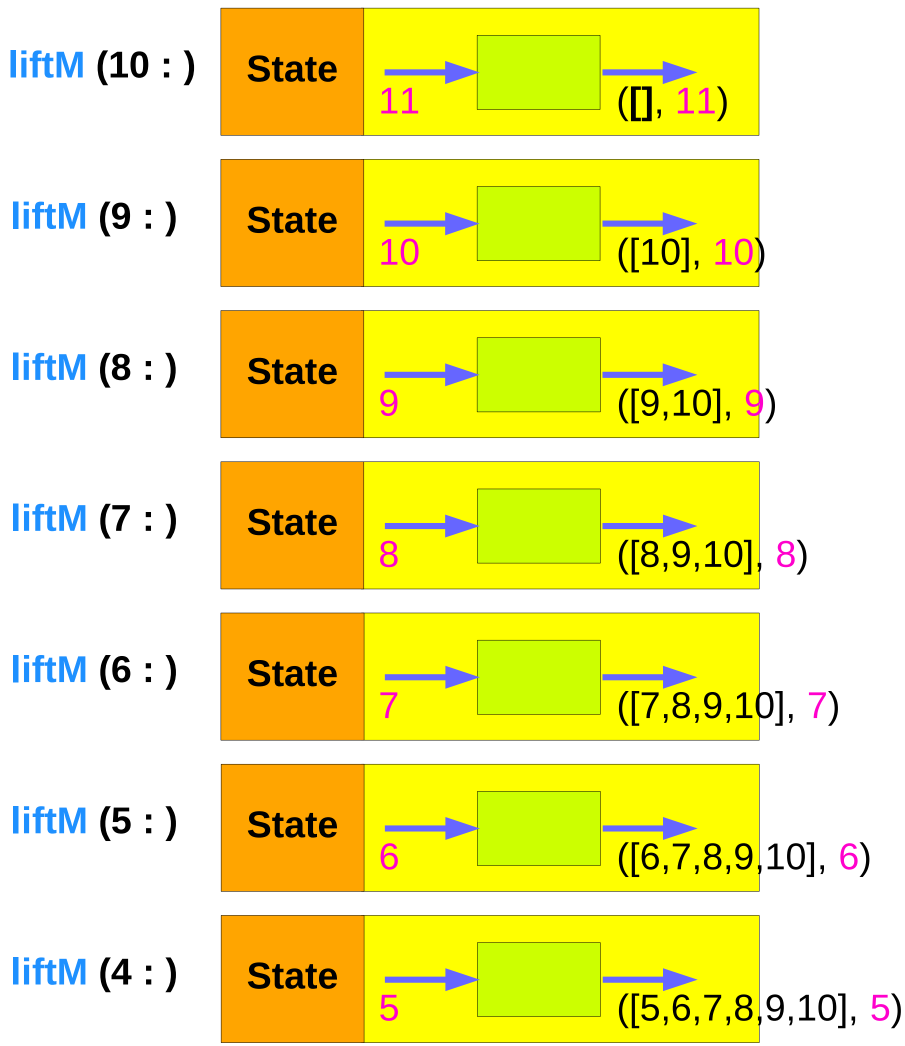


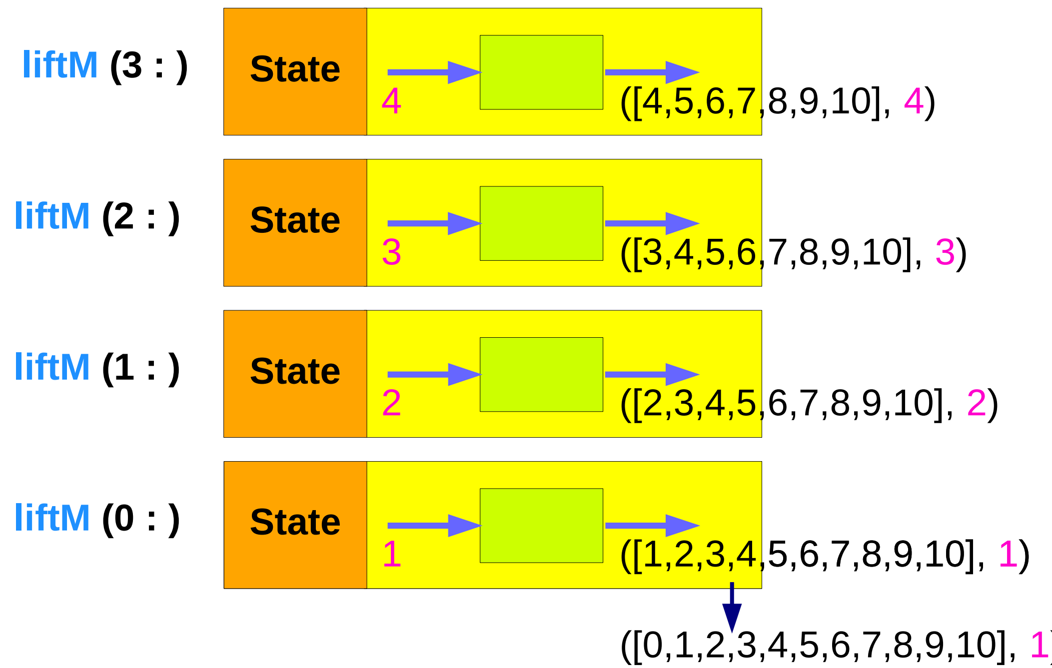



```
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return []
                  else step
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – **liftM (a:) continue**






```
collectUntil f comp = step
  where
    step = do a <- comp
               liftM (a : ) continue
    continue = do b <- get
               if f b then return []
                  else step
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – sequence comparison

```
collectUntil :: (s -> Bool) -> State s a -> State s [a]
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return []  else step
```

update the current state

then **get** and then **merge**

```
collectUntil f comp = do
    st <- get
    if f st  then return [ ]
             else do
               x  <- comp
               xs <- collectUntil f comp
               return (x : xs)
```

get the current state

then **update** and **merge**

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Another example of collecting – merge comparison

```
collectUntil :: (s -> Bool) -> State s a -> State s [a]
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return []  else step
```

Since a is part of the result in both branches of the 'if'

a is the common part of both ‘then’ part and ‘else’ part

continue :: State s [a]

liftM (a :) continue :: State s [a]

```
collectUntil f comp = do
    st <- get
    if f st  then return [ ]
             else do
               x  <- comp
               xs <- collectUntil f comp
               return (x : xs)
```

xs :: [a]
x : xs :: [a]

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

Example of collecting – source codes

```haskell
import Control.Monad.Trans.State

collectUntil f comp = do
    st <- get
    if f st     then return [ ]
                else do
                  x  <- comp
                  xs <- collectUntil f comp
                  return (x : xs)

simpleState :: State Int Int
simpleState = state $ \x -> (x,x+1)

-- evalState (collectUntil (>10) simpleState) 0
-- [0,1,2,3,4,5,6,7,8,9,10]
```

```haskell
import Control.Monad.Trans.State
import Control.Monad

simpleState :: State Int Int
simpleState = state $ \x -> (x,x+1)

-- evalState (collectUntil (>10) simpleState) 0
-- [0,1,2,3,4,5,6,7,8,9,10]

collectUntil :: (s -> Bool) -> State s a -> State s [a]
collectUntil f s = step
  where
    step = do a <- s
              liftM (a:) continue
    continue = do s' <- get
                  if f s'
                    then return []
                    else step
```

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

liftM and mapM

```
liftM    :: (Monad m) => (a -> b)     -> m a   -> m b
mapM     :: (Monad m) => (a -> m b) -> [a]     -> m [b]
```

liftM lifts a function of type a -> b to a monadic counterpart.

mapM applies a function which yields a monadic value to a list of values,

yielding list of results embedded in the monad.

```
> liftM (map toUpper) getLine
Hallo
"HALLO"

> :t mapM return "monad"
mapM return "monad" :: (Monad m) => m [Char]
```

https://stackoverflow.com/questions/5856709/what-is-the-difference-between-liftm-and-mapm-in-haskell

References

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