State Monad – Methods (6B)

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

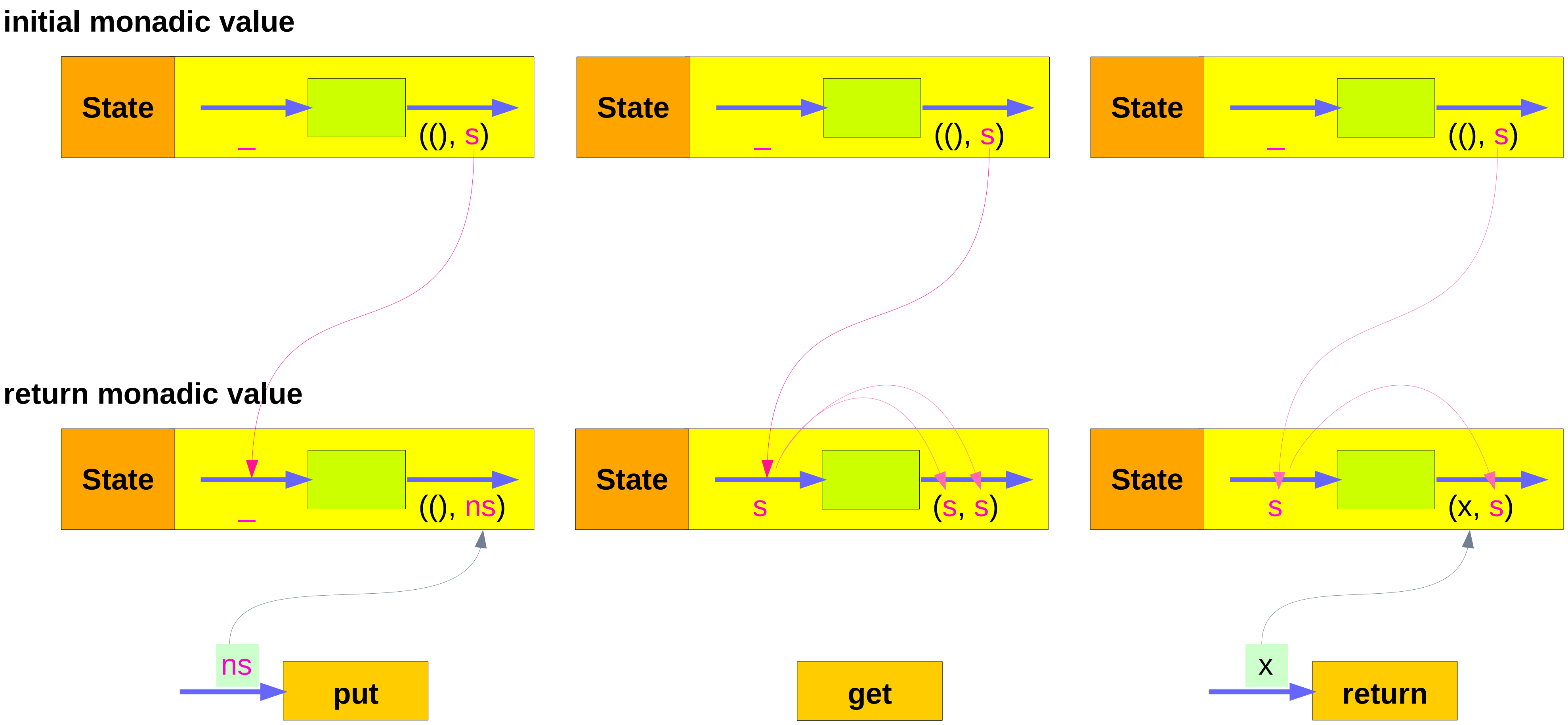
This document was produced by using LibreOffice.

Based on

Haskell in 5 steps

https://wiki.haskell.org/Haskell_in_5_steps

put, **get**, **return** methods summary



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

put changes the current state

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

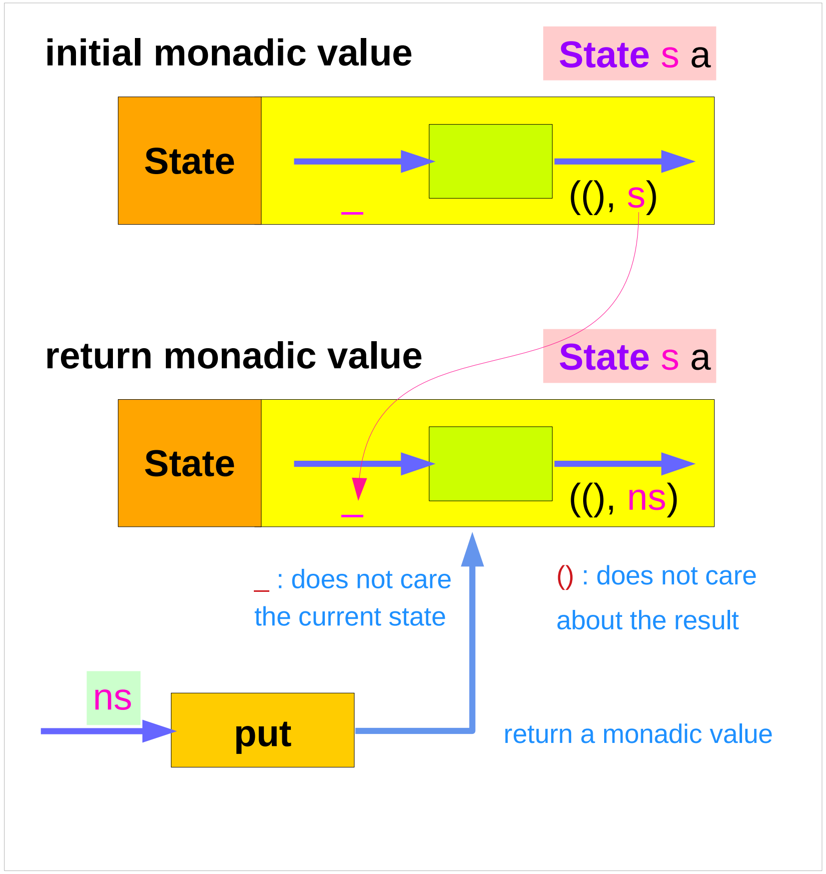
put ns = **state** **$** _ -> ((), ns)

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**.



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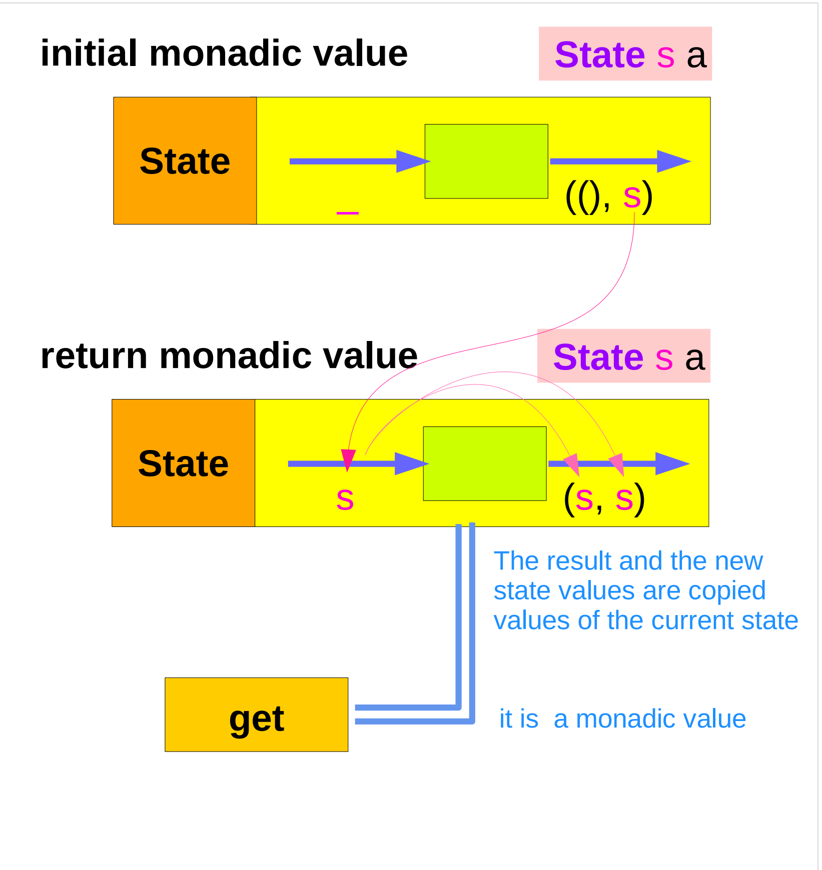
get gives the current state

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 changes the result value

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

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

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

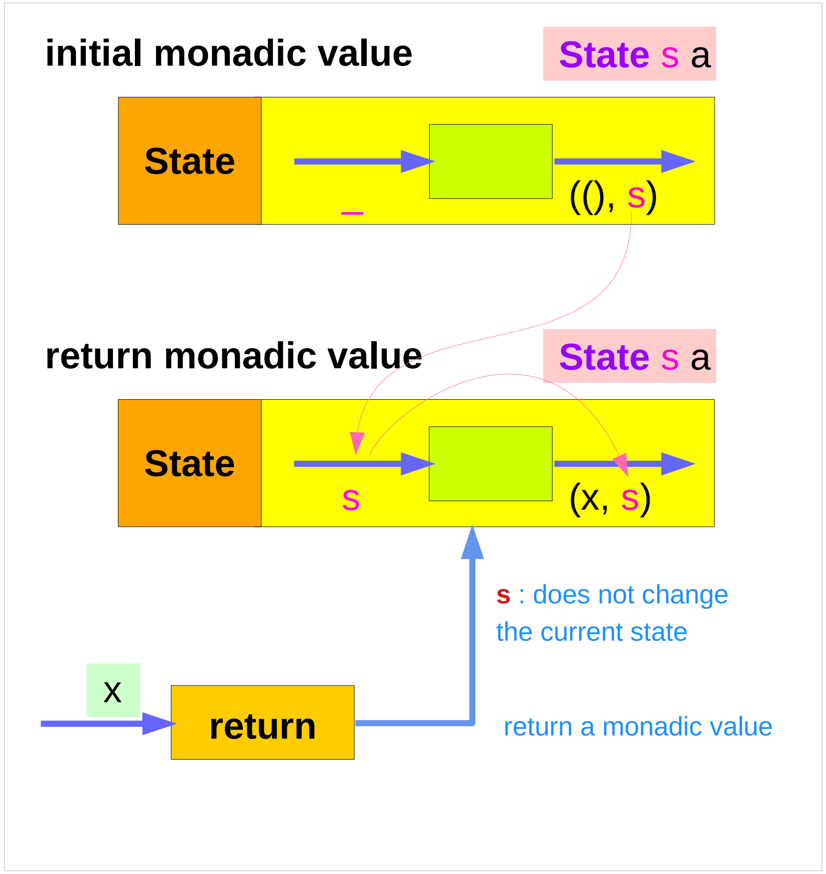
results in a **state processor** function

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 via state

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

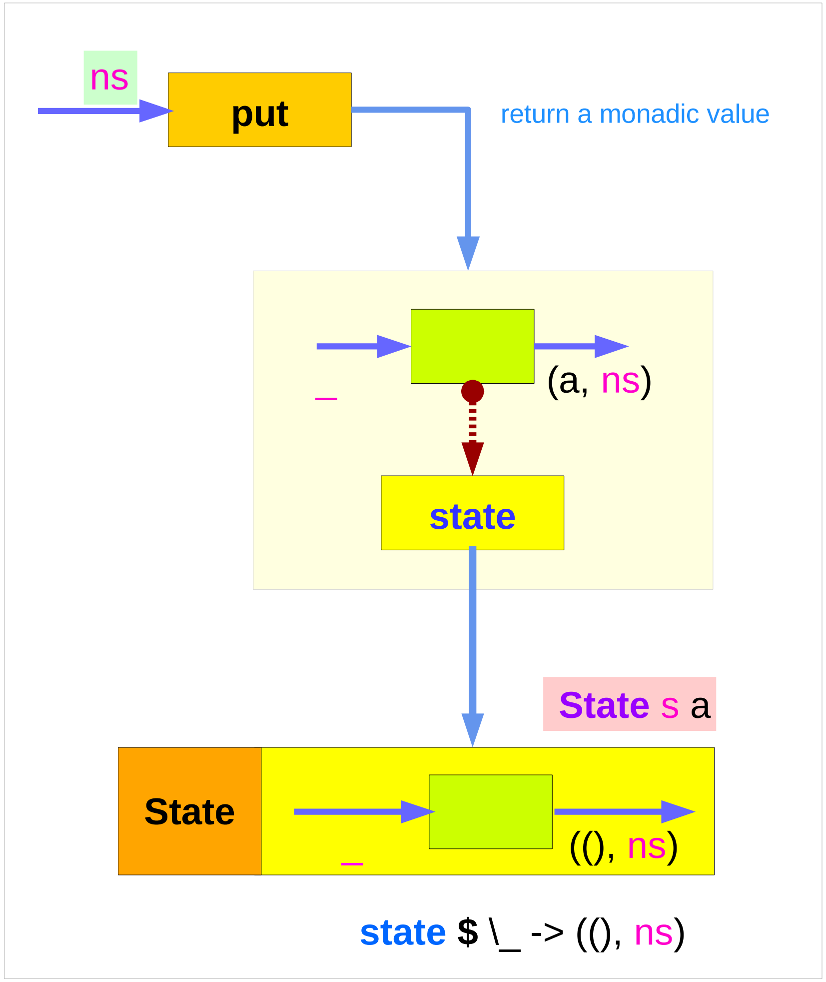
put s **::** **State** s a

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

-- setting a state to ns

-- regardless of the old state

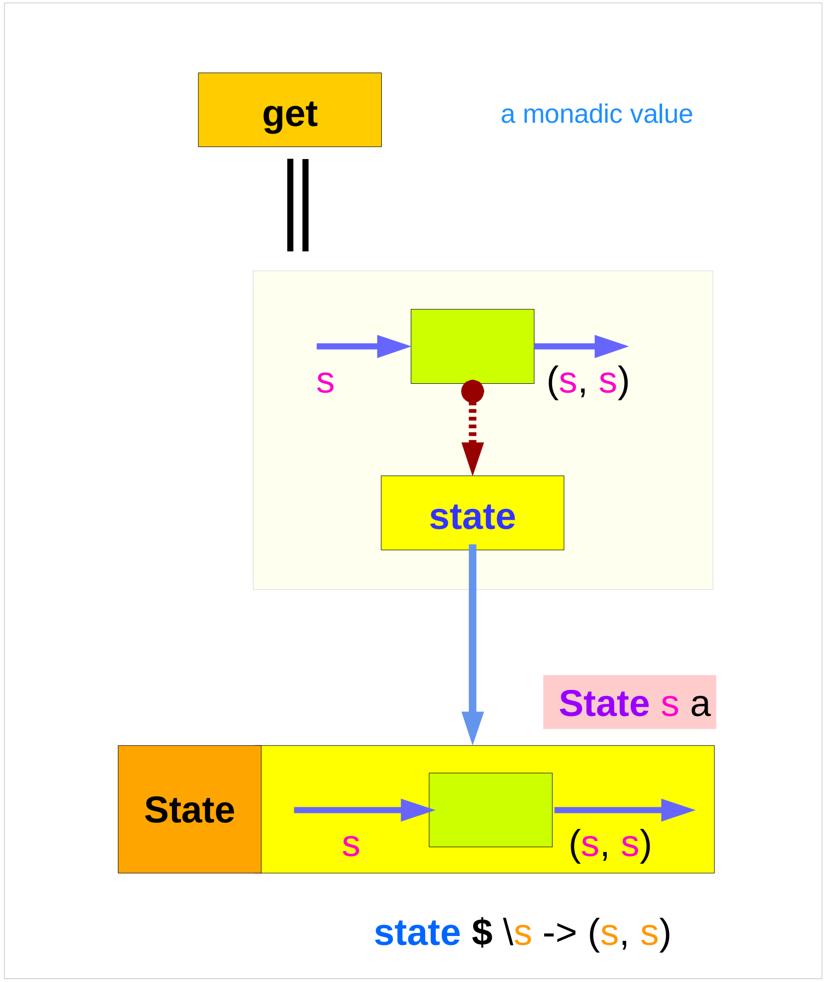
-- setting the result to ()



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

get is a monadic value via **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 via **state**

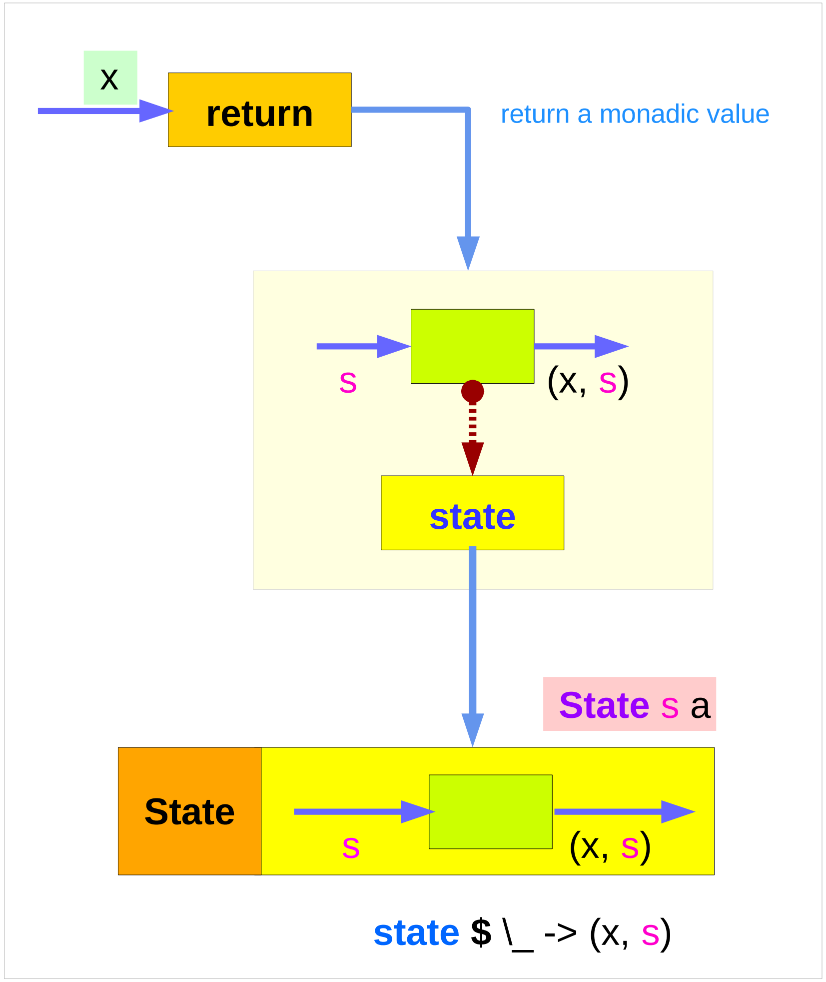
return **::** s **->** **State** s a

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

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

-- do not change a state s

-- setting the result to x



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

Threading **put** via **runState**

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

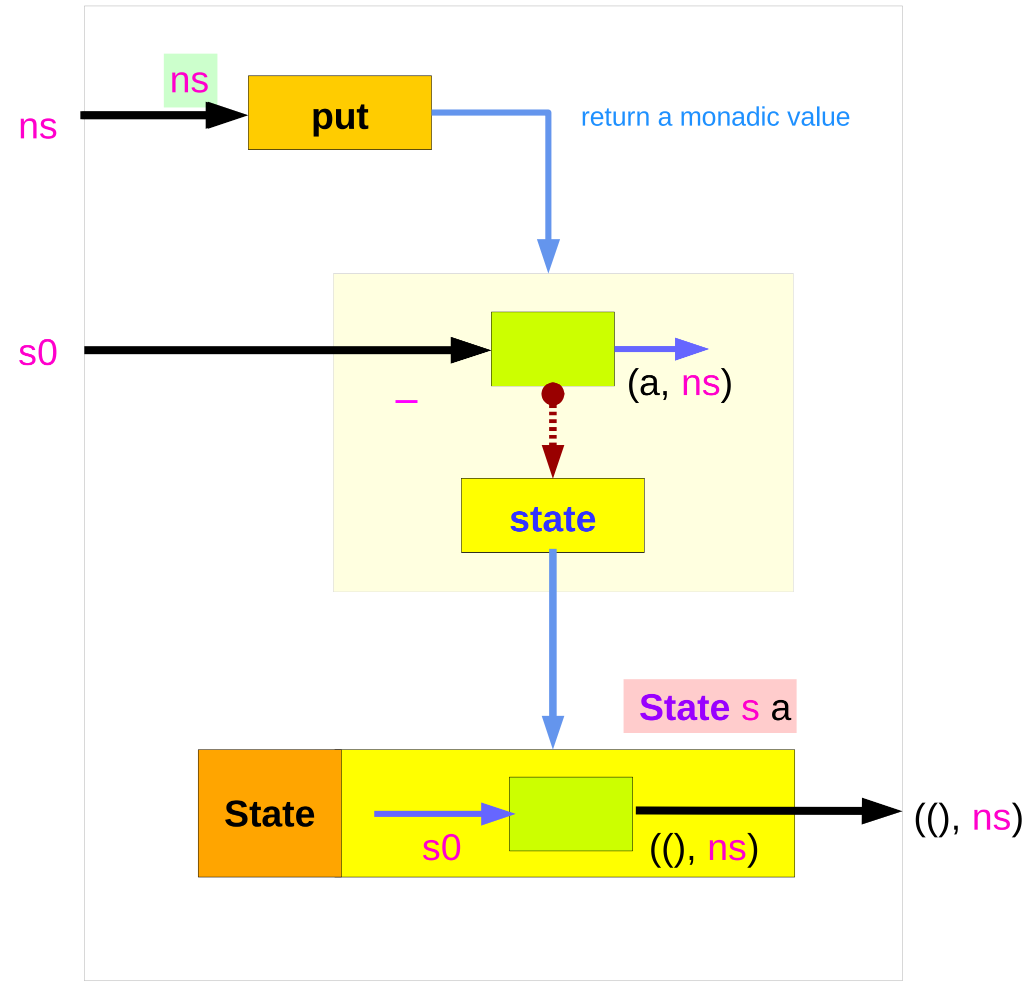
put s **::** **State** s a

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

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

runState **(put 5)** 1

((),5)



Initial state s0 can be supplied either by **runState**

or by the initial **monadic value**

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

Running **get** via **runState**

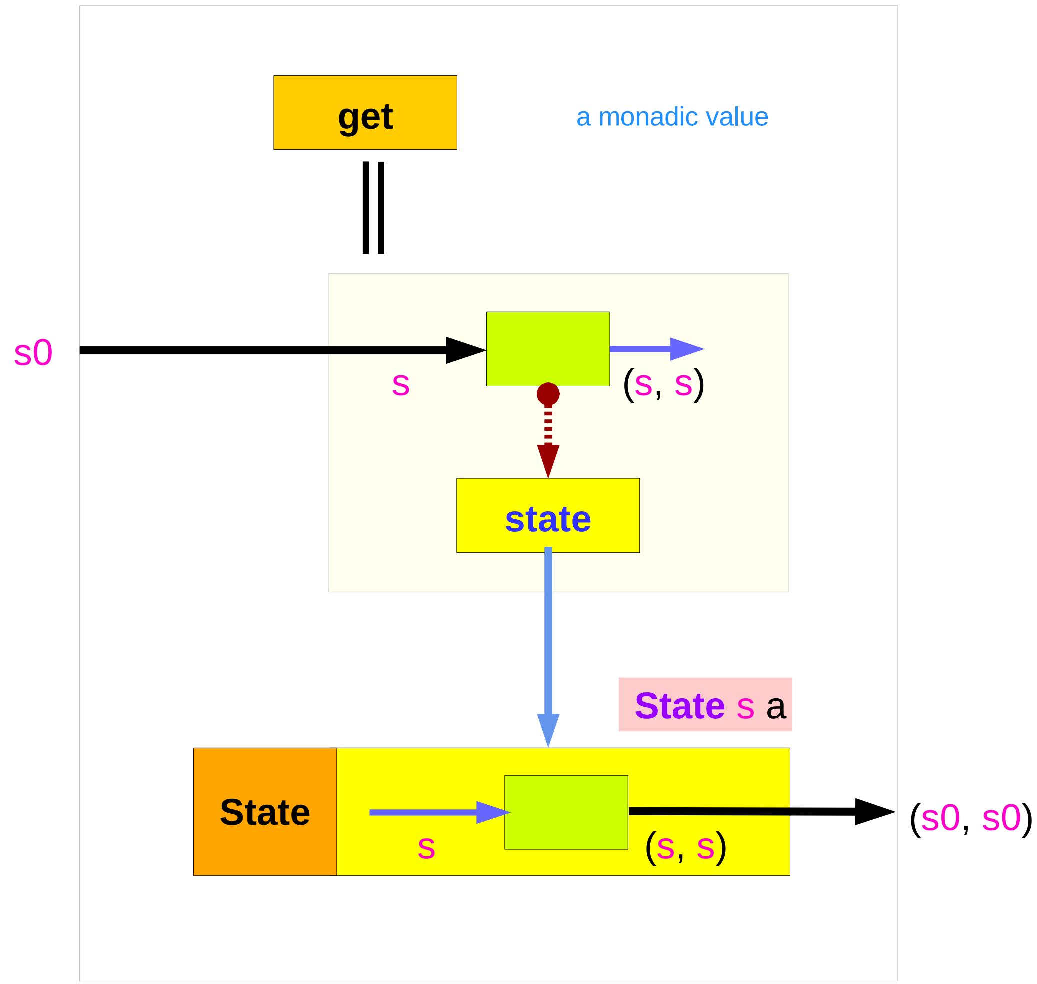
get :: **State** s s

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

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

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

(1,1)



Initial state s0 can be supplied either by **runState**

or by the initial **monadic value**

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

Running return via runState

return :: s -> State s a

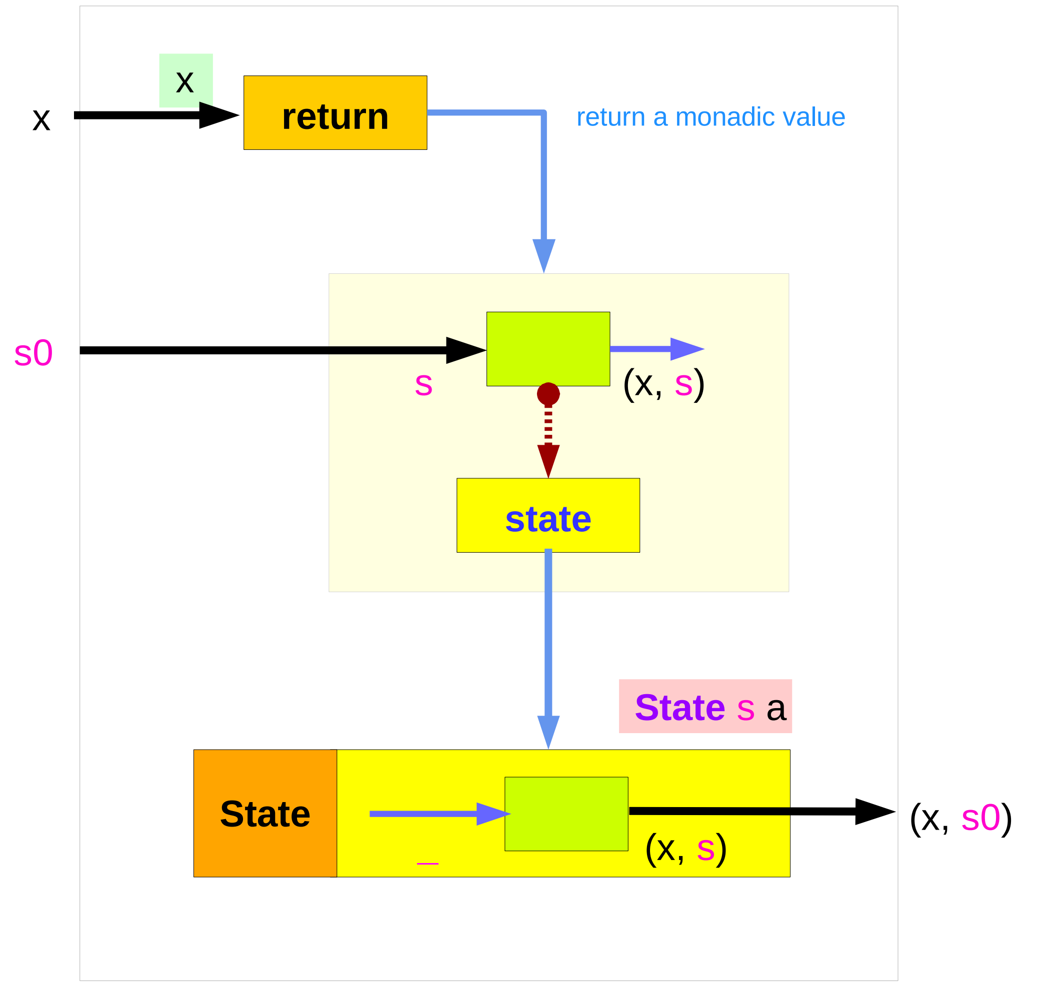
return s :: State s a

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

runState (return x) s0

runState (return 3) 1

(3,1)



Initial state s0 can be supplied either by **runState**

or by the initial **monadic value**

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

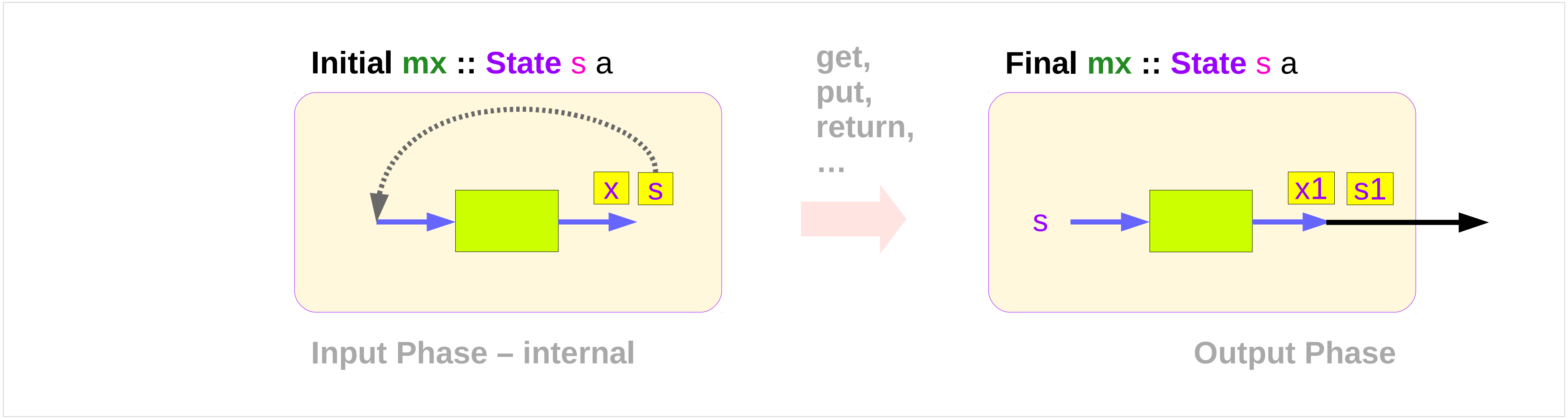
Example codes (2)

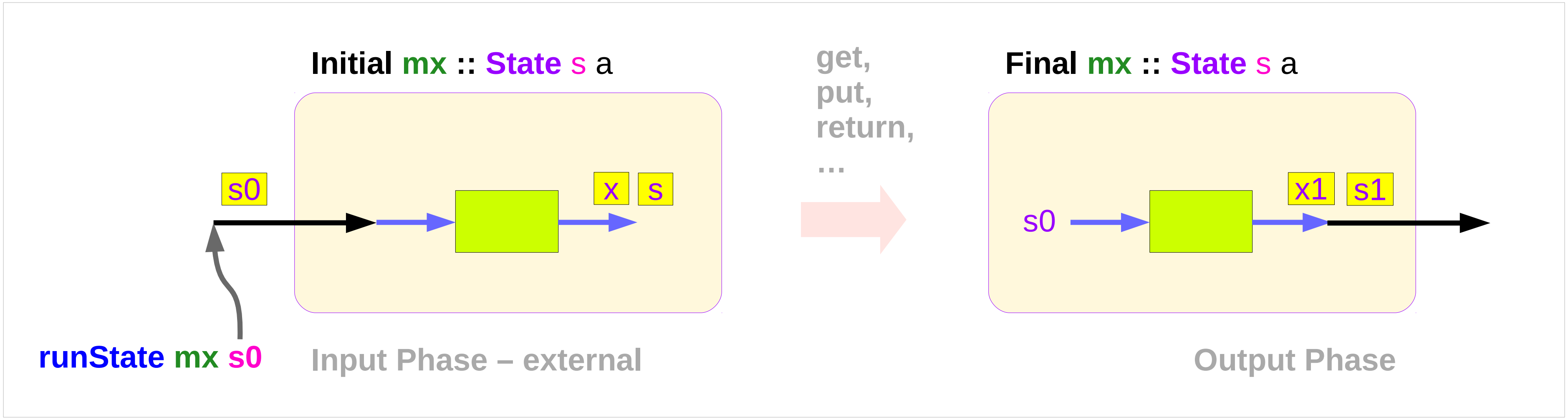
```
import Control.Monad.Trans.State

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

Think two phases (input, output)



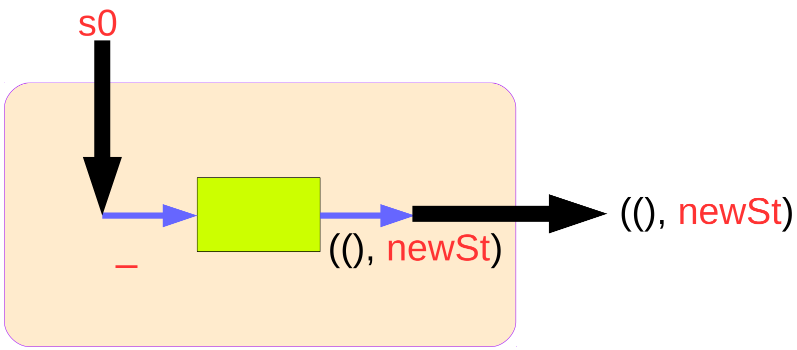


Executing the state processor – **put**

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

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

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



applying the function

runState (**put** 5) 1

((),5)

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

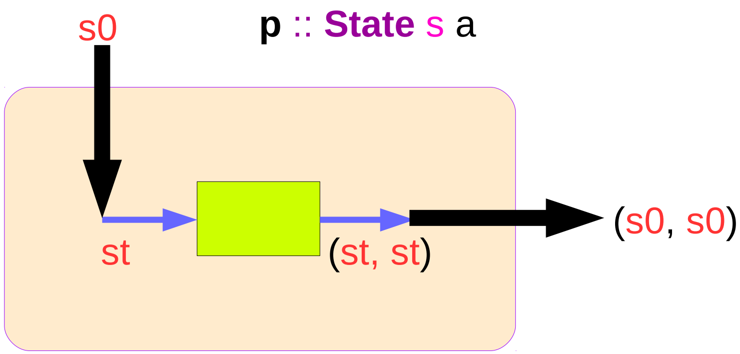
https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

Executing the state processor – **get**

get :: **State** s s

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

runState (**get**) s0 ⇨ (s0, s0)



applying the function

runState get 1

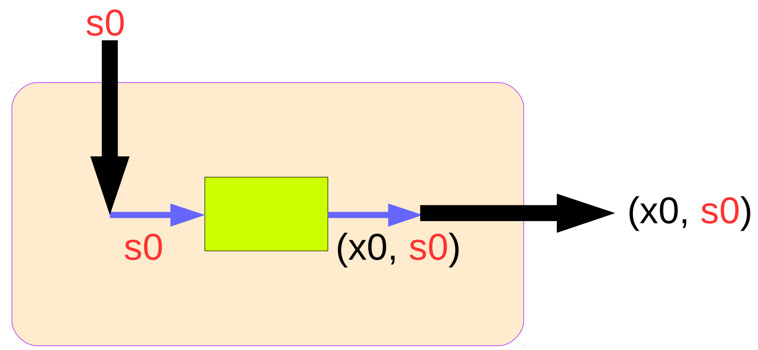
(1,1)

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

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

Executing the state processor – **return**

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

runState (return x0) s0        (x, s)
```



applying the function

```
runState return 3 1

   (3,1)
```

set the new result value and leave the state unchanged.

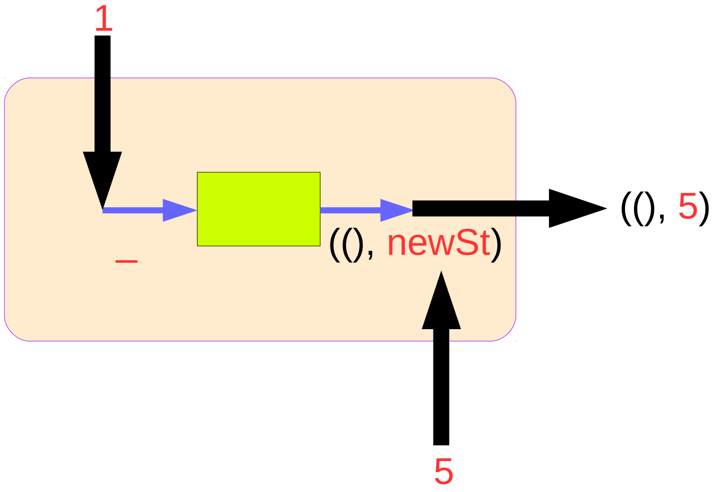
https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

State Monad Examples – **put**

runState (**put** 5) 1

(( ),5)

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



put :: s -> State s a

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

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

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

initial state = 1 :: Int

final value = () :: ()

final state = 5 :: Int

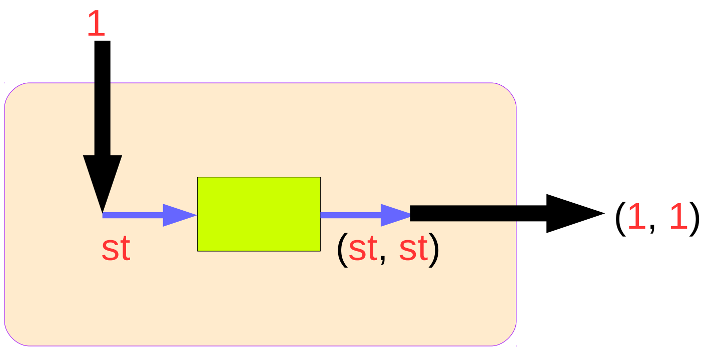
https://wiki.haskell.org/State_Monad

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)

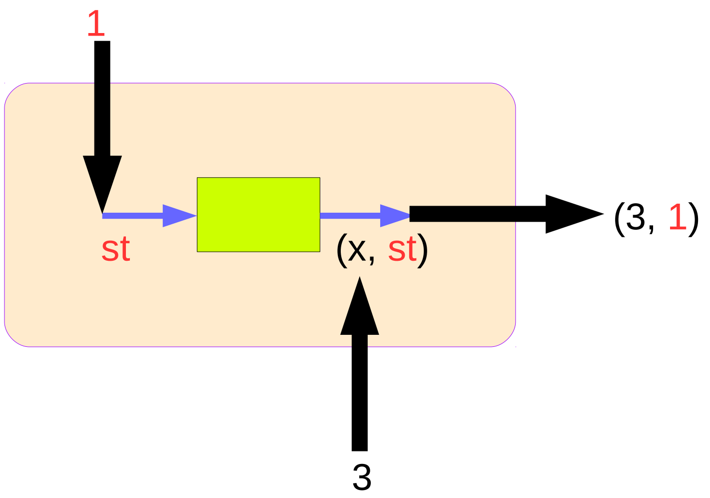
https://wiki.haskell.org/State_Monad

State Monad Examples – **return**

runState return 3 1

(3,1)

set the new result value and leave the state unchanged.



return :: Int -> **State** Int Int

runState return 3 :: Int -> (Int, Int)

initial state = 1 :: Int

final value = 3 :: Int

final state = 1 :: Int

return :: s -> State s a

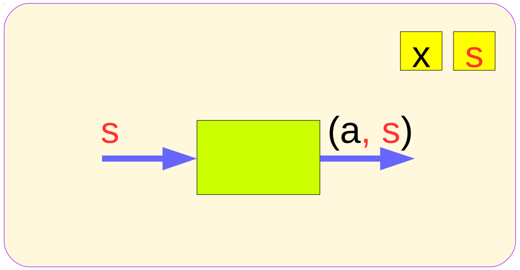
return x **= state $** s -> (x, s)

https://wiki.haskell.org/State_Monad

Think an unwrapped state processor

(**return** 5) ➡ 1 -> (5,1) -- a way of thinking
get ➡ 1 -> (1,1) -- a way of thinking
(**put** 5) ➡ 1 -> ((),5) -- a way of thinking

Think an **unwrapped** state processor

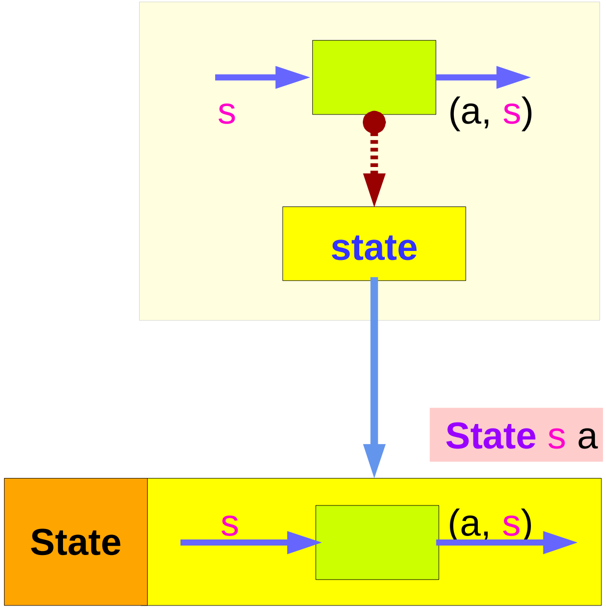


a value of type (**State** s a) is
a **function** from initial state s
to final value a and final state s: (a,s).

these are usually wrapped,
but shown here unwrapped for simplicity.

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

wrapping the state processor



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**.

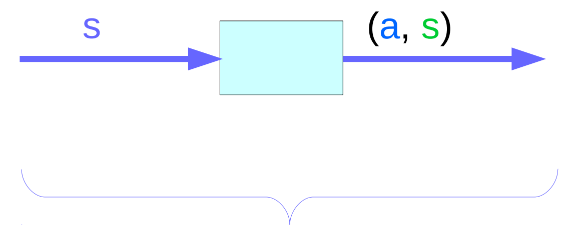
That function would have the following type:

s -> (a,s)

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

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

s -> (a, s)



a <u>function</u> is an executable <u>data</u>

when <u>executed</u>, a <u>result</u> is produced

action, execution, result

s -> (a, s)

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

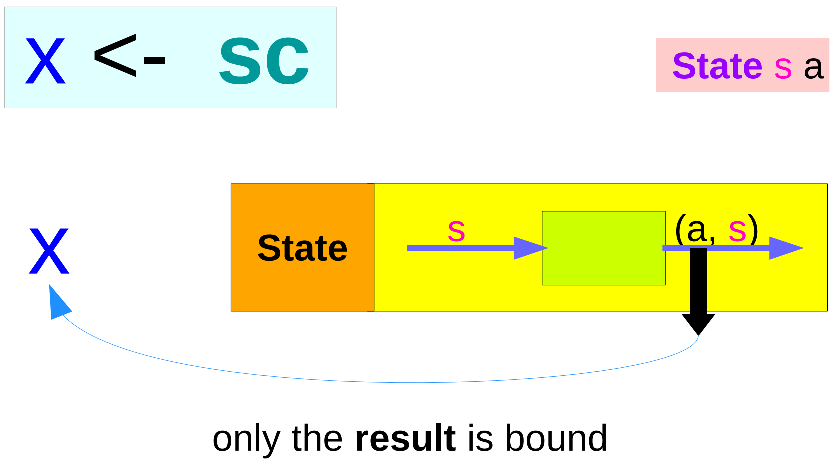
Stateful Computations inside the State Monad

inside a monad,

when **sc** is a stateful computation

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

can be assigned to **x**

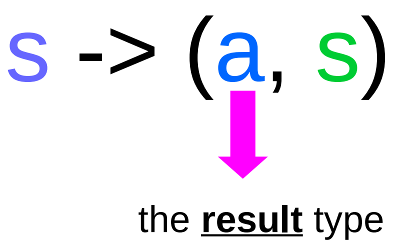


x <- **sc**

sc :: **State** s a

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

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



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

get inside the State Monad

inside the **State** monad,

get returns **State** monadic value whose new state and result values are the current state value

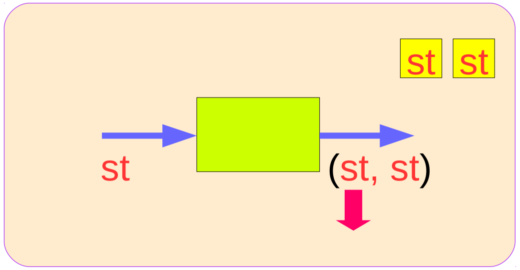
x <- get

the stateful computation is performed over the monadic value returned by **get**

the result of the stateful computation of **get** is **st**::s, thus **x** will get the st

- **get executed**
- **State monadic value**
- **stateful computation**
- **result :: s**

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



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

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

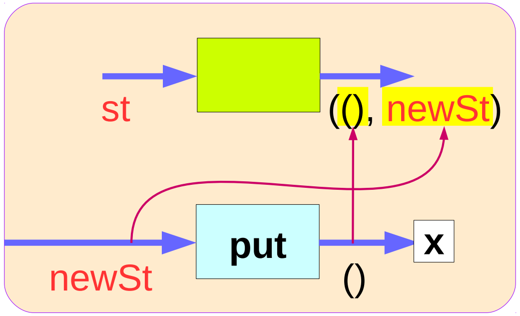
put inside State Monad

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

in **x <- put newSt**
put :: s -> ()   **the result type :: ()**

-- a way of thinking

stateful computation of **put**



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

get inside State Monad

get :: **State** s s

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

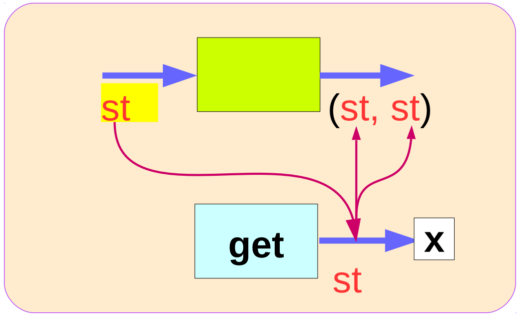
in **x <- get**

get :: s

the result type :: s

-- a way of thinking

stateful computation of **get**



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

return inside State Monad

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

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

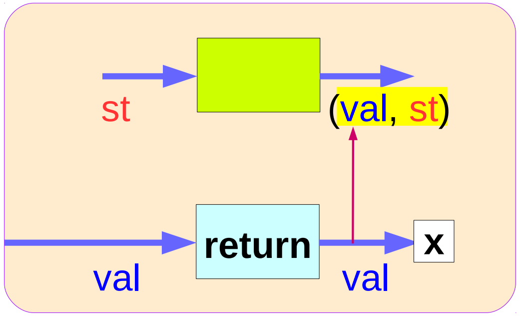
in **x <- return val**

return :: s -> s

the result type :: s

-- a way of thinking

stateful computation of **put**



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

-- read the state of the current instance

-- pass the state to **p**, get new state

-- save new state

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

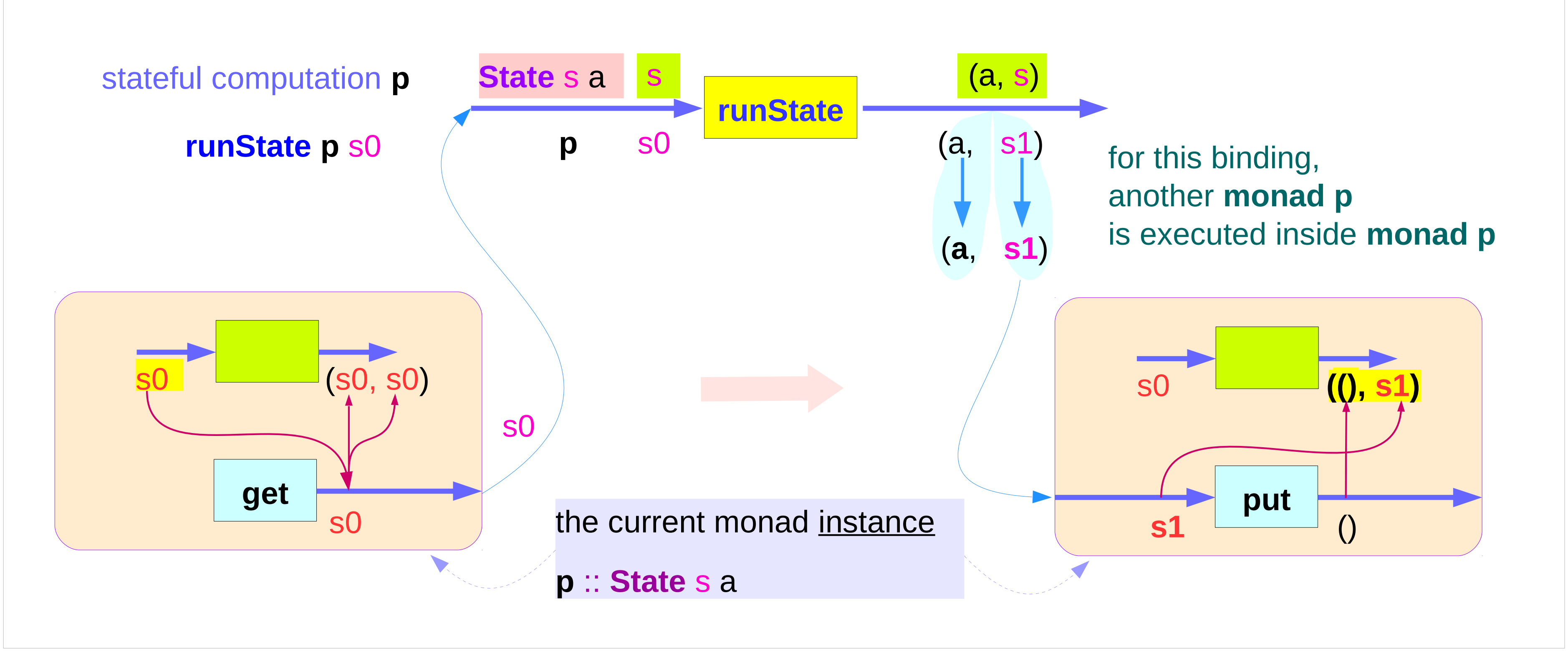
Redundant computation examples (1)

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

the same binding variable a

the same state s1

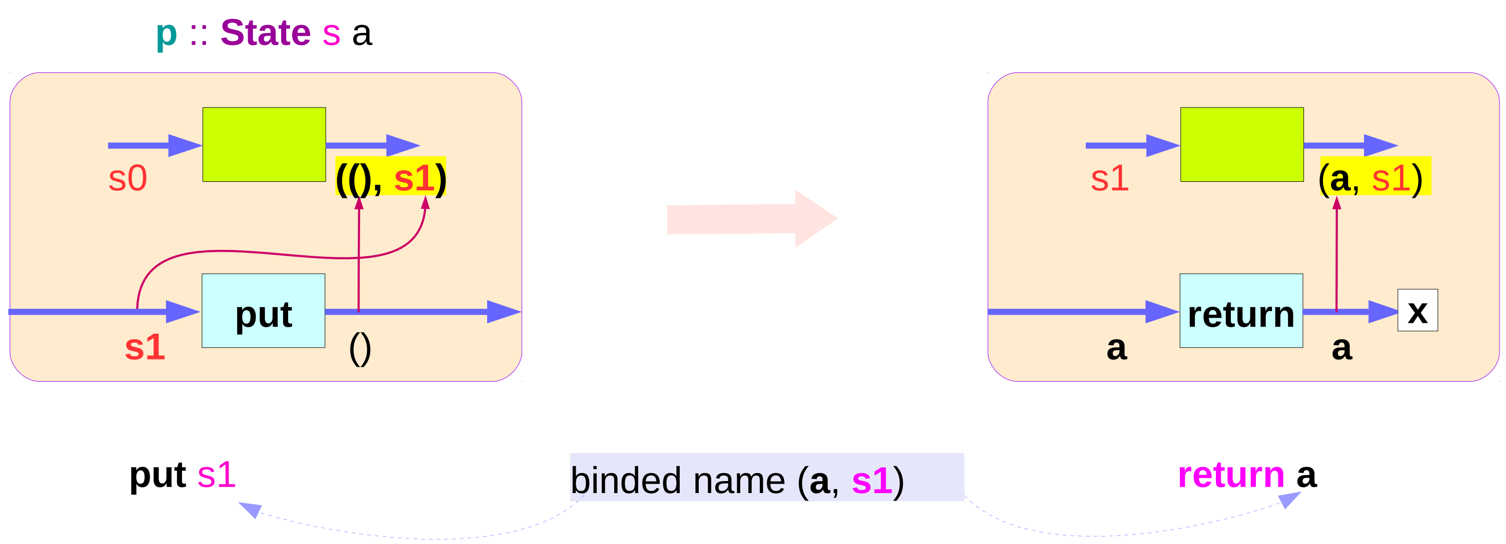
```
a <- p
```



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

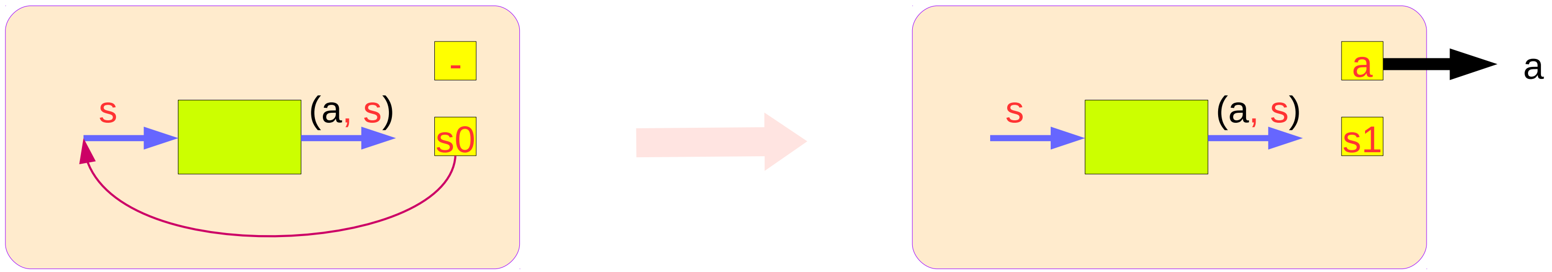
Redundant computation examples (3)

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~~

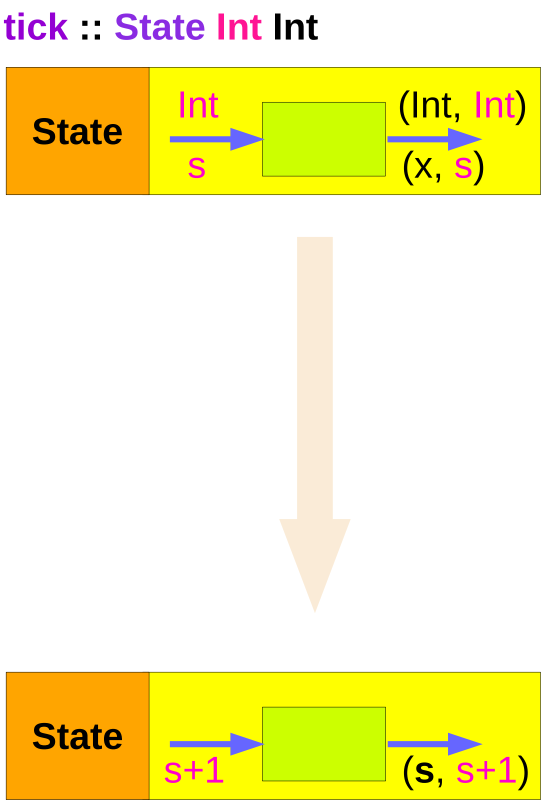
Add one to the given number using the state monad:

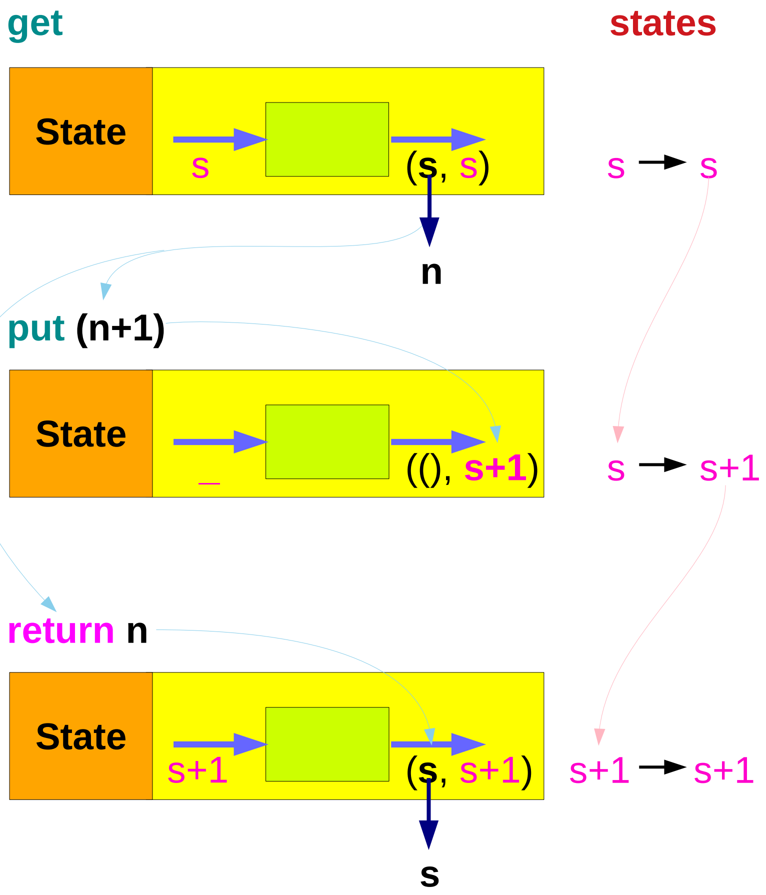
A contrived addition example. Works only with positive numbers:

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
```

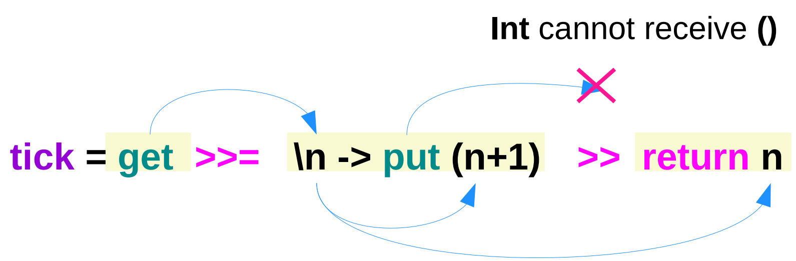


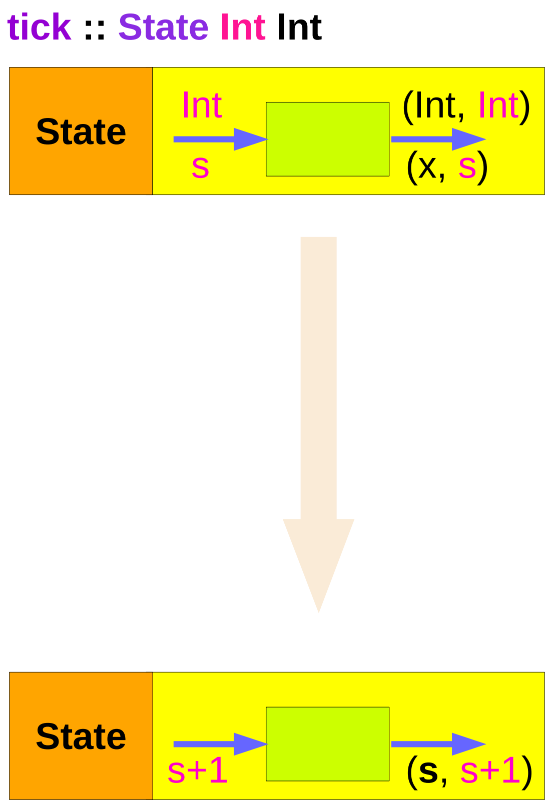


https://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-State-Lazy.html

Counter Example – tick without **do**

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

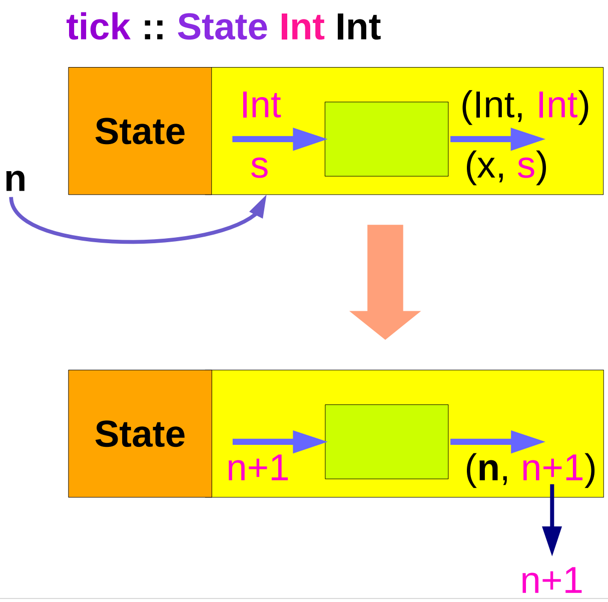




https://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-State-Lazy.html

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]
```

(3,4) → (4, 5)

(3,4) → (4,5) → (5,6)

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

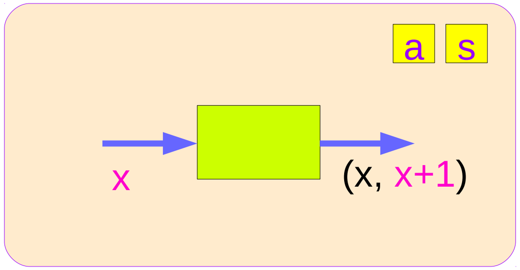
```
collectUntil f comp = do
    st <- get                           -- Get the current state
    if f st  then return [ ]            -- If it satisfies predicate, return
             else do                    -- Otherwise...
                x  <- comp              -- Perform the computation s
                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
f  :: s -> Bool
x  :: a
xs  :: [a]
```

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

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

simpleState :: State s a



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

return the same monadic type value

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)
```

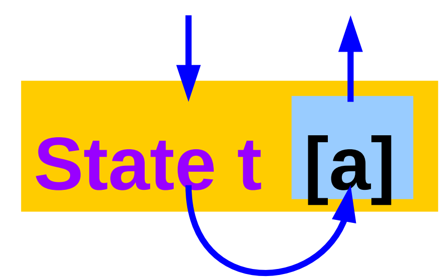
```
return :: State t [a] type
collectUntil f comp   :: State t [a]  type
xs <- collectUntil f comp -- stateful computation
xs :: [a]
```

```
*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]

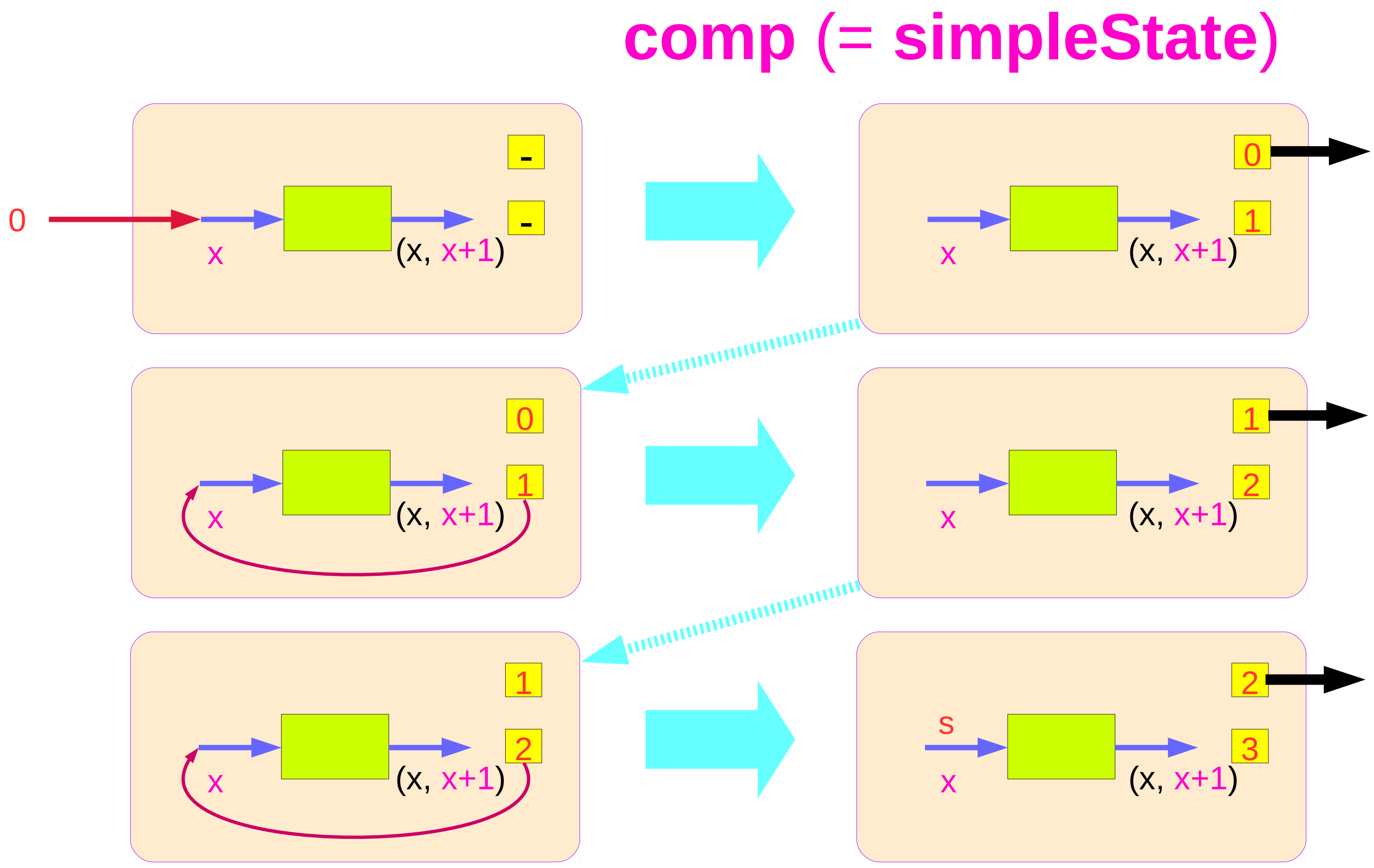
(>10) :: (t -> Bool)

simpleState :: State t a

```
*Main> evalState (collectUntil (>10) simpleState) 0
simpleState = state (\x -> (x,x+1))
```

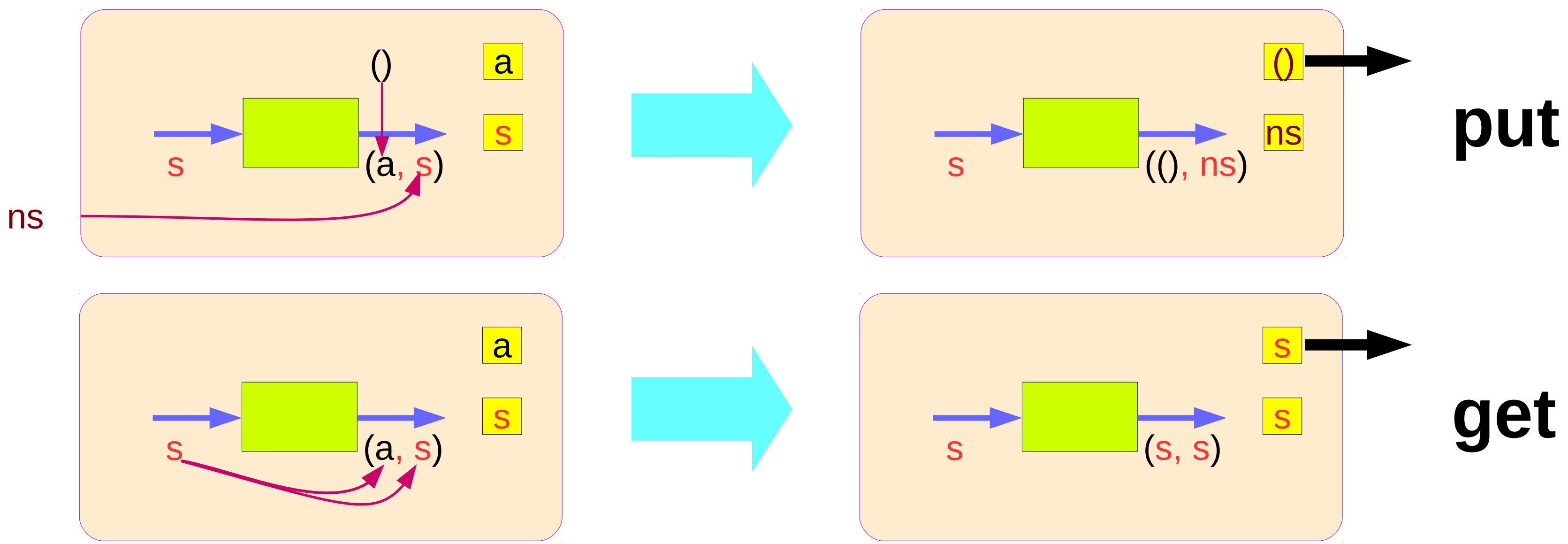
https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell

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
```

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

a <- comp

b <- get

return []

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

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

a <- comp

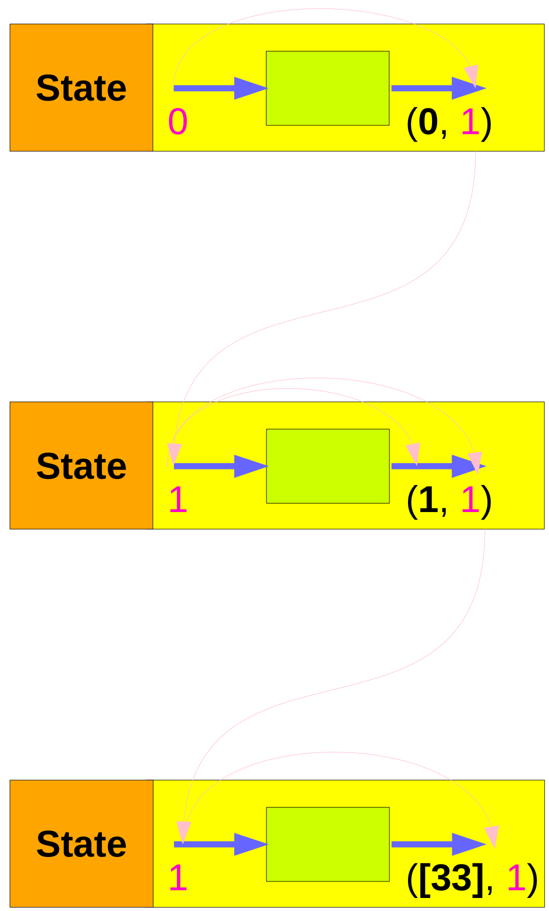
a=0

b <- get

b=1

return [33]

[33]

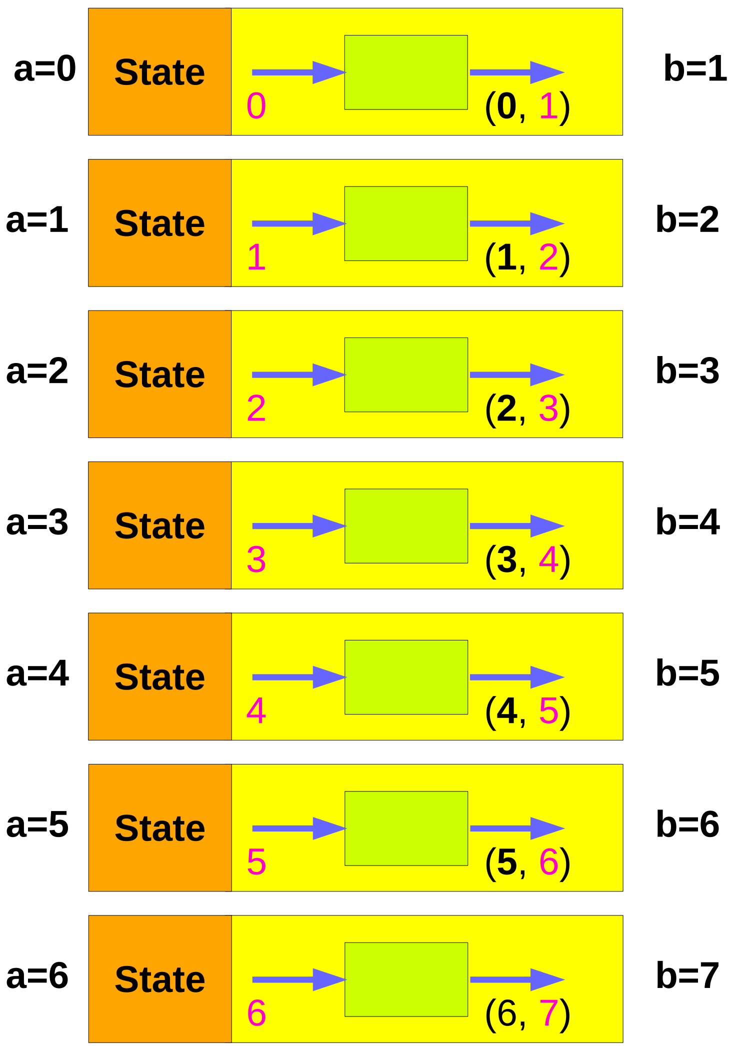


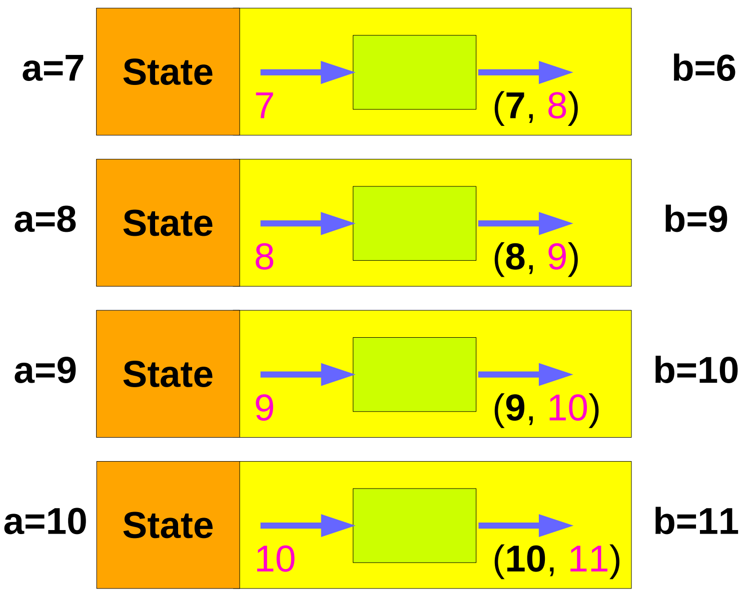
state (\x -> (x,x+1))

```
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**

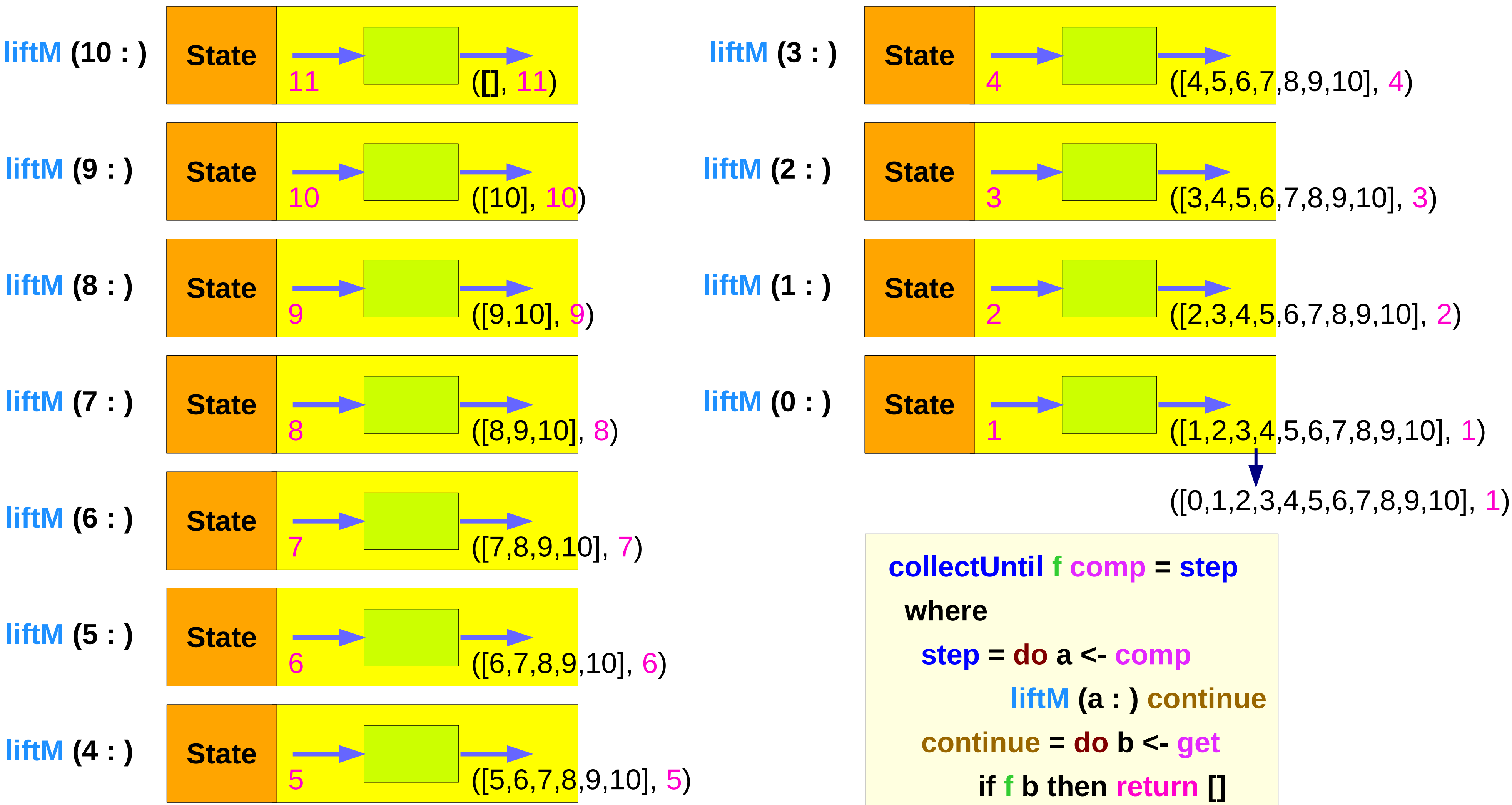





```
collectUntil f comp = step
  where
    step = do a <- comp
              liftM (a : ) continue
    continue = do b <- get
                  if f b then return []
                         else step
```

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
```

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

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]

xs :: [a]

x : xs :: [a]

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

Example of collecting – source codes

```
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]
```

```
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