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

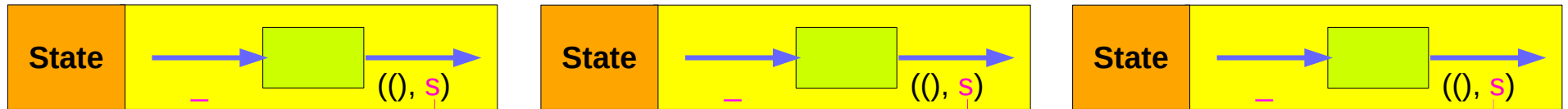https://wiki.haskell.org/Haskell_in_5_steps
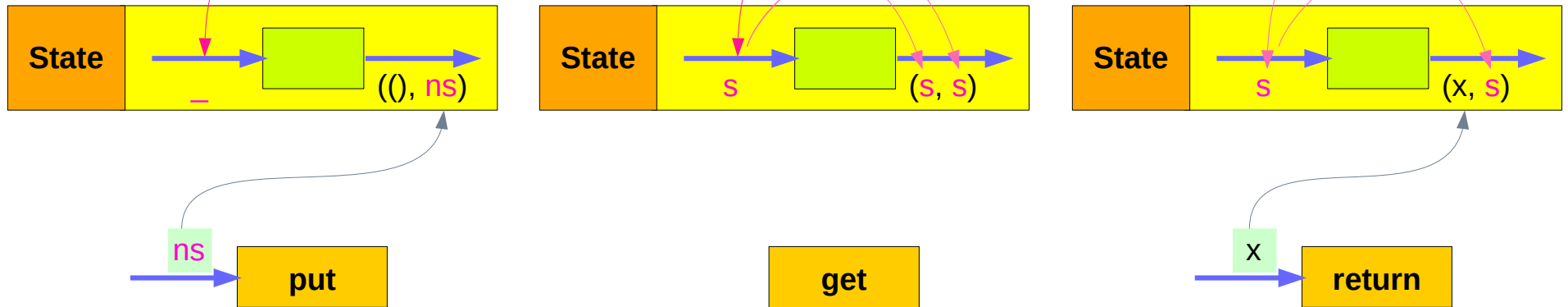
put, **get**, **return** methods summary

initial monadic value

return monadic value

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

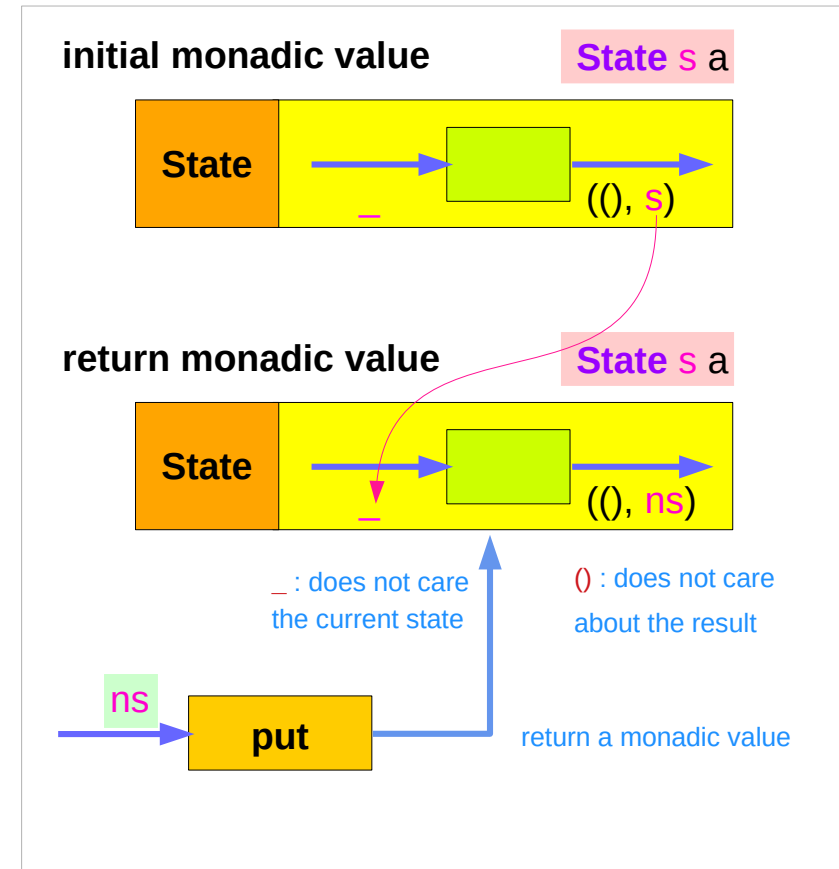# **put** changes the current state

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**.

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

initial monadic value   **State** s a

State   ((), s)
          _

return monadic value   **State** s a

State   ((), ns)
          _

_ : does not care   () : does not care
the current state   about the result

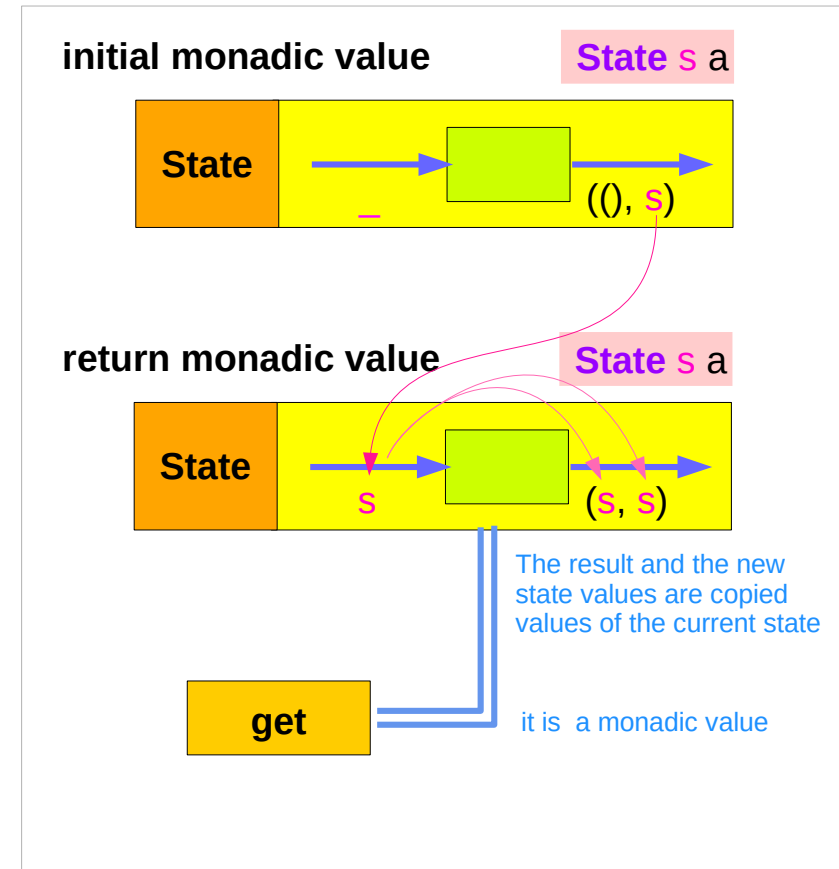ns → **put**   return a monadic value

get gives the current state

get :: **State** s s

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

get <u>generates</u> a **state processor**

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

- the state will remain <u>unchanged</u>
- a <u>copy</u> of the state will be made available
  through the result returned

initial monadic value   **State** s a

return monadic value   **State** s a

The result and the new state values are copied values of the current state

it is a monadic value

return changes the result value

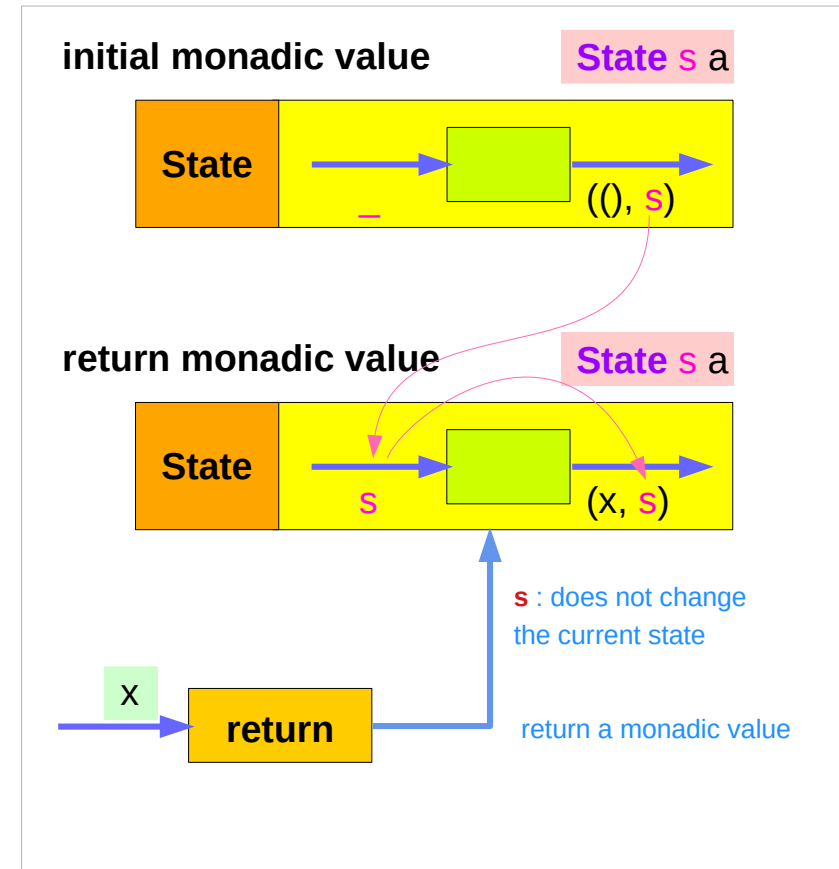**return** :: a -> **State** s a

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

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

results in a **state processor** function

    which <u>takes</u> a state (s) and

    <u>returns</u> it <u>unchanged</u> (s),

    together <u>with</u> the value x

finally, the function is <u>wrapped</u> up by **state.**

initial monadic value   **State** s a

State   ((), s)

return monadic value   **State** s a

State   s   (x, s)

s : does not change the current state

x   **return**   return a monadic value

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

put returns a monadic value via **state**

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

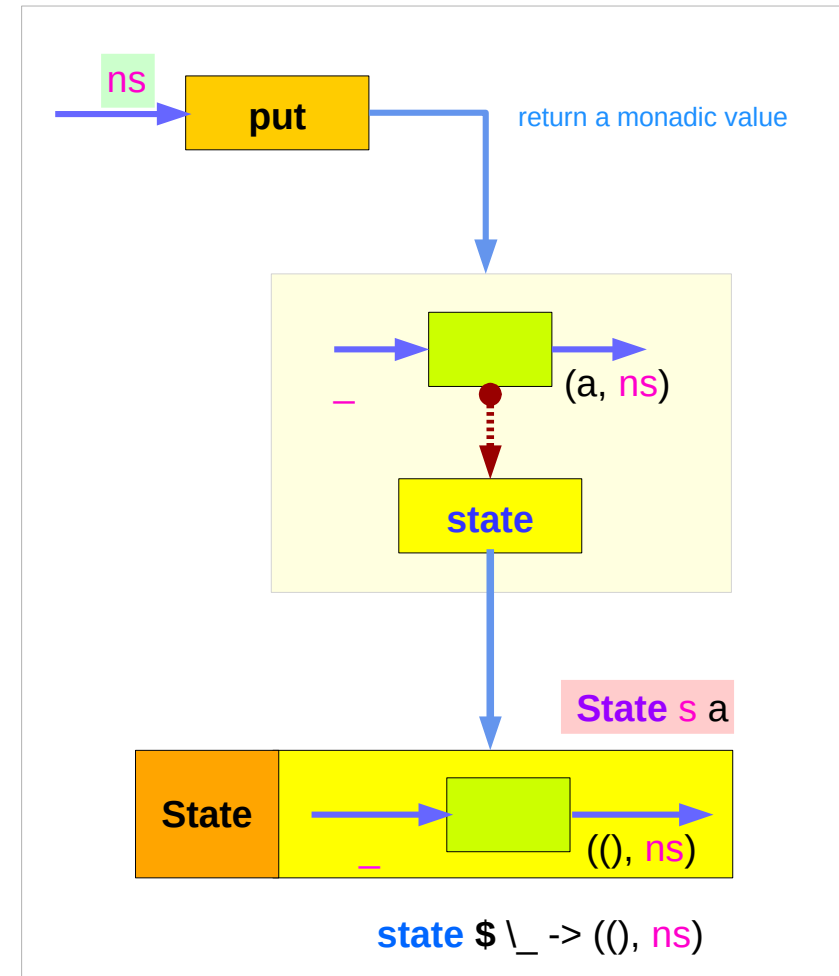**put** s **:: State** s a

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

-- setting a state to ns
-- regardless of the old state
-- setting the result to ()

ns

put   return a monadic value

_   (a, ns)

state

State s a

State   _   ((), ns)

state $ _ -> ((), ns)

https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State
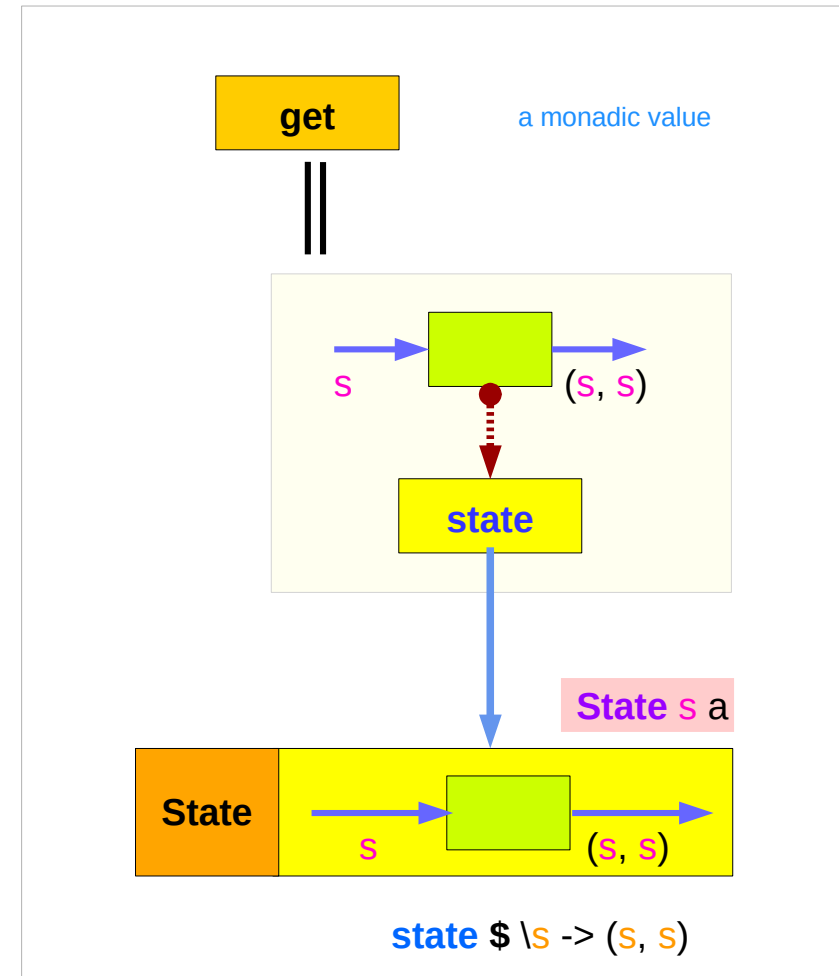
get is a monadic value via **state**

get :: State s s

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

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

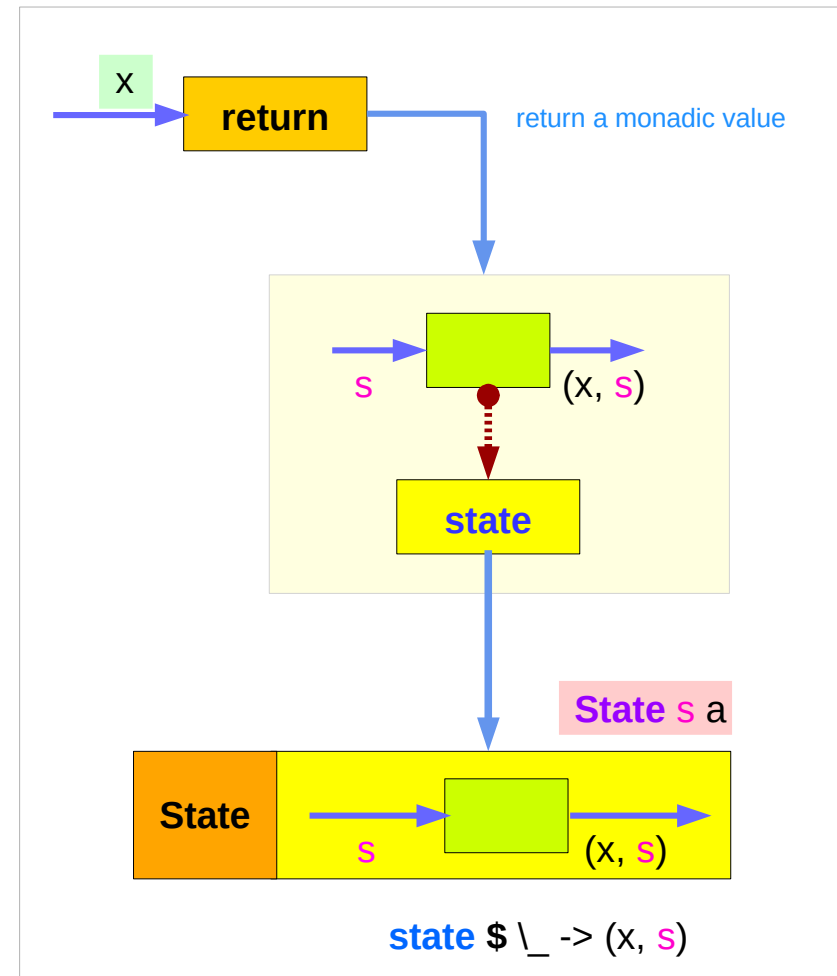# **return** returns a monadic value via **state**

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

state $ _ -> (x, s)

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

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

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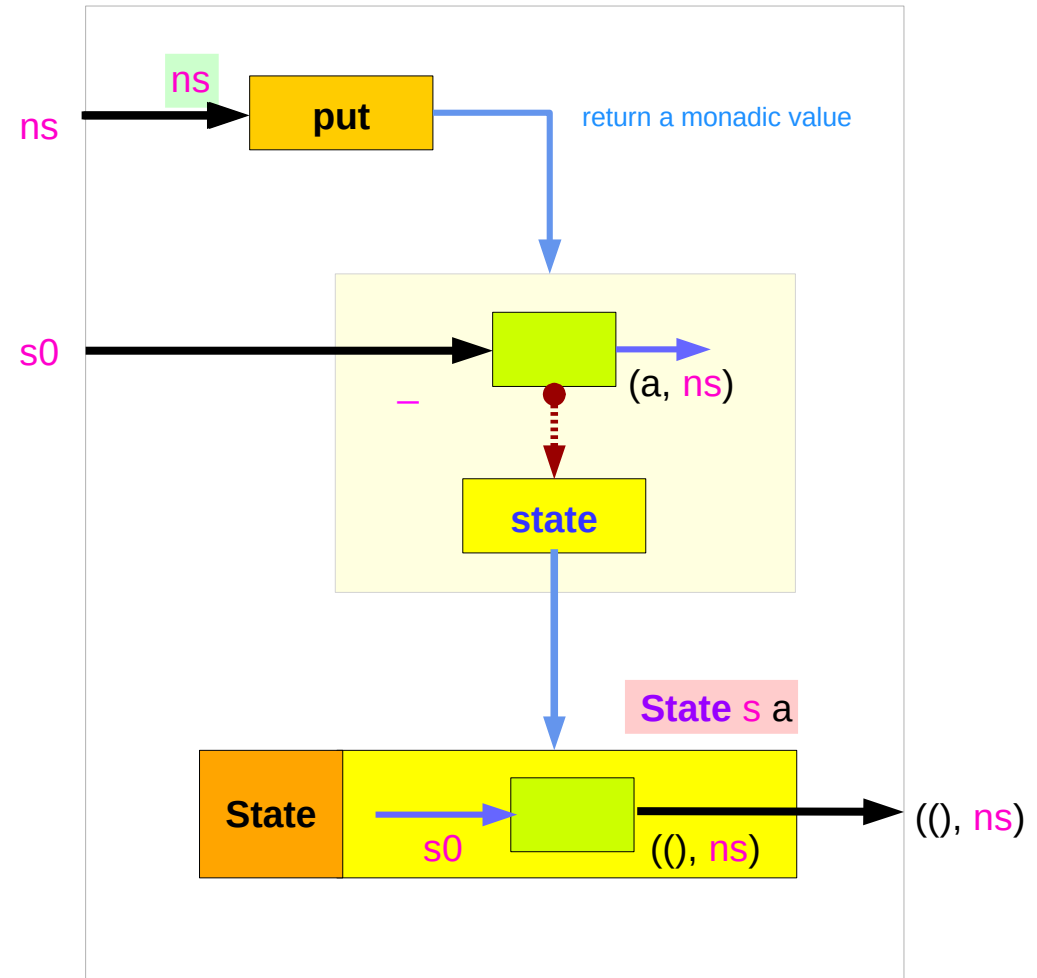
put s **:: State** s a

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**

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**

get

a monadic value

s0

s

(s, s)

state

State s a

State

s

(s, s)

(s0, s0)
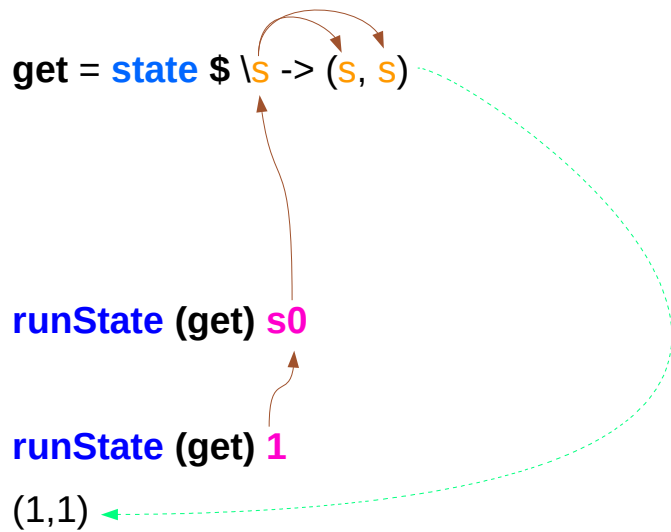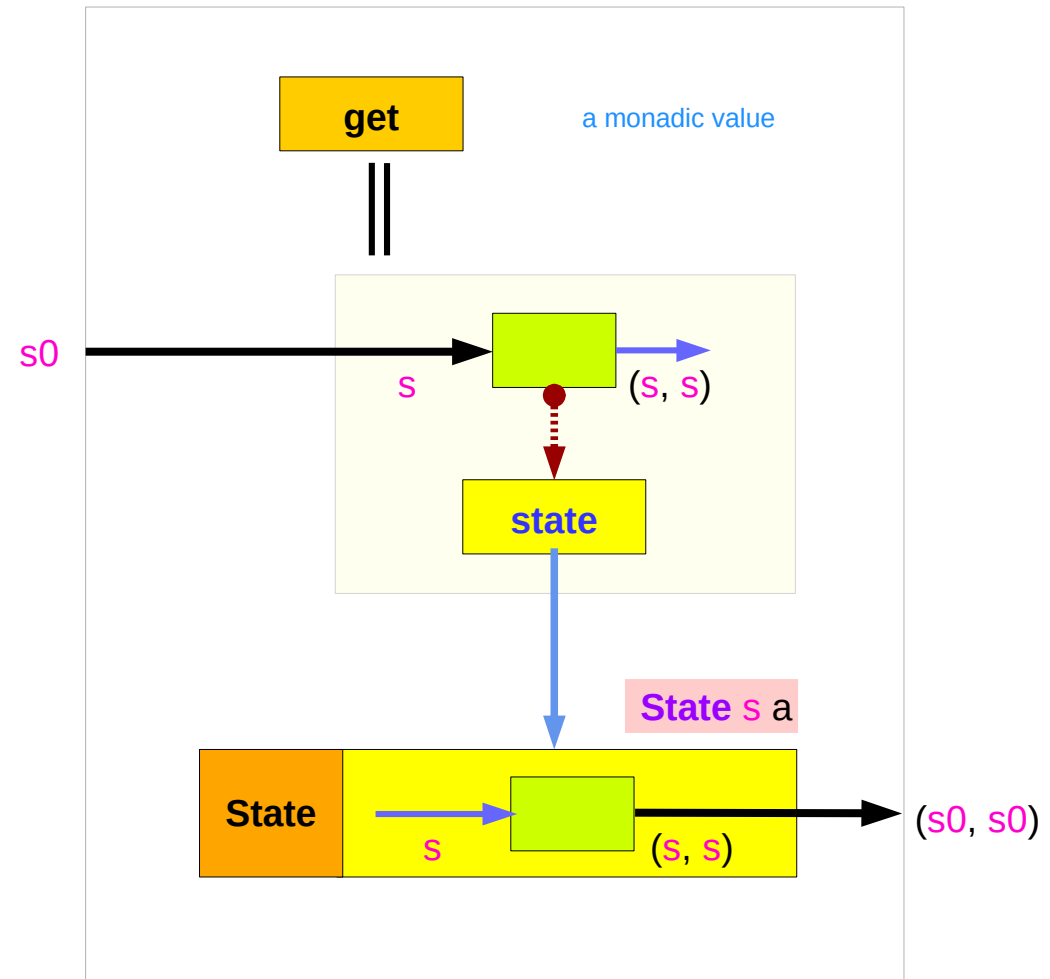
https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

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**
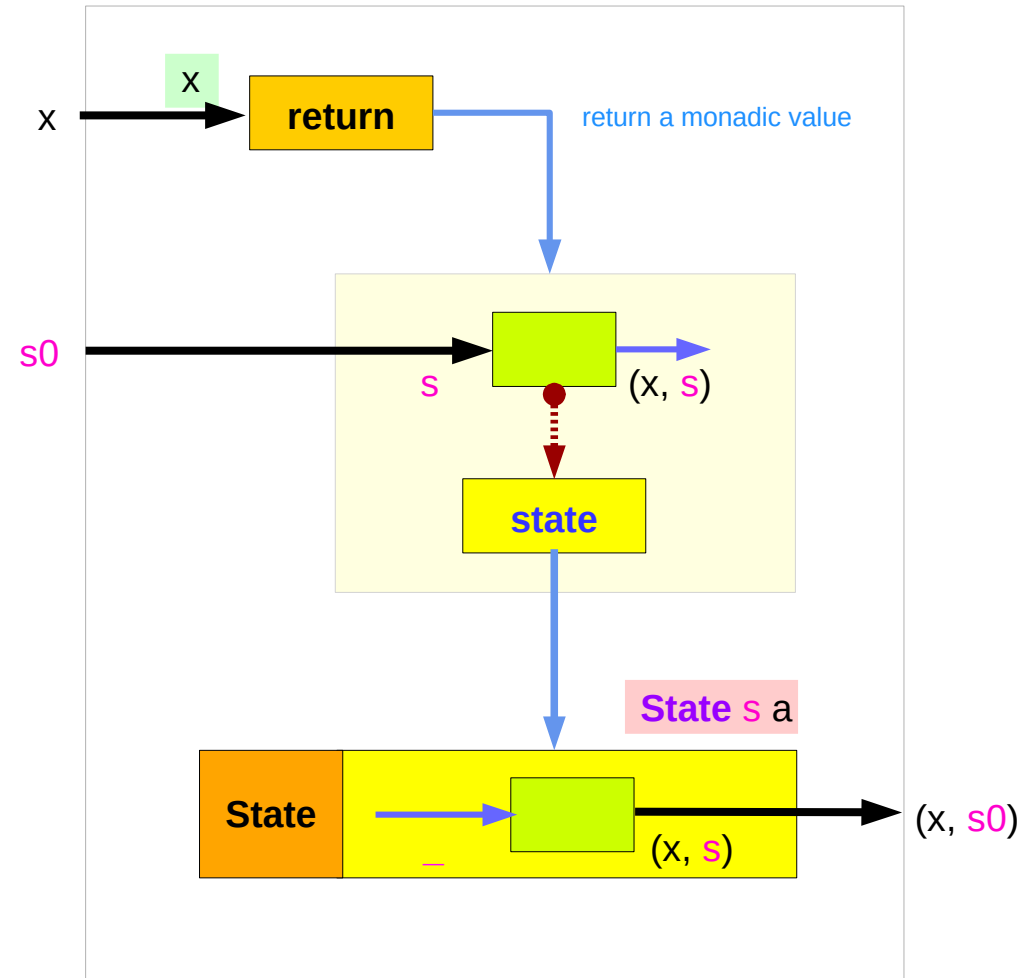
or by the initial **monadic value**

x

return

return a monadic value

s0

s

(x, s)

state

State s a

State

_

(x, s)

(x, s0)

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

```
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)

Initial mx :: State s a

Final mx :: State s a

get,
put,
return,
…

x s

s

x1 s1

Input Phase – internal

Output Phase

Initial mx :: State s a

Final mx :: State s a

get,
put,
return,
…

s0

x s

s0

x1 s1

runState mx s0

Input Phase – external

Output Phase
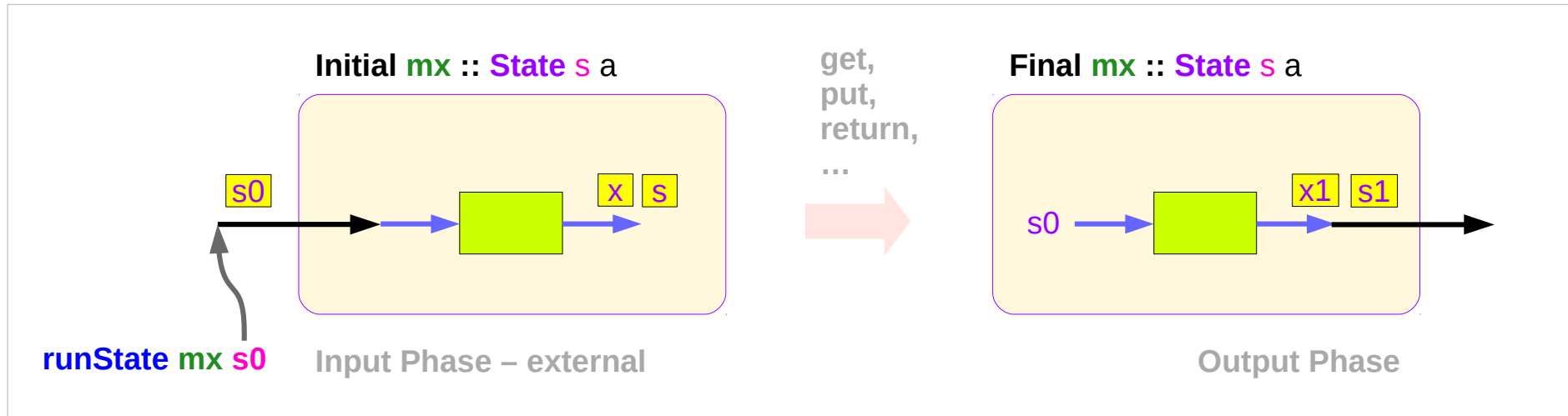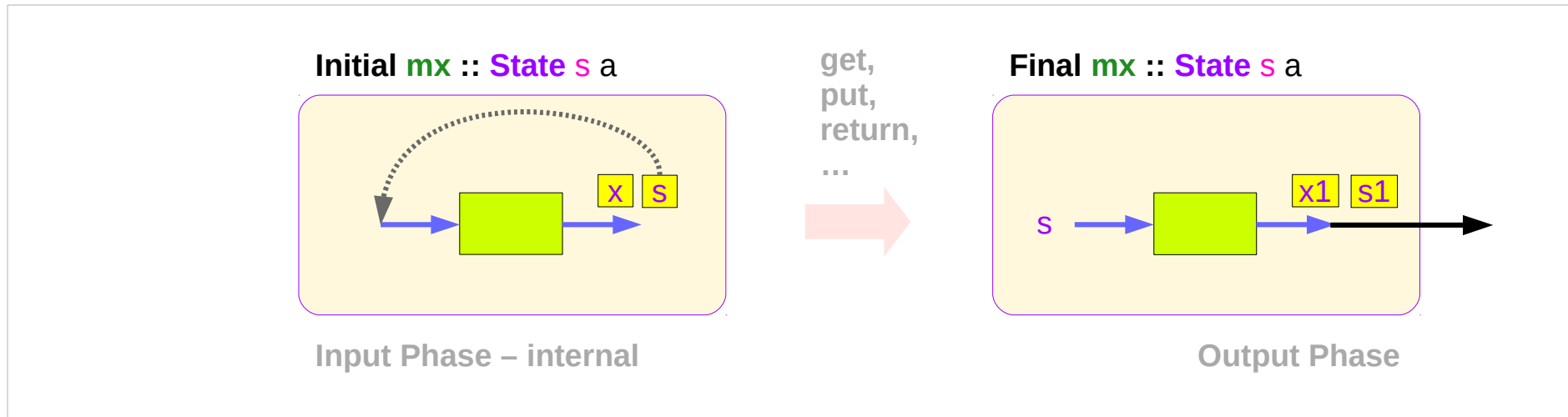
Executing the state processor – **put**

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

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

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

s0
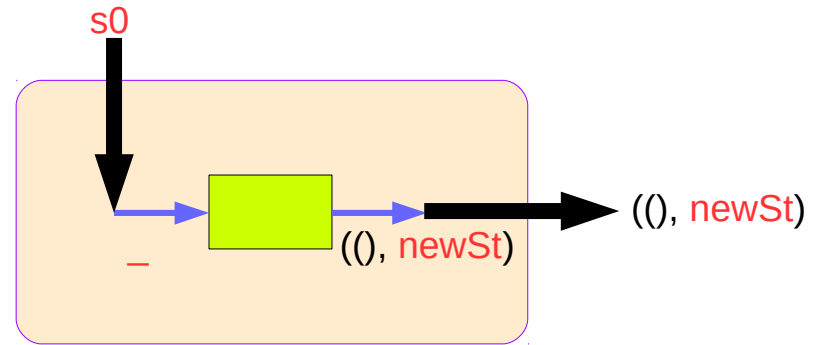
applying the function

---

runState (**put** 5) 1

    ((),5)

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

Executing the state processor – **get**

get :: **State** s s

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

runState (**get**) s0   ➡   (s0, s0)

s0   **p** :: **State** s a

st   (st, st)   (s0, s0)
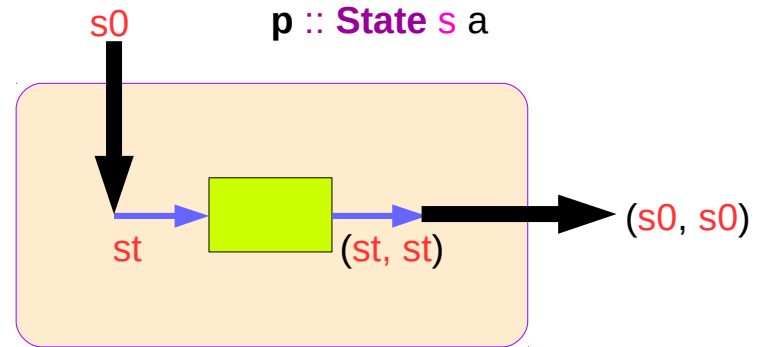
applying the function

runState get 1

(1,1)

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

Executing the state processor – **return**

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

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

runState (**return** x0) s0 ➡ (x, s)
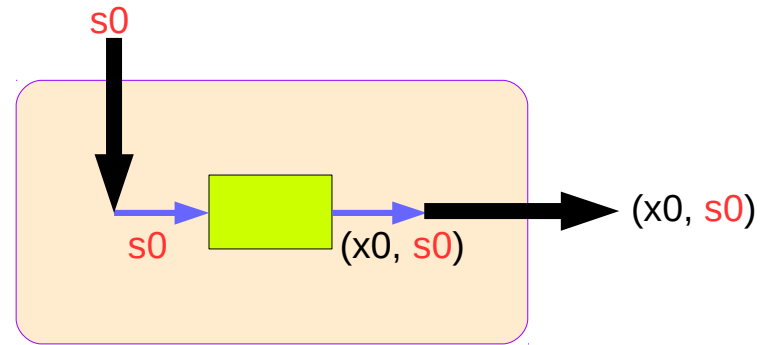
applying the function

runState **return** 3 1

(3,1)

set the new result value and leave the state unchanged.

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
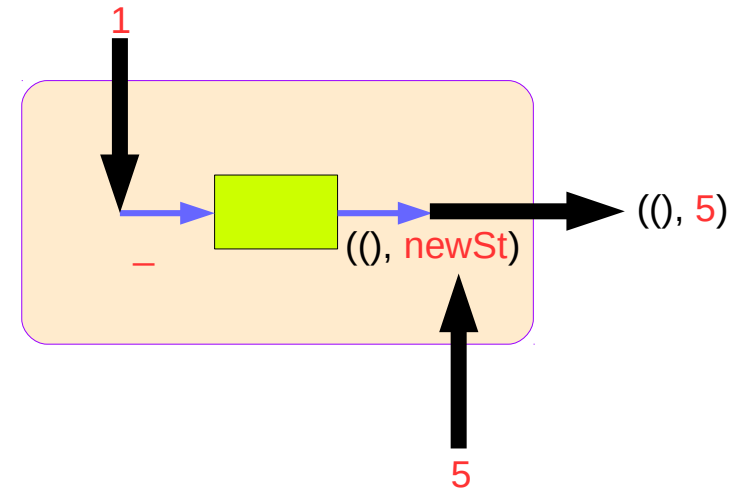
https://wiki.haskell.org/State_Monad

State Monad Examples – **get**

runState get 1

  (1,1)

set the result value to the state and leave the state unchanged.
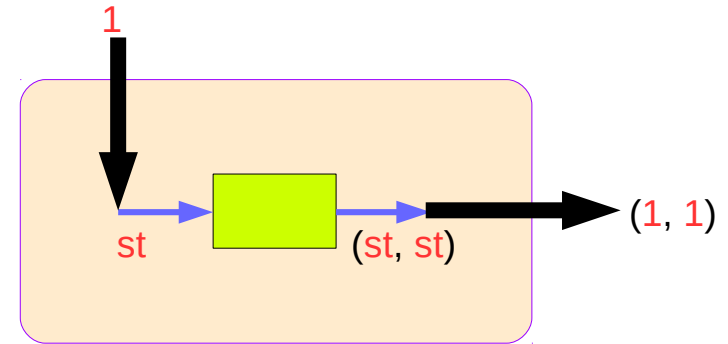
   get :: **State** Int Int

   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.

1
st   (x, st)   (3, 1)
3
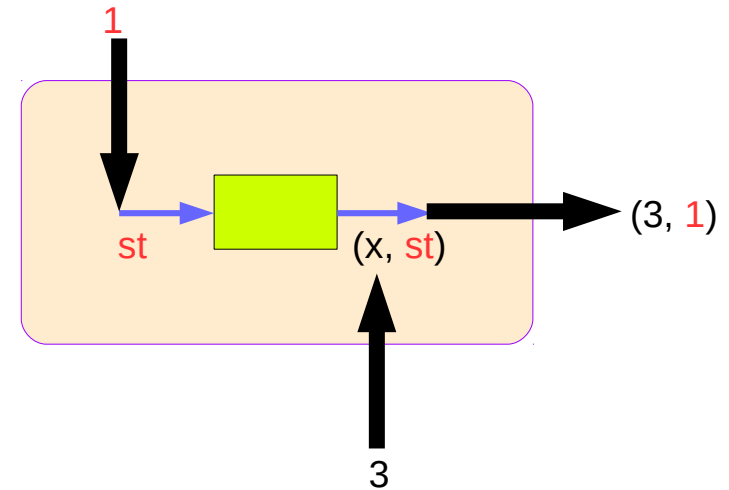
return :: Int -> **State** Int Int

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

x | s

s ➡ [ ] (a, s)

---

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

a **function** <u>from</u> initial state s

<u>to</u> final value a and final state s: (a,s).

these are usually wrapped,

but shown here unwrapped for simplicity.

s ➡ [ ] ➡ (a, s)

state

State s a

State | s ➡ [ ] (a, s)

(**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
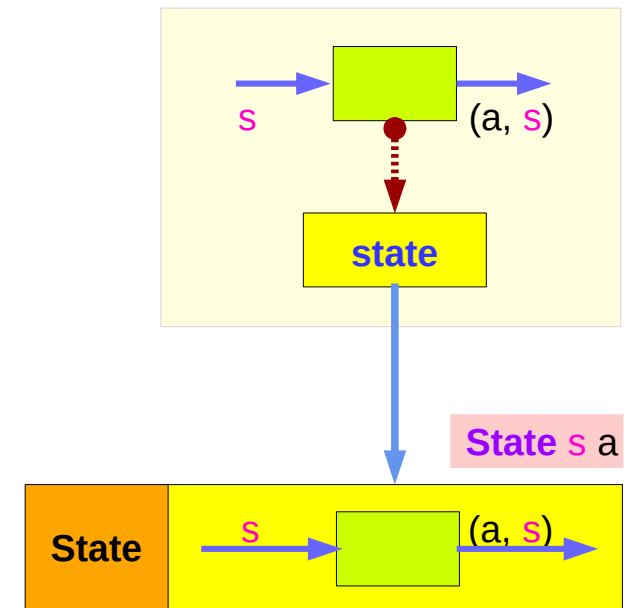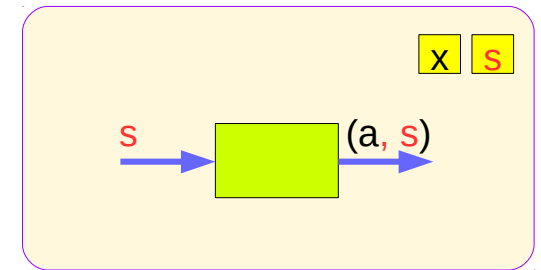
State Monad Examples – **return**, **get**, and **put**

Return leaves the <u>state</u> <u>unchanged</u> and <u>sets</u> the <u>result</u>:

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

runState (**return** 5) 1 ➡ (5,1)

Get leaves <u>state</u> <u>unchanged</u> and <u>sets</u> the <u>result</u> to the <u>state</u>:

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

runState **get** 1 ➡ (1,1)

Put <u>sets</u> the <u>result</u> to () and <u>sets</u> the <u>state</u>:

-- 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)

- <u>inside</u> a monad instance

- <u>unwrapped</u> implementations

  of **return**, **get**, and **put**

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

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

- <u>inside</u> a monad instance

- <u>unwrapped</u> 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

A Stateful Computation

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

    takes some **state** and

    returns a **value** along with some **new state**.
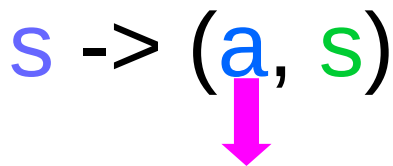
That function would have the following type:

$$s \to (a, s)$$

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

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

$$s \to (a, s)$$

$$s \to (a, s)$$
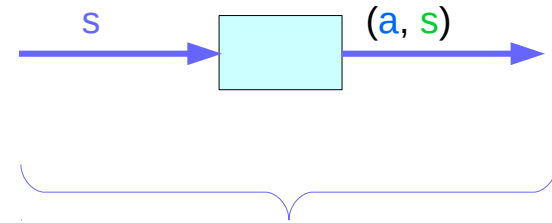
a <u>function</u> is an executable <u>data</u>

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

action, execution, result

$$s \to (a, s)$$

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

Stateful Computations inside the State Monad

inside a monad,

when **sc** is a **s**tateful **c**omputation

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

can be assigned to **x**
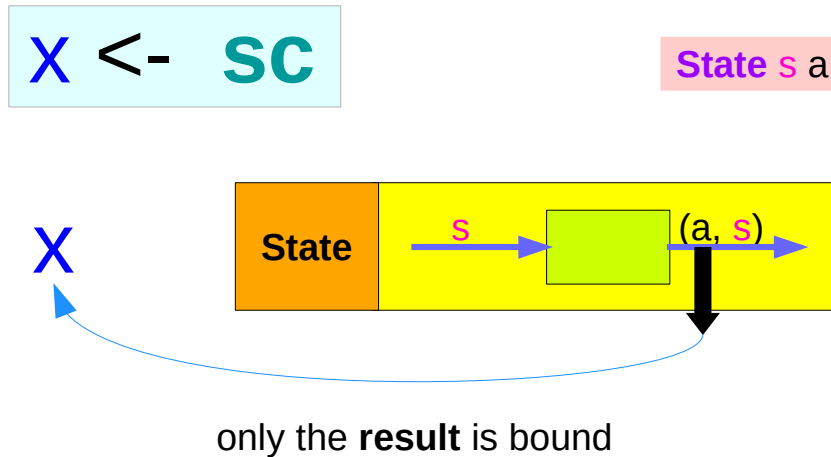
x <- **sc**

sc :: State s a

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

x :: State s a

$$s \rightarrow (a, s)$$

the **result** type

X <- SC

State s a

X

State   s   (a, s)

only the **result** is bound

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

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

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

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

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell
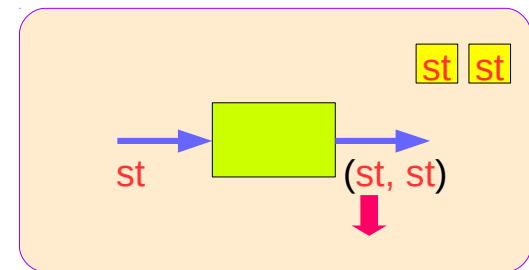
put and **get** inside State Monad

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

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

> **put ::** s **-> ()**
>
> **the result type :: ()**

-- a way of thinking

stateful computation of **put**

---
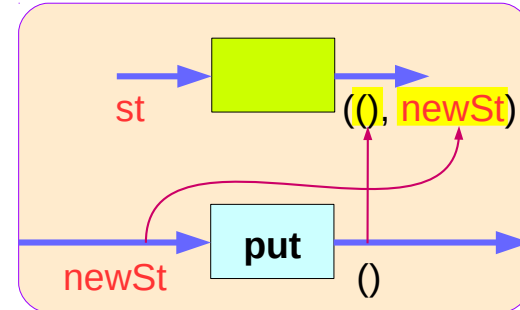
get :: State s s

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

> **get ::** s
>
> **the result type :: s**

-- a way of thinking

-- no such a function

stateful computation of **get**
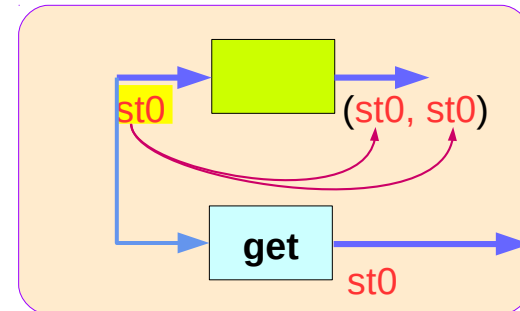
https://en.wikibooks.org/wiki/Haskell/Understanding_monads/State

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

let (a,s1) = **runState p** s0   -- pass the state to **p**, get new state

put s1   -- save new state

return a

||

a <- **p**   -- the stateful computation **p** updates the state to s1

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

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

---

stateful computation **p**

runState p s0

State s a   s   →   **runState**   →   (a, s)

p   s0

(a,   s1)

(**a**,   **s1**)

for this binding,
another **monad p**
is executed inside **monad p**

s0   →   (s0, s0)

get   s0

s0

the current monad <u>instance</u>

p :: **State** s a

s0   →   ((), **s1**)

s1   **put**   ()

https://stackoverflow.com/questions/11250328/working-with-the-state-monad-in-haskell
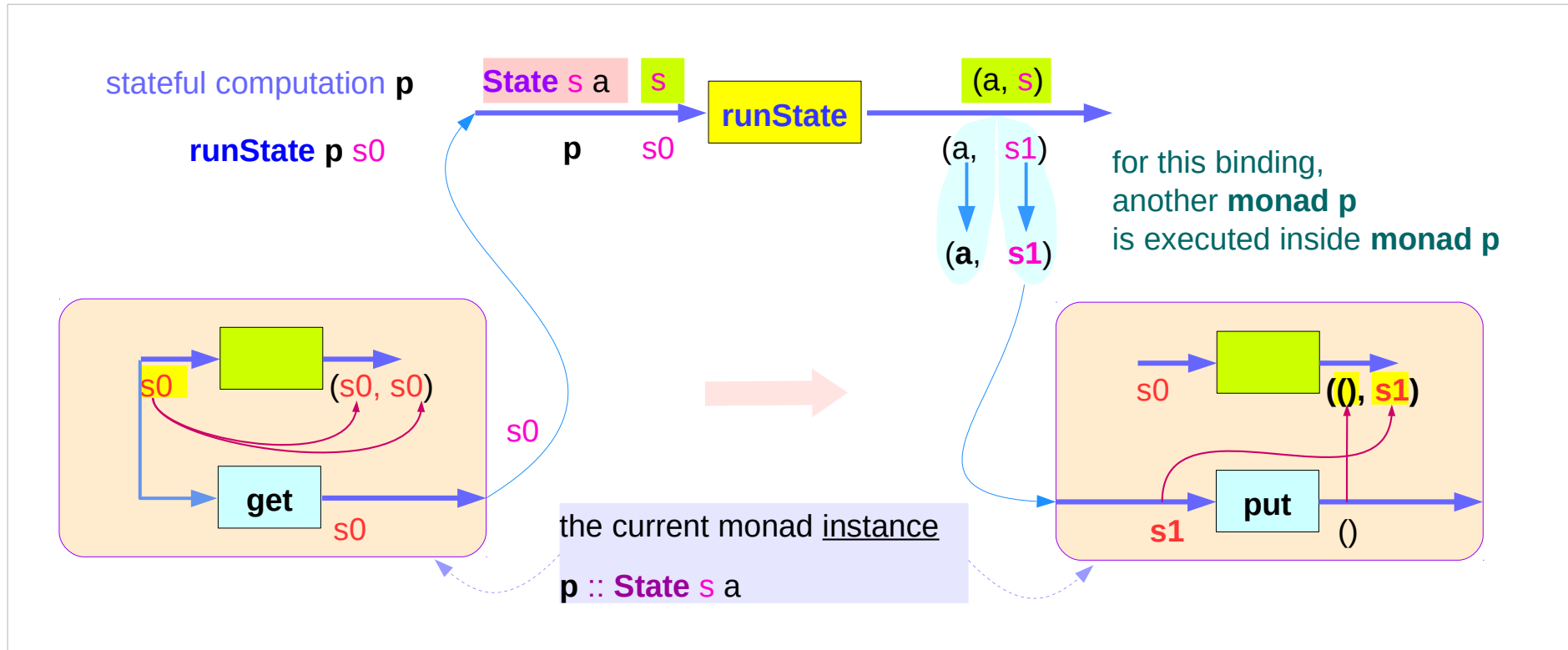
Redundant computation examples (2)

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

p :: State s a

put s1   binded name (a, s1)   return a
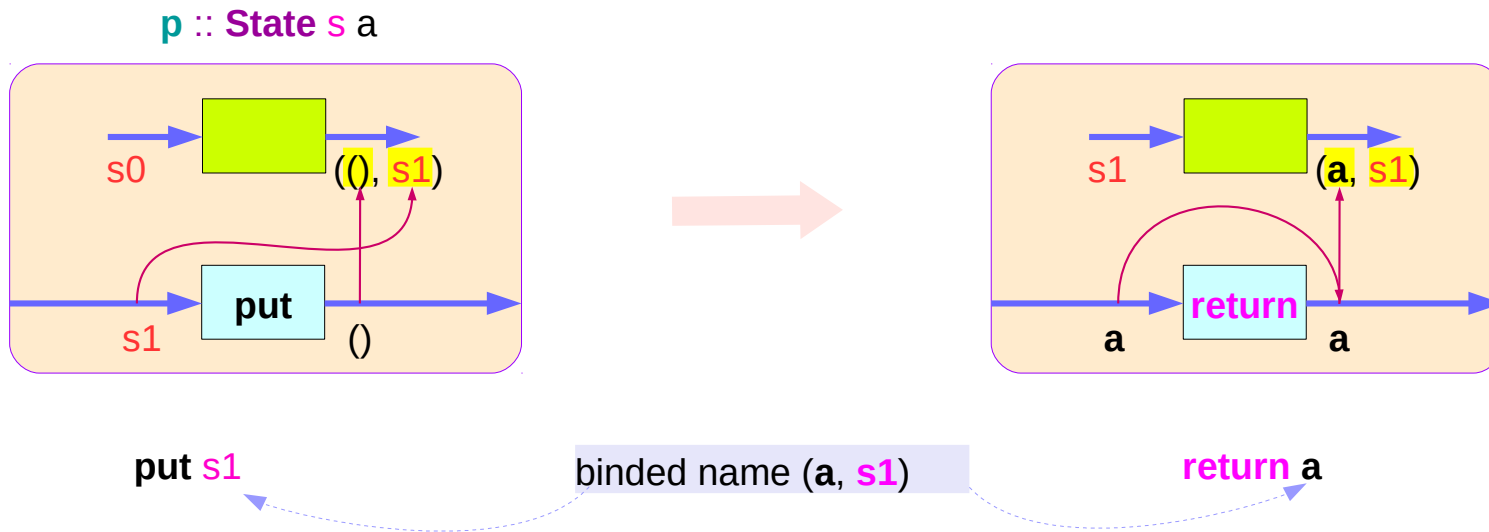
Redundant computation examples (3)

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
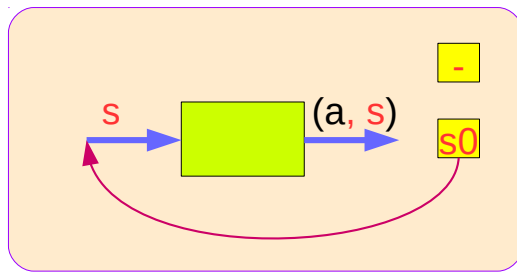
stateful computation **p**
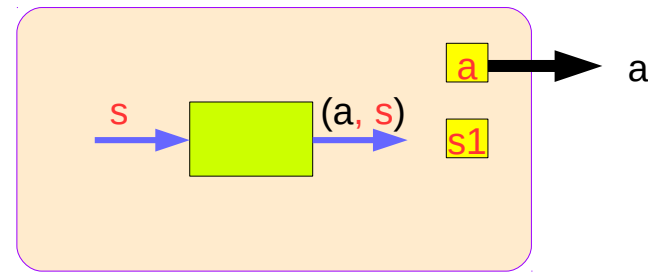
return the result a

runState p s0 ⟹ (a, s1)

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

Counter Example

```haskell
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:

Counter Example – tick

tick :: State Int Int

tick = do n <- get

      put (n+1)

      execState n

tick :: State Int Int

State	Int → s	(Int, Int) (x, s)

State	s+1	(s, s+1)

get   **states**

State	s	(s, s)

n   s → s

put (n+1)

State	_	((), **n+1**)

s → n+1

return n

State	n+1	(n, n+1)

n   n+1 → n+1
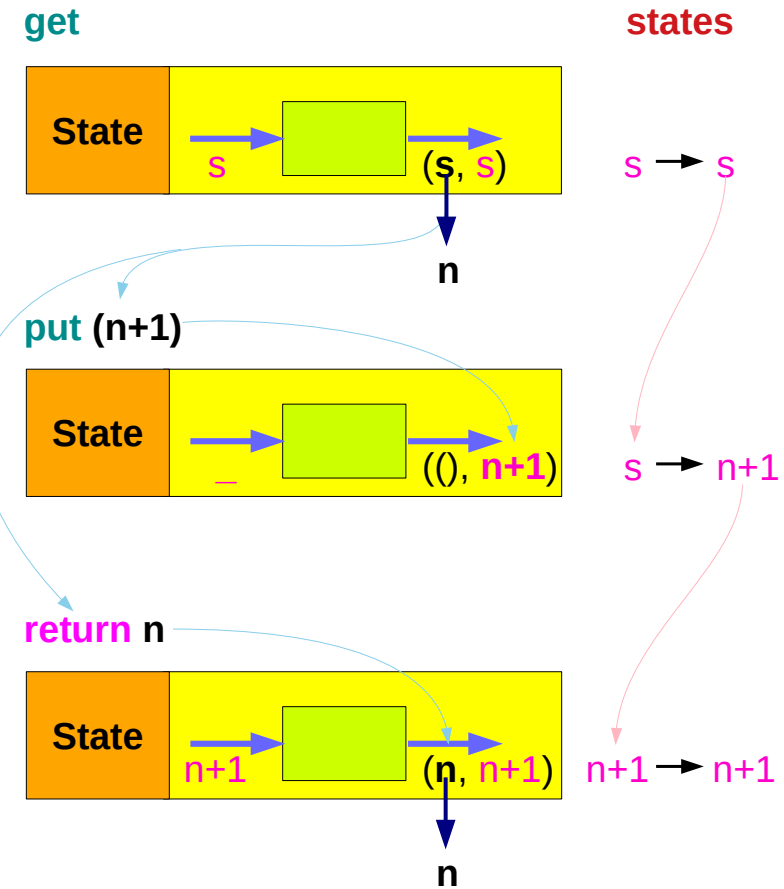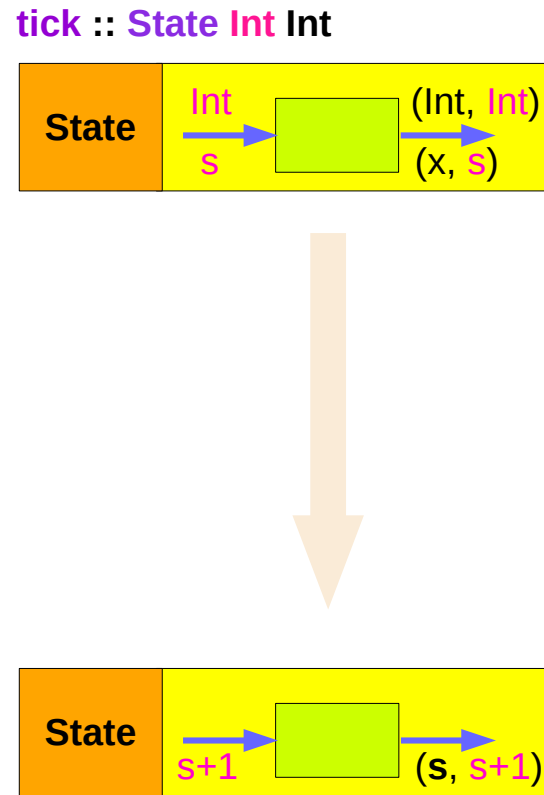
Counter Example – tick without **do**

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

| State | Int
s | | (Int, Int)
(x, s) |

| State | s+1 | | (s, s+1) |

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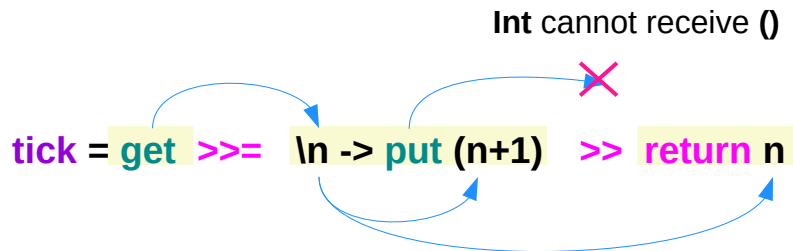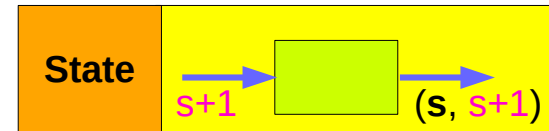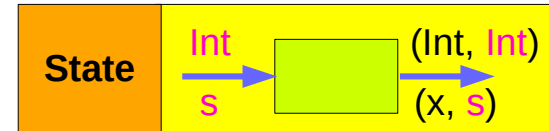
Counter Example – incrementing

tick :: State Int Int

tick = do n <- get

        put (n+1)

        return n

plusOne :: Int -> Int

plusOne n = execState tick n

tick :: State Int Int

https://hackage.haskell.org/package/mtl-2.2.2/docs/Control-Monad-State-Lazy.html
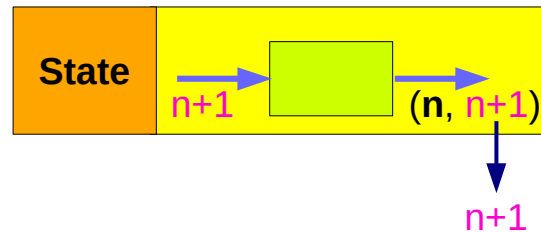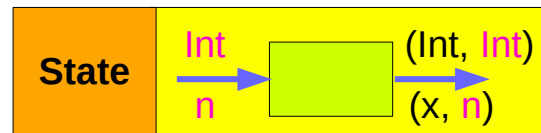
Counter Example – using sequence

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**

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))

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

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

simpleState :: State s a
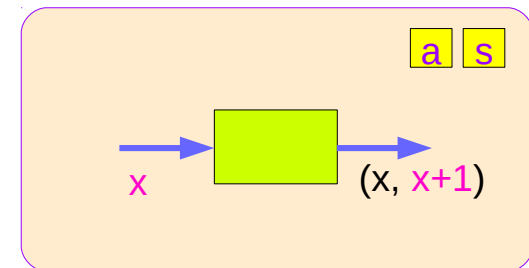
Example of collecting – stateful computations

```
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 <u>within</u> <u>the</u> <u>same</u> <u>monad</u>

- enables **branching** <u>within</u> <u>one</u> <u>do</u> <u>block</u>,

as long as <u>both branches</u> of the **if statement**

results in the <u>same monadic</u> type.

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))

$$t \rightarrow ([a], t)$$

the <u>result</u> type

State t [a]

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**
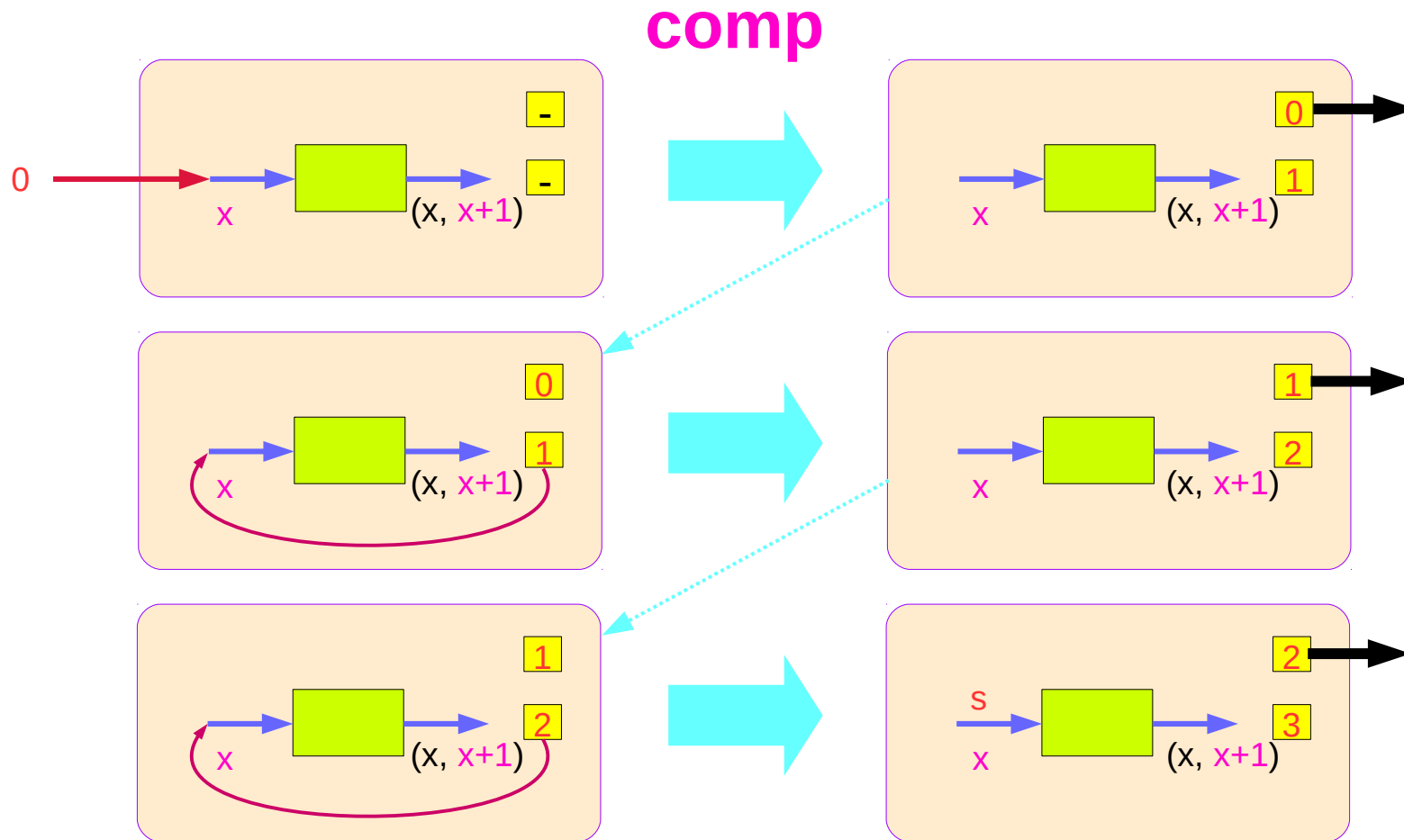
comp

Stateful Computations of **put** & **get**
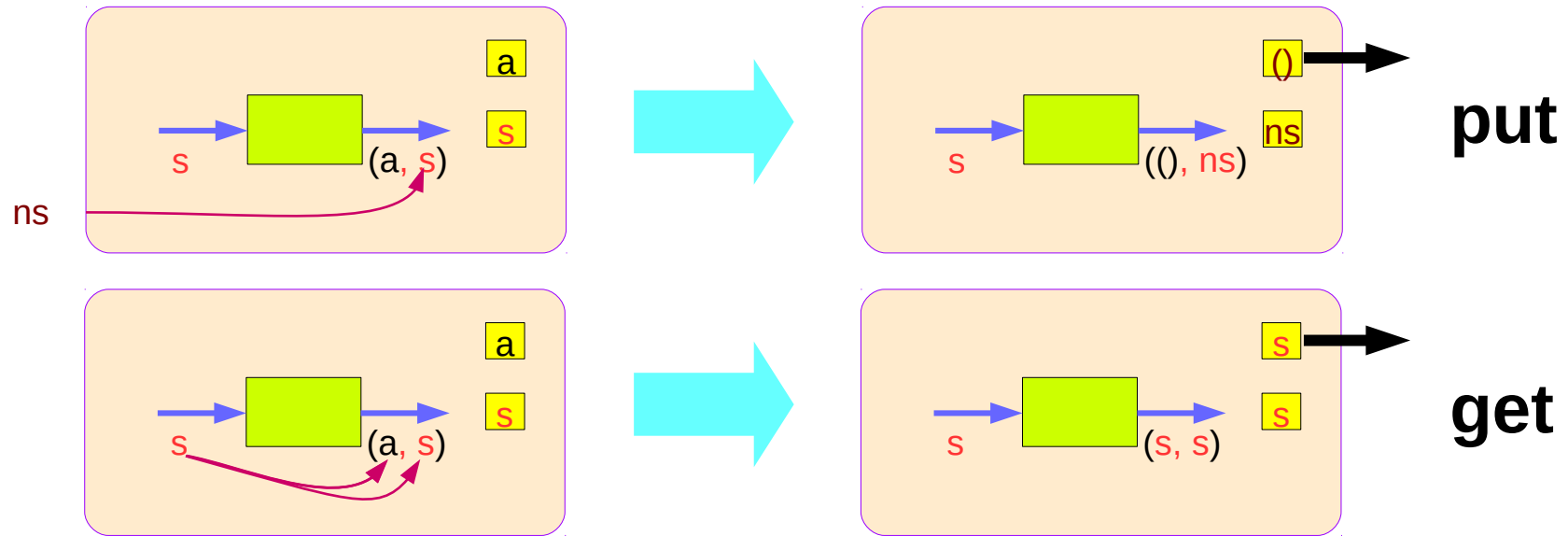
Another example of collecting returned values

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

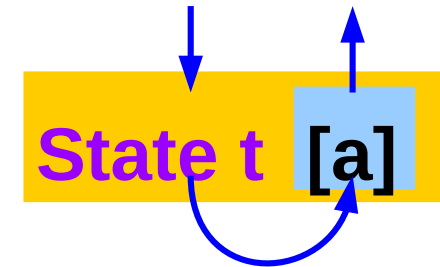
*Main> evalState (collectUntil (>10) simpleState) 0

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

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

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 []
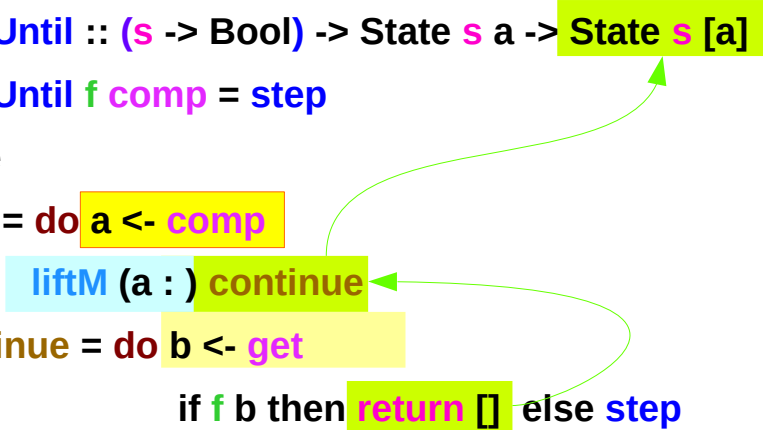
          else step

    -

    if f b then return [] else step

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

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]
```

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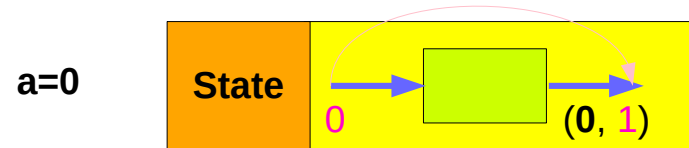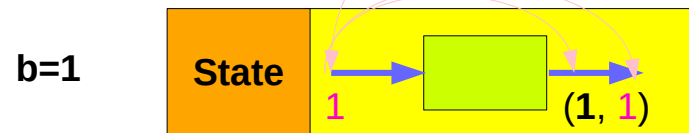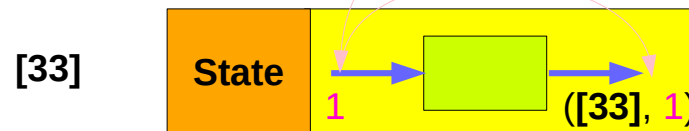
state (\x -> (x,x+1))

State | 0 | (**0**, 1)

b <- get b=1

State | 1 | (**1**, 1)

return [33] [33]

State | 1 | ([33], 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**

a=0 | State | 0 → (**0**, 1) | b=1
a=1 | State | 1 → (**1**, 2) | b=2
a=2 | State | 2 → (**2**, 3) | b=3
a=3 | State | 3 → (**3**, 4) | b=4
a=4 | State | 4 → (**4**, 5) | b=5
a=5 | State | 5 → (**5**, 6) | b=6
a=6 | State | 6 → (**6**, 7) | b=7

a=7 | State | 7 → (**7**, 8) | b=6
a=8 | State | 8 → (**8**, 9) | b=9
a=9 | State | 9 → (**9**, 10) | b=10
a=10 | State | 10 → (**10**, 11) | b=11

```
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**

liftM (10 :) | State | 11 → → ([], 11)

liftM (9 :) | State | 10 → → ([10], 10)

liftM (8 :) | State | 9 → → ([9,10], 9)

liftM (7 :) | State | 8 → → ([8,9,10], 8)

liftM (6 :) | State | 7 → → ([7,8,9,10], 7)

liftM (5 :) | State | 6 → → ([6,7,8,9,10], 6)

liftM (4 :) | State | 5 → → ([5,6,7,8,9,10], 5)

liftM (3 :) | State | 4 → → ([4,5,6,7,8,9,10], 4)

liftM (2 :) | State | 3 → → ([3,4,5,6,7,8,9,10], 3)

liftM (1 :) | State | 2 → → ([2,3,4,5,6,7,8,9,10], 2)

liftM (0 :) | State | 1 → → ([1,2,3,4,5,6,7,8,9,10], 1)

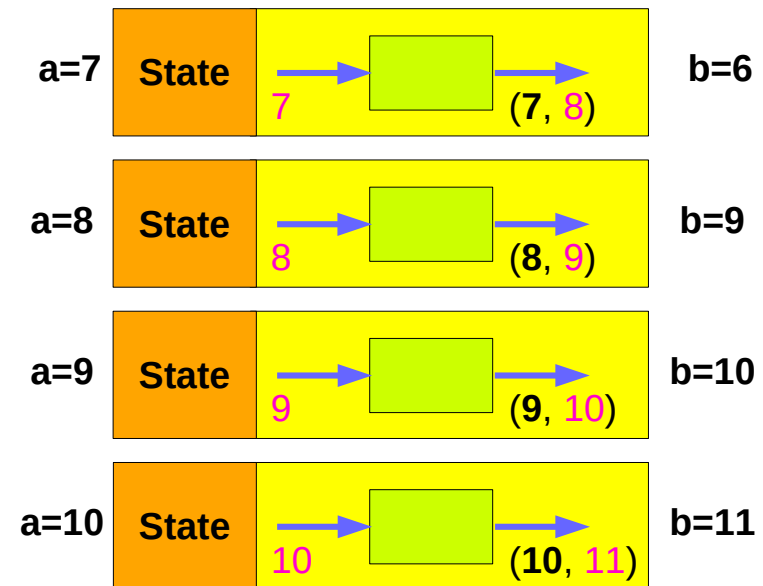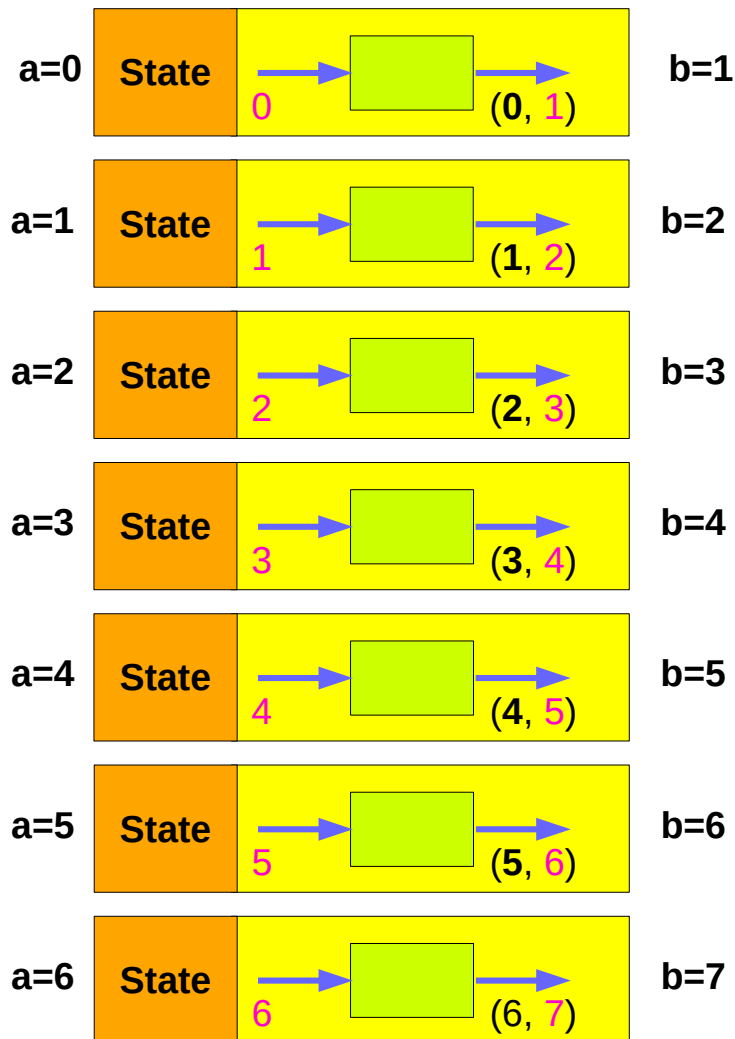([0,1,2,3,4,5,6,7,8,9,10], 1)
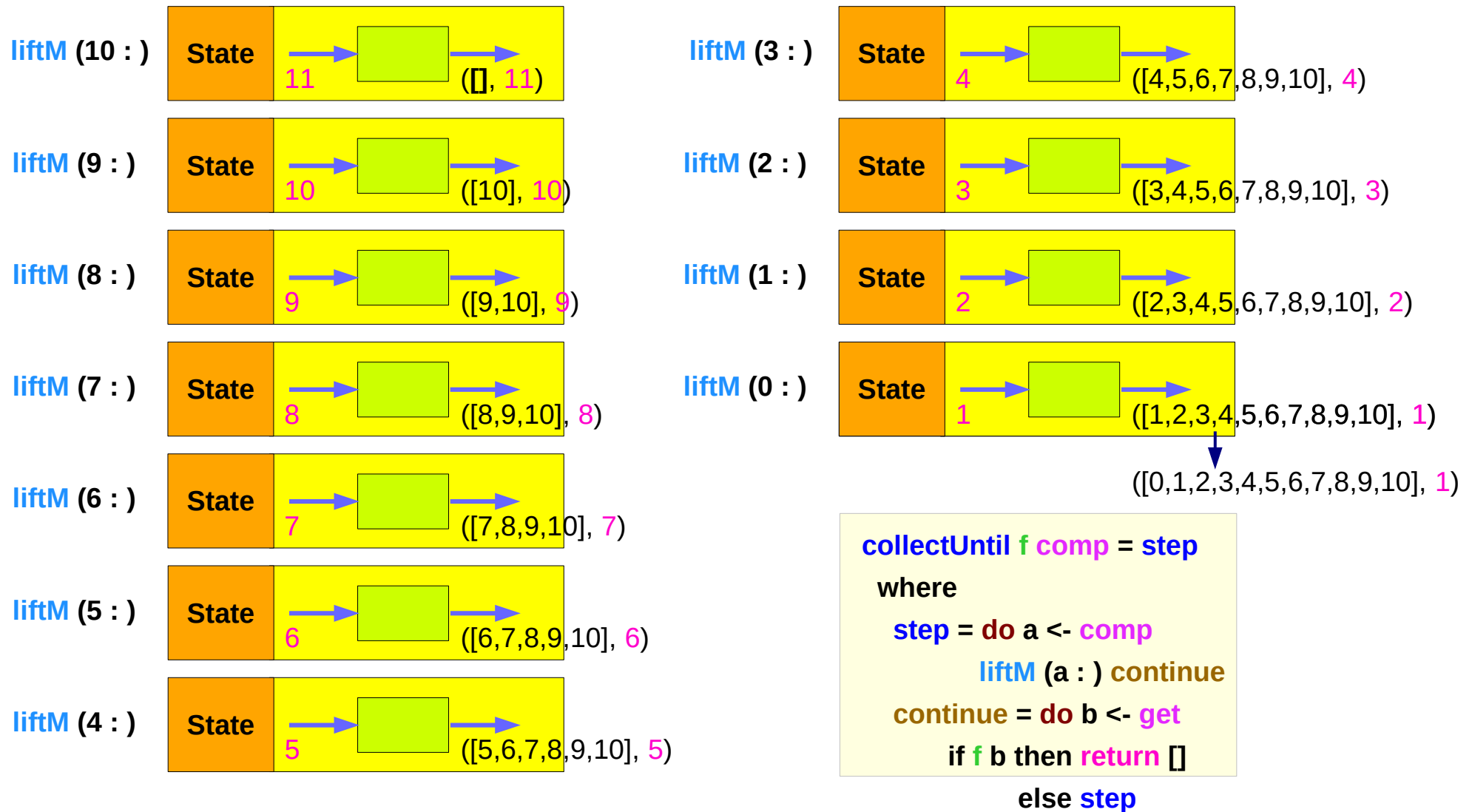
```
collectUntil f comp = step
  where
  step = do a <- comp
            liftM (a : ) continue
  continue = do b <- get
             if f b then return []
             else step
```

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

Another example of collecting – 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**

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]

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
```

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 <u>monadic</u> <u>counterpart</u>.

mapM applies a function which <u>yields</u> a <u>monadic</u> <u>value</u> to a <u>list of values</u>,

      <u>yielding</u> <u>list</u> of <u>results</u> <u>embedded</u> in the <u>monad</u>.

> **liftM** (**map toUpper**) **getLine**

Hallo

"HALLO"

> :t **mapM** return "monad"

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

References

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

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