
Functional Programming

<http://proglang.informatik.uni-freiburg.de/teaching/functional-programming/2019/>

Exercise Sheet 6 – First steps with monads - state

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In this exercise, we will be using the state monad. Documentation available at

<https://hackage.haskell.org/package/transformers-0.5.5.0/docs/Control-Monad-Trans-State-Lazy.html>

Along with the usual monad operations, the state monad allows to access the state contained in the monad. For example, the following function increments a counter and returns the old value.

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

You then use the `runState` function to perform the operations and obtain the final state.

Exercise 1 (Pseudo random number generator)

A common way to generate (pseudo-)random numbers is through the use of a series. For example, Donald Knuth in the Art of Programming presents the following series:

$$x_n = (6364136223846793005 * x_{n-1} + 1442695040888963407) \bmod 2^{64}$$

This style of pseudo-random number generator is known as a linear congruential generator¹. Implement the following API using the traditional State monad operations:

```
type Random a = State Int a
fresh :: Random Int
runPRNG :: Random a -> Int -> a
```

Exercise 2 (While – Evaluation)

Implement an interpreter for the miniwhile language presented in Ex05 using a State monad containing the memory. One could start with the following definitions:

```
type Value = ....
type Id = String
type Memory = Map Name Value
```

```
eval :: Program -> Memory
```

Here are some hints to make things simpler:

- You could write separate evaluation functions for statements and expressions. Each evaluation functions will run in the interpreter monad. For instance, we could consider the following definitions:

```
type InterpM = State Memory
evalStatement :: Statement -> InterpM ()
```

- Assume that variables always store `integer` values. At the beginning all variables have the value 0. (Since the While language also supports Boolean values, you must represent them as numbers, à la C)
- The module `Control.Monad` contains many useful functions for programming with Monads.

We will see how to add errors and printing in later exercises.

¹https://en.wikipedia.org/wiki/Linear_congruential_generator