01-TREES

5/6 WED

Haskell Crash Course Part III

Writing Applications

Lets write the classic "Hello world!" program.

For example, in Python you may write:

None → None

```
def main(): ()      ()
    print "hello, world!"

main()
```

and then you can run it:

```
$ python hello.py
hello world!
```

```
main :: () -> ()
main = \_ -> ()
```

'build'

02-WHILE

```
data Dir a = File a
           | SubD a [Dir a]
```

In → output

side-effect

Haskell is a ***Pure*** *language.*

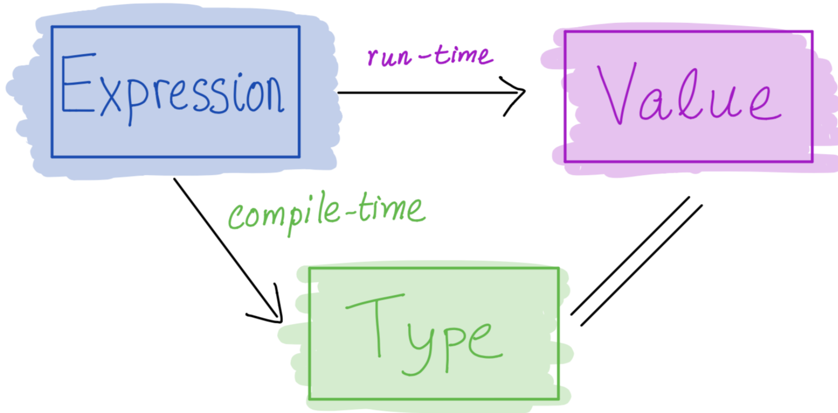
Not a *value* judgment, but a precise *technical* statement:

The "Immutability Principle":

- A function must *always* return the same output for a given input
- A function's behavior should *never change*

(foo 3) →

No Side Effects

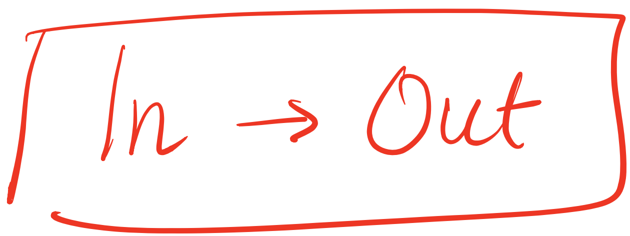


Haskell's most radical idea: `expression =*> value`

- When you evaluate an expression you get a value and
- **Nothing else happens**

Specifically, evaluation must not have an **side effects**

- *change* a global variable or
- *print* to screen or
- *read* a file or
- *send* an email or



- *launch* a missile.

But… how to write "Hello, world!"

But, we **want** to …

- **print** to screen
- **read** a file
- **send** an email

Thankfully, you *can* do all the above via a very clever idea: `Recipe`

Recipes

This analogy is due to Joachim Brietner (https://www.seas.upenn.edu/~cis194/fall16/lectures/06-io-and-monads.html)

Haskell has a special type called `IO` – which you can think of as `Recipe`

```
type Recipe a = IO a
```

Recipe a
= "Description of a comp. with effects that produces a value 'a'"

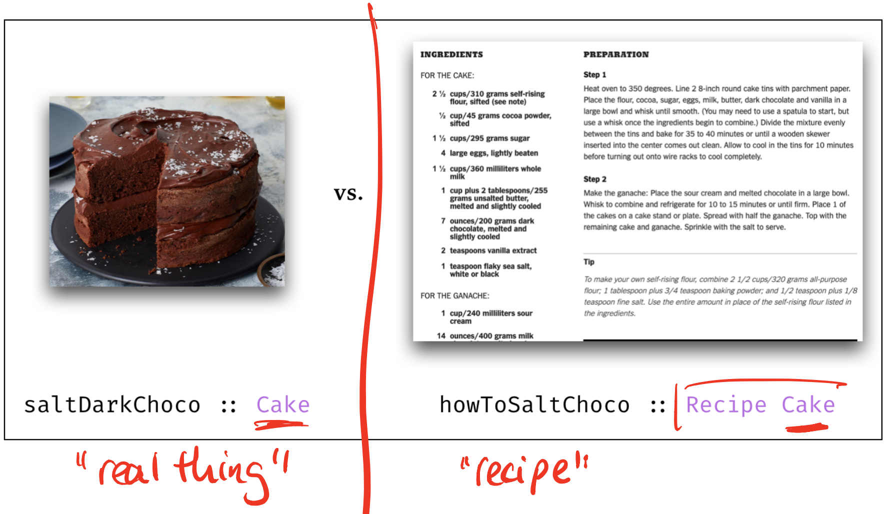
A *value* of type `Recipe a`

- is a **description** of a *computation* that can have *side-effects*
- which **when executed** performs some effectful I/O operations
- to **produce** a value of type `a`.

Recipes have No Side Effects

A value of type `Recipe a` is

- A **description** of a computation that can have side-effects



Cake vs. Recipe

(L) chocolate *cake*, **(R)** a *sequence of instructions* on how to make a cake.

They are different (*Hint*: only one of them is delicious.)

Merely having a `Recipe Cake` has no effects! The recipe

- Does not make your oven *hot*
- Does not make your your floor *dirty*

Only One Way to Execute Recipes

Haskell looks for a special value

```
main :: Recipe ()
```

The value associated with `main` is handed to the **runtime system and executed**

Baker Aker

The Haskell runtime is a *master chef* who is the only one allowed to cook!

How to write an App in Haskell

Make a `Recipe ()` that is handed off to the master chef `main`.

- `main` can be arbitrarily complicated
- composed of **smaller** sub-recipes

A Recipe to Print to Screen

```
putStrLn :: String -> Recipe ()
```

The function `putStrLn`

(putStrLn msg)

- takes as input a `String`
- returns as output a `Recipe ()`

`putStrLn msg` is a `Recipe ()` - *when executed* prints out `msg` on the screen.

```
main :: Recipe ()
main = putStrLn "Hello, world!"
```

... and we can compile and run it

```
$ ghc --make hello.hs
$ ./hello
Hello, world!
```

QUIZ: How to Print Multiple Things?

Suppose I want to print *two* things e.g.

```
$ ghc --make hello.hs
$ ./hello2
Hello!
World!
```

Can we try to compile and run this:

```
main = (putStLn "Hello!", putStrLn "World!")
```

A. Yes!

B. No, there is a type error!

C. No, it compiles but produces a different result!

A Collection of Recipes

Is just … a *collection* of Recipes!

```
recPair :: (Recipe (), Recipe ())
recPair = (putStrLn "Hello!", putStrLn "World!")

recList :: [Recipe ()]
recList = [putStrLn "Hello!", putStrLn "World!"]
```

... we need a way to **combine** recipes!

Combining? Just **do** *it!*

We can *combine* many recipes into a single one using a **`do`** block

```
foo :: Recipe a3
foo = do r1        -- r1 :: Recipe a1
         r2        -- r2 :: Recipe a2
         r3        -- r3 :: Recipe a3
```

(or if you *prefer* curly braces to indentation)

```
foo = do { r1;     -- r1 :: Recipe a1
           r2;     -- r2 :: Recipe a2
           r3      -- r3 :: Recipe a3
         }
```

The **do** block combines sub-recipes `r1`, `r2` and `r3` into a *new* recipe that

- Will execute each sub-recipe in *sequence* and
- Return the value of type `a3` produced by the last recipe `r3`

Combining? Just **do** *it!*

So we can write

```
main = do putStrLn "Hello!"
          putStrLn "World!"
```

or if you prefer

```
main = do { putStrLn "Hello!";
            putStrLn "World!"
          }
```

EXERCISE: Combining Many Recipes

Write a function called `sequence` that

- Takes a *list* of recipes `[r1,...,rn]` as input and
- Returns a *single* recipe equivalent to `do {r1; ...; rn}`

```
sequence :: [Recipe a] -> Recipe a
sequence rs = ???
```

When you are done you should see the following behavior

```
-- Hello.hs

main = sequence [putStrLn "Hello!", putStrLn "World!"]
```

and then

```
$ ghc --make Hello.hs
$ ./hello
Hello!
World!
```

Using the Results of (Sub-) Recipes

Suppose we want a function that **asks** for the user's name

```
$ ./hello
What is your name?
Ranjit               # <<<<< user enters
Hello Ranjit!
```

We can use the following sub-recipes

```
-- | read and return a line from stdin as String
getLine  :: Recipe String

-- take a string s, return a recipe that prints  s
putStrLn :: String -> Recipe ()
```

But how to

- *Combine* the two sub-recipes while
- *Passing* the result of the first sub-recipe to the second.

Naming Recipe Results via "Assignment"

You can write

```
x <- recipe
```

to *name* the result of executing `recipe`

- `x` can be used to refer to the result in *later* code

Naming Recipe Results via "Assignment"

Lets, write a function that *asks* for the user's name

```haskell
main = ask

ask :: Recipe ()
ask = do name <- getLine;
         putStrLn ("Hello " ++ name ++ "!")
```

Which produces the desired result

```
$ ./hello
What is your name?
Ranjit              # user enters
Hello Ranjit!
```

EXERCISE

Modify the above code so that the program *repeatedly* asks for the users's name *until* they provide a *non-empty* string.

```haskell
-- Hello.hs

main = repeatAsk

repeatAsk :: Recipe ()
repeatAsk = _fill_this_in


isEmpty :: String -> Bool
isEmpty s = length s == 0
```

When you are done you should get the following behavior

```
$ ghc --make hello.hs

$ ./hello
What is your name?
# user hits return
What is your name?
# user hits return
What is your name?
# user hits return
What is your name?
Ranjit  # user enters
Hello Ranjit!
```

EXERCISE

Modify your code to *also* print out a **count** in the prompt

```
$ ghc --make hello.hs

$ ./hello
(0) What is your name?
                          # user hits return
(1) What is your name?
                          # user hits return
(2) What is your name?
                          # user hits return
(3) What is your name?
Ranjit                    # user enters
Hello Ranjit!
```

That's all about IO

You should be able to implement `build` from `Directory.hs`

Using these library functions imported at the top of the file

```
import System.FilePath   (takeDirectory, takeFileName, (</>))
import System.Directory  (doesFileExist, listDirectory)
```

The functions are

- `takeDirectory`
- `takeFileName`
- `(</>)`
- `doesFileExist`
- `listDirectory`

`hoogle` the documentation to learn about how to use them.

(https://ucsd-cse230.github.io/sp20/feed.xml) (https://twitter.com/ranjitjhala) (https://plus.google.com/u/0/104385825850161331469) (https://github.com/ranjitjhala)