PROGRAMMING IN HASKELL

Chapter 6.1 – Map, Modules*, IO

*From ‘Learn you a Haskell’ (http://learnyouahaskell.com/)

A few things before we start

- map
- Modules
  - Data.List
  - Data.Char
  - Data.Text
  - Writing our own Modules
- Encryption Example
- IO (Briefly)

The map Function

The higher-order library function called map applies a function to every element of a list.

```
map :: (a → b) → [a] → [b]
```

For example:

```
> map (+1) [1,3,5,7]

[2,4,6,8]
```

The map Function

We will examine more higher-order functions later

```
map :: (a → b) → [a] → [b]
```

For example:

```
> map toUpper ”cat”
>”CAT”
```

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The Haskell prelude

So far, we've been using built-in functions provided in the Haskell prelude. This is a subset of a larger library that is provided with any installation of Haskell. (Google for Hoogle to see a handy search engine for these.)

Examples of other modules:

- Text
- concurrent programming
- complex numbers
- char
- sets
- …

Example: Data.List

To load a module, we need to import it:

```
import Data.List
```

All the functions in this module are immediately available, e.g.

```
numUniques xs:: (Eq a) => [a] -> Int
numUniques xs =  length ( nub xs)
```

This is a function in Data.List that removes duplicates from a list.

Modules

You can also load modules from the command prompt:

```
ghci> :m + Data.List
```

Or several at once:

```
ghci> :m + Data.List Data.Map Data.Set
```

Or import only some, or all but some:

```
import Data.List (nub, sort)   OR
import Data.List hiding (nub)
```

Duplication of namespace

If duplication of names is an issue, we can extend the namespace:

```
import qualified Data.Map
:
Data.Map.filter isUpper ......
```

When the Data.Map gets a bit long, we can provide an alias:

```
import qualified Data.Map as M
```

And now we can just type M.filter, and the normal list filter will just be (prelude) filter.

Data.List examples

Data.List has a lot more functionality than we've seen. A few examples:

```
ghci> intersperse '.' "MONKEY"
"M.O.N.K.E.Y"
ghci> intersperse 0 [1,2,3,4,5,6]
[1,0,2,0,3,0,4,0,5,0,6]
```

```
ghci> intercalate " " ["hey","there","guys"]
"hey there guys"
ghci> intercalate [0,0,0] [[1,2,3],[4,5,6],
                           [7,8,9]]
[1,2,3,0,0,0,4,5,6,0,0,0,7,8,9]
```

Data.List – more examples


```
ghci> transpose [[1,2,3], [4,5,6],  [7,8,9]]
[[1,4,7],[2,5,8],[3,6,9]]

ghci> transpose ["hey","there","guys"]
["htg","ehu","yey","rs","e"]
```

```
ghci> concat ["foo","bar","car"]
"foobarcar"
ghci> concat [[3,4,5],[2,3,4],[2,1,1]]
[3,4,5,2,3,4,2,1,1]
```

Data.List (you can come back to this later)


```
ghci> and $ map (>4) [5,6,7,8]
True
ghci> and $ map (==4) [4,4,4,3,4]
False
```

```
ghci> any (==4) [2,3,5,6,1,4]
True
ghci> all (>4) [6,9,10]
True
```

Example: adding vectors

Functions are often represented as vectors:
8x^3 + 5x^2 + x - 1 is represented as
[8,5,1,-1].

So we can easily use List functions to add these vectors:

```
ghci> map sum ( transpose [[0,3,5,9],
     [10,0,0,9],[8,5,1,-1]]
[18,8,6,17])   -- we can use $ here .. later
```

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Data.Char module

The Data.Char module: includes a lot of useful functions that may look familiar.

Examples: isAlpha, isLower, isSpace, isDigit, isPunctuation,…

```
ghci> all isAlphaNum "bobby283"
True
ghci> all isAlphaNum "eddy the fish!”
False
ghci> groupBy ((==) `on` isSpace)
      "hey guys its me"
["hey"," ","guys"," ","its"," ","me"]
```

Data.Char - more

The Data.Char module has a datatype that is a set of comparisons on characters. There is a function called generalCategory that returns the information. (This is a bit like the Ordering type for numbers, which returns LT, EQ, or GT)

```
ghci> generalCategory ' '
Space
ghci> generalCategory 'A'
UppercaseLetter
ghci> generalCategory 'a'
LowercaseLetter
ghci> generalCategory '.'
OtherPunctuation
ghci> generalCategory '9'
DecimalNumber
ghci> map generalCategory "¥t¥nA9?|"
```

Data.Char - Functions that can convert between Ints and Chars:


```
ghci> map digitToInt "FF85AB"

[15,15,8,5,10,11]
ghci> intToDigit 15
'f'
ghci> intToDigit 5
'5'
```

```
ghci> chr 97
'a'
ghci> map ord "abcdefgh"
[97,98,99,100,101,102,103,1
04]
```

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Data.Text

- This is strongly preferred over String for real-world text.
- As it clashes with Prelude for a number of functions, best to use with qualified, i.e.

```
import qualified Data.Text as T
```

Note when using you need to add the following at the top of the file :

```
{-# LANGUAGE OverloadedStrings #-}
```

Data.Text

We will use Data.Text when working on some kinds of data:

- See more at https://hackage.haskell.org/package/text-1.2.4.1/docs/Data-Text.html

See lab exercise on Data.Text for an example on using Data.Text and some of its functions:

toLower,
filter,
pack, unpack

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Making our own modules

We specify our own modules at the beginning of a file. For example, if we had a set of geometry functions:

```
module Geometry
( sphereVolume
, sphereArea
, cubeVolume
, cubeArea
, cuboidArea
, cuboidVolume
) where
```

These functions are 'exposed' or available to users of the module

Writing functions within module


```
sphereVolume :: Float -> Float
sphereVolume radius = (4.0 / 3.0) * pi *
        (radius ^ 3)

sphereArea :: Float -> Float
sphereArea radius = 4 * pi * (radius ^ 2)

cubeVolume :: Float -> Float
cubeVolume side = cuboidVolume side side side
…  etc.
```

‘private’ helper functions


```
cuboidVolume :: Float -> Float -> Float
        -> Float
cuboidVolume a b c = rectangleArea a b * c

cuboidArea :: Float -> Float ->
           Float -> Float
cuboidArea a b c = rectangleArea a b * 2 + rec
tangleArea a c * 2 + rectangleArea c b * 2

rectangleArea :: Float -> Float -> Float
rectangleArea a b = a * b
```

To make these functions ‘private’, simply omit them from list of functions listed after module name at top of .hs

Nesting functions

Can also nest these. Make a folder called Geometry, with 3 files inside it, first up Sphere.hs

```
module Geometry.Sphere
( volume
, area
) where

volume :: Float -> Float
volume radius = (4.0 / 3.0) * pi * (radius ^ 3)
area :: Float -> Float
area radius = 4 * pi * (radius ^ 2)
```

Cuboid.hs


```
module Geometry.Cuboid
( volume
, area
) where

volume :: Float -> Float -> Float -> Float
volume a b c = rectangleArea a b * c


…
```

etc.

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Application – Caesar Ciphers

Caesar ciphers (more here)
A primitive encryption cipher which encodes messages by shifted them a fixed amount in the alphabet.

Example: hello with shift of 3

```
encode :: Int -> String -> String
encode shift msg =
    let ords = map ord msg
        shifted = map (+ shift) ords
    in  map chr shifted
```

Using encode


```
ghci> encode 3 "Heeeeey"
"Khhhhh|"

ghci> encode 4 "Heeeeey"
"Liiiii}"

ghci> encode 1 "abcd"
"bcde"
```

Decoding just reverses the encoding


```
decode :: Int -> String -> String
decode shift msg =
     encode (negate shift) msg
```

```
ghci> encode 3 "I'm a little teapot"
"Lp#d#olwwoh#whdsrw"
ghci> decode 3 "Lp#d#olwwoh#whdsrw"
"Im a little teapot"
ghci> decode 5 . encode 5 $ "This is a sentence"
"This is a sentence"
```

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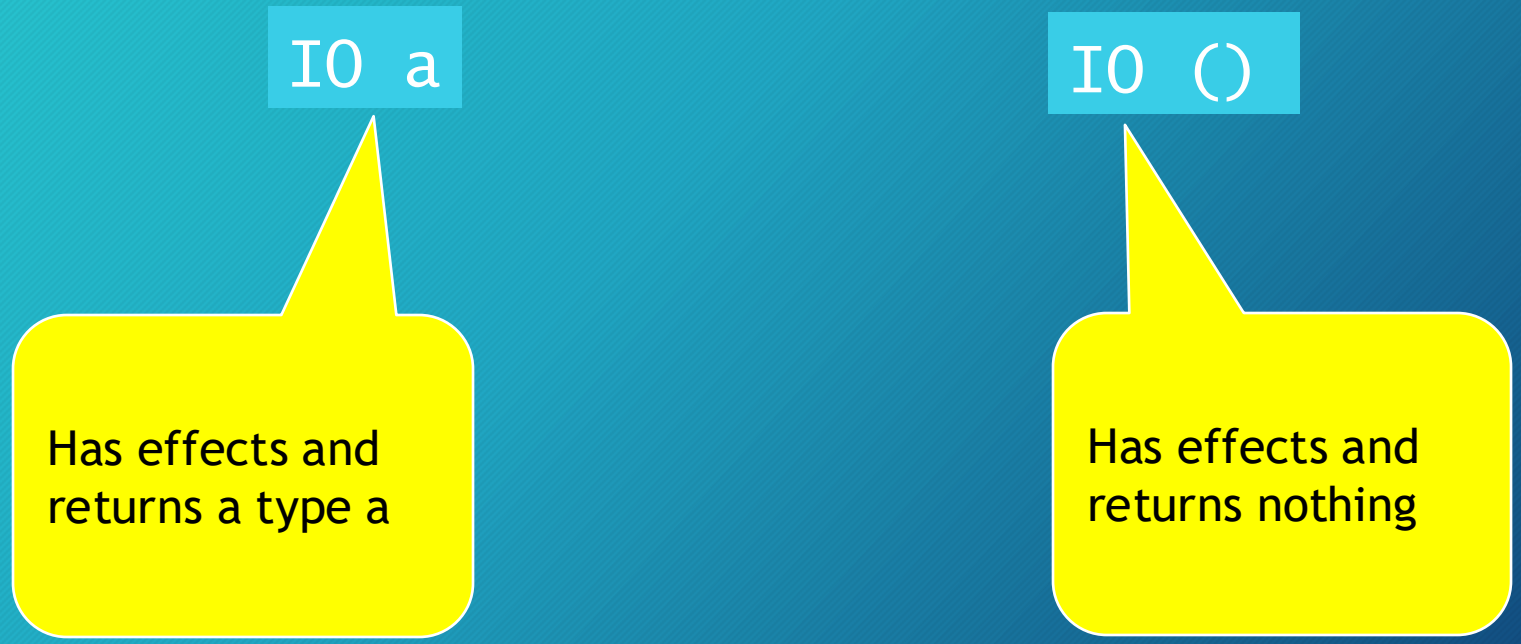
IO Briefly

- Purity in Haskell means that functions should not have any side-effects.
- This means that functions should not effect state or change the outside world in any way
- This includes the use of IO (e.g., reading from keyboard, writing to console)
- We need to use such IO but the Haskell compromise is that anything with such side-effects is clearly marked as such.. How..

IO Briefly

- We type the function to clearly show that IO is involved



IO Briefly – the main function

- The Haskell compiler looks for a special value

```
main :: IO ()
```

- This will actually get handed to the runtime system and executed.


ANY
QUESTIONS?