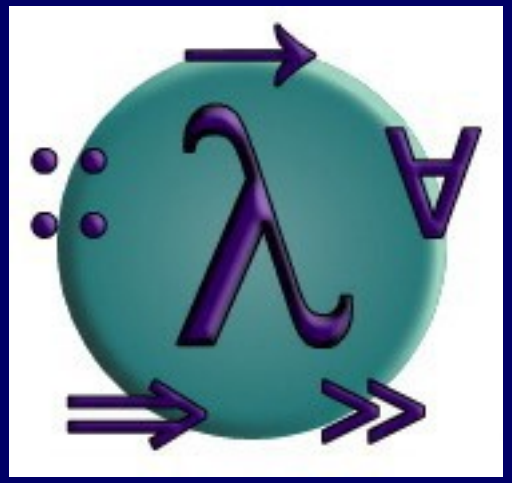
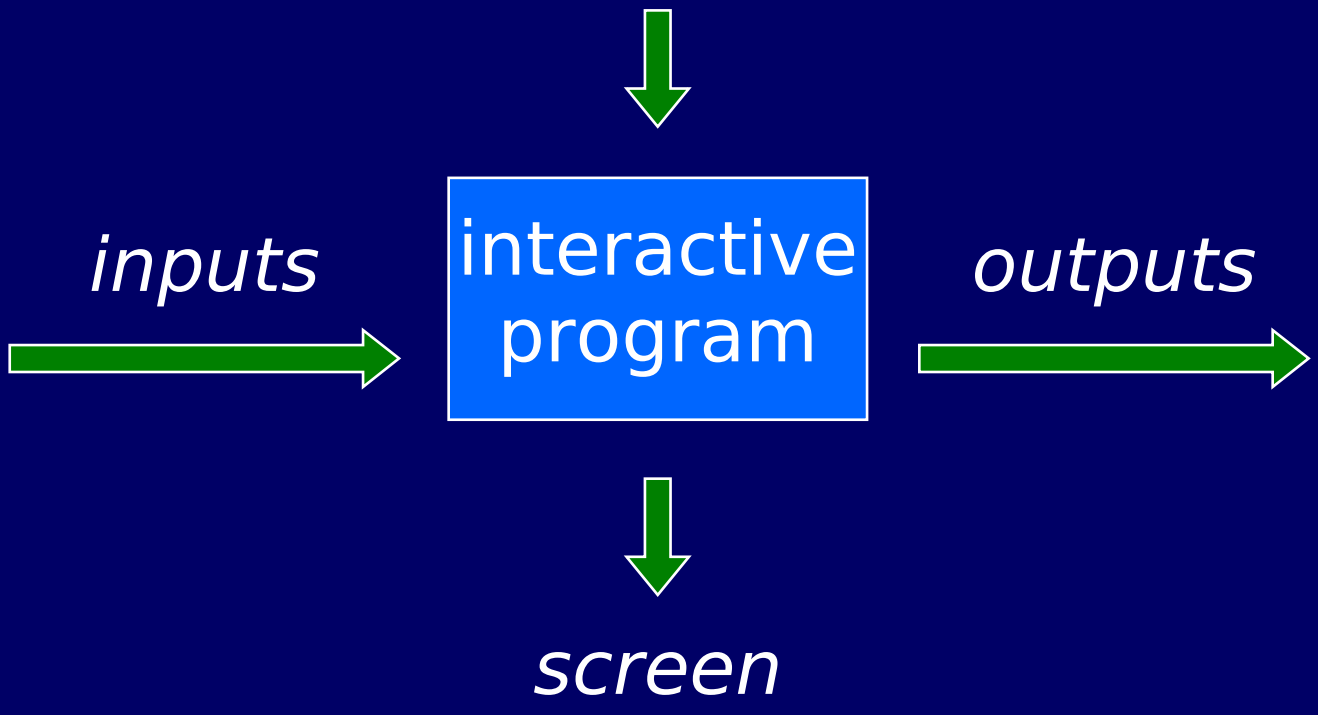
PROGRAMMING IN HASKELL



Part 4 - Interactive Programs and Monads

Introduction

We would also like to use Haskell to write interactive programs that read from the keyboard and write to the screen, as they are running.



The Problem

Haskell programs are pure mathematical functions:

- Haskell programs have no side effects.

However, reading from the keyboard and writing to the screen are side effects:

- Interactive programs have side effects.

The Solution

Interactive programs can be written in Haskell by using types to distinguish pure expressions from impure actions that may involve side effects.

```
IO a
```

The type of actions that return a value of type a.

For example:

```
IO Char
```

The type of actions that return a character.

```
IO ()
```

The type of purely side effecting actions that return no result value.

Note:

- () is the type of tuples with no components.

Basic Actions

The standard library provides a number of actions, including the following three primitives:

- The action getChar reads a character from the keyboard, echoes it to the screen, and returns the character as its result value:

```
getChar :: IO Char
```

- The action putChar c writes the character c to the screen, and returns no result value:

```
putChar :: Char → IO ()
```

- The action return v simply returns the value v, without performing any interaction:

```
return :: a → IO a
```

Sequencing

A sequence of actions can be combined as a single composite action using the keyword do.

For example:

```
a :: IO (Char,Char)
a  = do x ← getChar
        getChar
        y ← getChar
        return (x,y)
```

Derived Primitives

- Reading a string from the keyboard:

```
getLine :: IO String
getLine  = do x ← getChar
              if x == '\n' then
                 return []
               else
                 do xs ← getLine
                    return (x:xs)
```

- Writing a string to the screen:

```
putStr        :: String → IO ()
putStr []      = return ()
putStr (x:xs) = do putChar x
                   putStr xs
```

- Writing a string and moving to a new line:

```
putStrLn    :: String → IO ()
putStrLn xs = do putStr xs
                 putChar '\n'
```

Example

We can now define an action that prompts for a string to be entered and displays its length:

```
strlen :: IO ()
strlen  = do putStr "Enter a string: "
             xs ← getLine
             putStr "The string has "
             putStr (show (length xs))
             putStrLn " characters"
```

For example:

```
> strlen

Enter a string: abcde
The string has 5 characters
```

Note:

- Evaluating an action executes its side effects, with the final result value being discarded.

The Monad Class

The IO type is an instance of the monad class.

```
class Monad m where
  return :: a -> m a
  (>>=)  :: m a -> (a -> m b) -> m b
```

(>>=) is the bind operator of the monad.

Do notation

The do notation is just syntactic sugar for the bind operator >>=.

```
e1 >>= \v1 ->
e2 >>= \v2 ->
return (f v1 v2)
```

```
do v1 <- e1
   v2 <- e2
   return (f v1 v2)
```

The Maybe Monad

The Maybe data type is useful when interacting with databases, dictionaries, ...

```
data Maybe a = Nothing | Just a

instance Monad Maybe where
  return x = Just x
  Nothing >>= f = Nothing
  Just x >> = f = f x
```

The List Monad

```
instance Monad [] where
  return x = [x]
  xs >>= f = concatMap f xs
```

where

```
concatMap :: (a -> [b]) -> [a] -> [b]
```

Homework!

Prepare Chap. 18.2 “The Monad Class” from *The Haskell School of Expression* by Paul Hudak till next time.