FP101x - Functional Programming

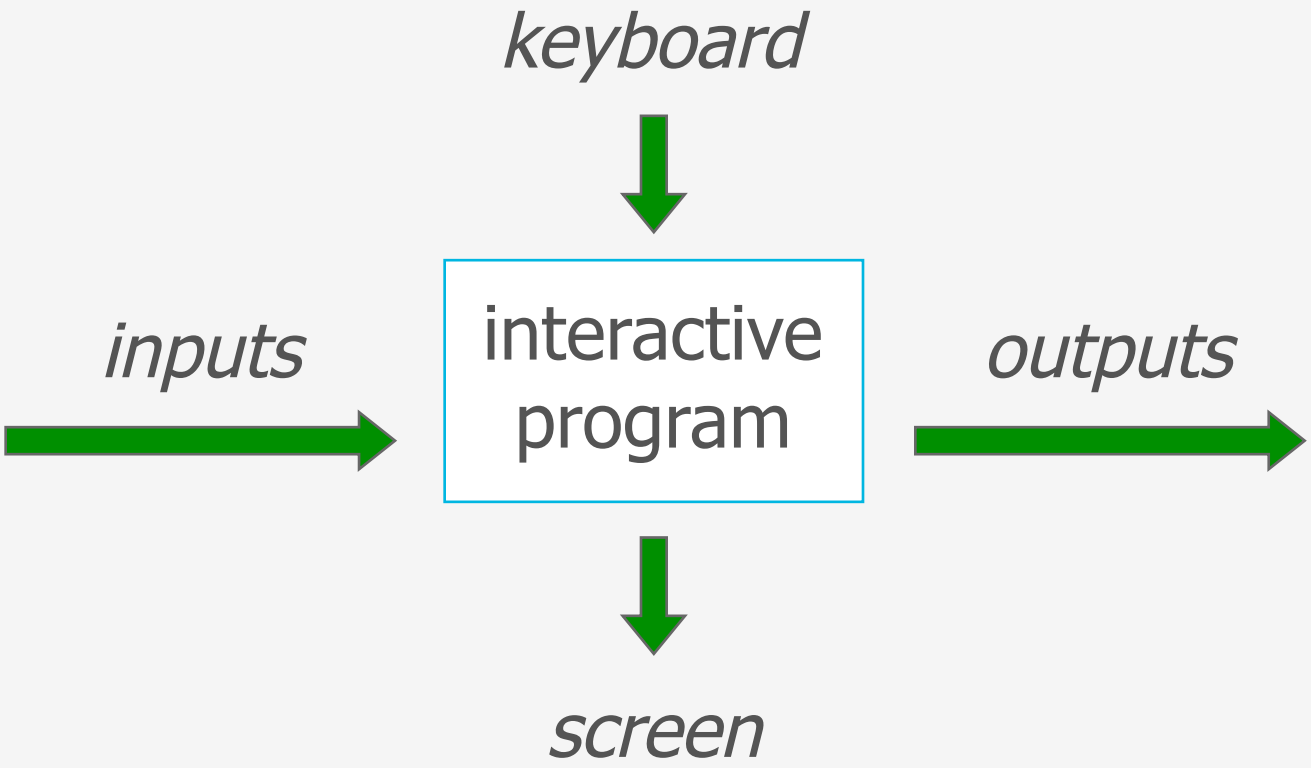
Programming in Haskell – Interactive Programs

Erik Meijer

Introduction

To date, we have seen how Haskell can be used to write batch programs that take all their inputs at the start and give all their outputs at the end.

However, 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:

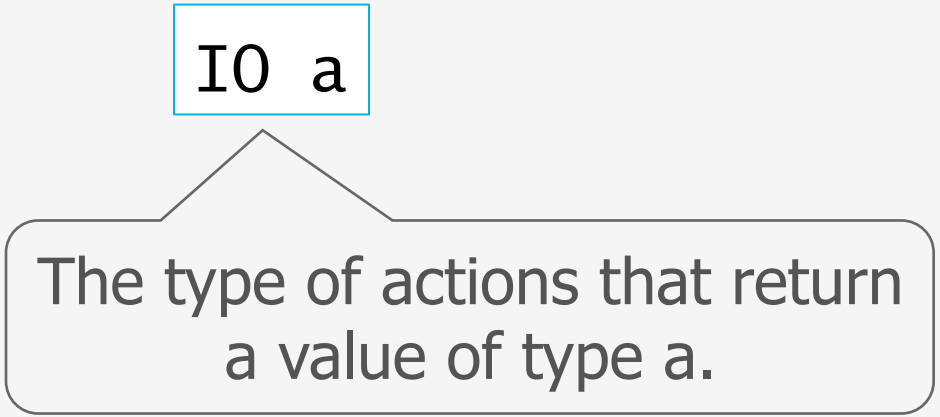
- Haskell programs have no side effects.

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.



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.

Hangman

Consider the following version of hangman:

- One player secretly types in a word.
- The other player tries to deduce the word, by entering a sequence of guesses.
- For each guess, the computer indicates which letters in the secret word occur in the guess.

- The game ends when the guess is correct.

We adopt a top down approach to implementing hangman in Haskell, starting as follows:

```
hangman :: IO ()
hangman  =
   do putStrLn "Think of a word: "
      word ← sgetLine
      putStrLn "Try to guess it:"
      guess word
```

The action sgetLine reads a line of text from the keyboard, echoing each character as a dash:

```
sgetLine :: IO String
sgetLine  = do x ← getCh
               if x == '\n' then
                  do putChar x
                     return []
                else
                  do putChar '-'
                     xs ← sgetLine
                     return (x:xs)
```

The action getCh reads a single character from the keyboard, without echoing it to the screen:

```
import System.IO


getCh :: IO Char
getCh  = do hSetEcho stdin False
            c ← getChar
            hSetEcho stdin True
            return c
```

The function guess is the main loop, which requests and processes guesses until the game ends.

```
guess      :: String → IO ()
guess word =
   do putStr "> "
      xs ← getLine
      if xs == word then
         putStrLn "You got it!"
       else
         do putStrLn (diff word xs)
            guess word
```

The function diff indicates which characters in one string occur in a second string:

```
diff      :: String → String → String
diff xs ys =
   [if elem x ys then x else '-' | x ← xs]
```

For example:

```
> diff "haskell" "pascal"

"-as--ll"
```

Exercise

Implement the game of nim in Haskell, where the rules of the game are as follows:

- The board comprises five rows of stars:

```
1: * * * * *
2: * * * *
3: * * *
4: * *
5: *
```

- Two players take it turn about to remove one or more stars from the end of a single row.

- The winner is the player who removes the last star or stars from the board.

Hint:

Represent the board as a list of five integers that give the number of stars remaining on each row. For example, the initial board is [5,4,3,2,1].

Happy Hacking!