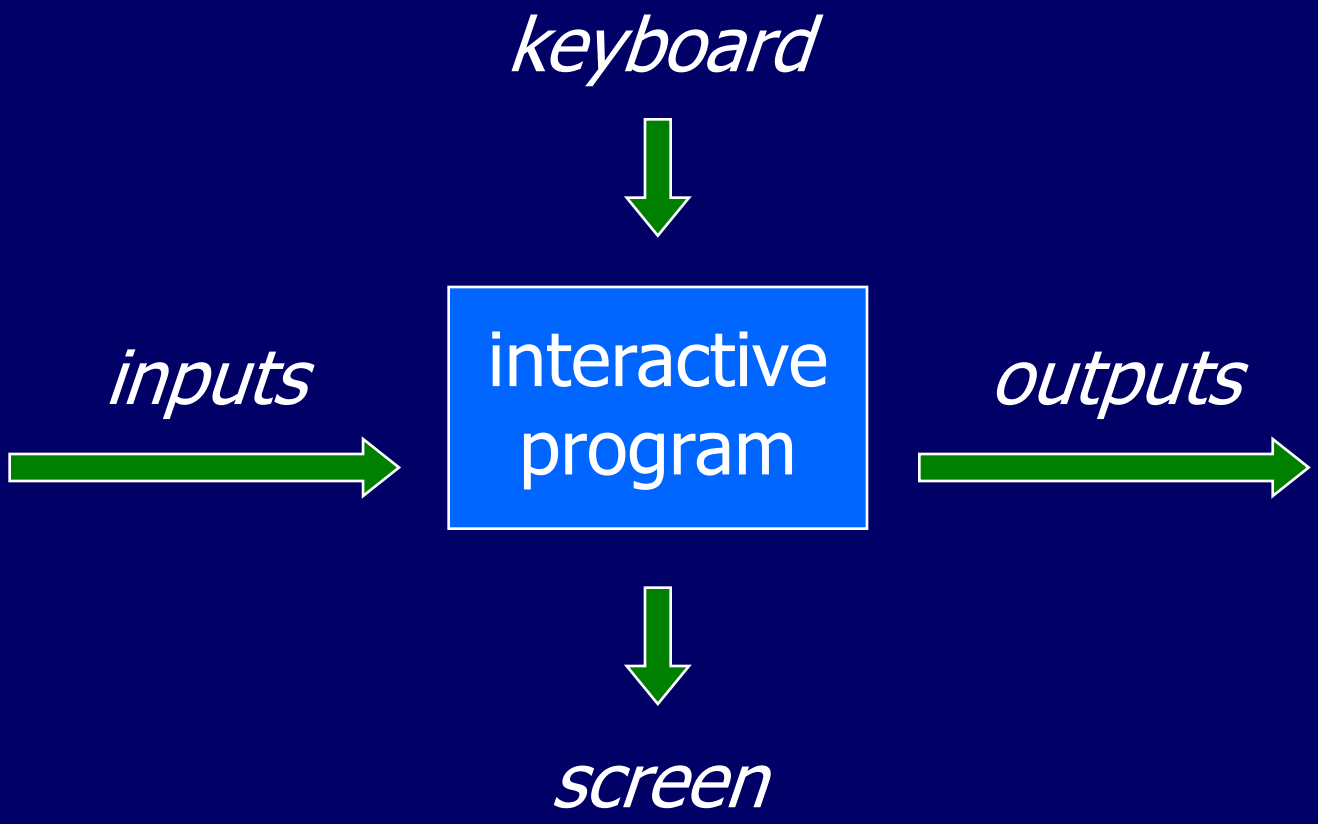
PROGRAMMING IN HASKELL

Chapter 10 - Interactive Programming

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.

```
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.

What is an Action?

Actions:

- Have the type IO t
- Are first-class values in Haskell – fit in seamlessly
- Produce an effect when they are performed, but not when evaluated. i.e. they produce an effect only when called by something else in an I/O context.
- Any expression may produce an action as its value, but the action will not perform I/O until it is executed inside another I/O action (or it is main)
- Performing (executing) an action of type IO t may perform I/O and will ultimately deliver a result of type t.

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
```

  - Look at it's type – it looks like a value rather than a function – actually, getChar stores an I/O action. When it's performed you get a Char.
  - The <- operator is used to "pull out" the result from performing the I/O action and store it in the variable.

- 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:

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

do notation

The do notation give us a way of building IO programs from the components that we have seen. It does two things :

- It is used to sequence I/O programs
- It is used to name the values returned by the IO actions – this means that the later actions can depend on values captured earlier in the program

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'
```

Other examples

- Writing a string four times:

```
put4times :: String → IO ()
put4times str
      = do putStr str
           putStr str
           putStr str
           putStr str
```

Other examples

- Reading input

```
read2lines :: IO ()
read2lines
      = do getLine
           getLine
           putStrLn “two lines read”
```

Other examples

- Using the input

```
getNput :: IO ()
getNput = do line <- getLine
             putStrLn line
```

- Note that in Haskell, each

  var <-

creates a new variable – so, this 'single assignment' is allowed (rather than 'updatable assignment')

- line <- getLine acts as a local definition

Other examples

- We can't change line but we can use it differently:

```
reverse2lines :: IO ()
reverse2lines =
          do   line1 <- getLine
               line1 <- getLine
               putStrLn(reverse line1)
               putStrLn(reverse line2)
```

Other examples

- We can also use local definitions:

```
reverse2lines2 :: IO ()
reverse2lines2 =
          do   line1 <- getLine
               line1 <- getLine
               let rev1 = reverse line1
               let rev2 = reverse line2
               putStrLn(rev1)
               putStrLn(rev2)
```

Pure Versus I/O

Pure code ensures that Haskell functions return the same result when given the same input and have no side effects. We use the execution of I/O actions to avoid these rules

Pure	Impure
Always produces the same result when given the same parameters	May produce different results for the same parameters
Never has side effects	May have side effects
Never alters state	May alter the global state of the program , system or world

Why purity matters

- In other languages (e.g. C, Java) cannot be sure of no side effects (need to read documentation, hope it's accurate).
- Many bugs are caused by unanticipated side effects.
- This can cause cascading effects when using multi-threading, other forms of parallelisms.
- In Haskell, isolating side effects into I/O actions provides a clear boundary between no side effects and potential side effects.

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: Haskell
The string has 7 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:"
             play 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
           x ← getChar
           hSetEcho stdin True
           return x
```

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

```
play :: String → IO ()
play word =
   do putStr "? "
      guess ← getLine
      if guess == word then
         putStrLn "You got it!"
      else
         do putStrLn (match word guess)
            play word
```

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

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

For example:

```
> match "haskell" "pascal"

"-as--ll"
```

Reading values in general

Haskell contains the class Read with the function

```
read :: Read a => String -> a
```

This can be used to parse a string representing a value of a particular type into that value

Example using read

- Suppose that we want to read an I/O program to read in an integer value.
- To read an integer from a line of input, we start by

```
do line <- getLine
```

- Then we need to sequence this with an I/O action to return the *line* interpreted as an *Integer*.
- We can convert the *line* to an integer by the expression

```
read line
```

Example using read

- What we need is the IO Integer action which returns this value – this is the purpose of return.

- Our program to read an integer is

```
getInt :: IO Integer
getInt =
   do line <- getLine
      return (read line)
```

Example using show

- Recall that to use a non-string type as a string, we use show

- Add two numbers and print result

```
add :: IO ()
add = do  putStrLn "something"
          num1 <- getInt
          num2 <- getInt
          putStrLn ("Sum is " ++ show (num1
          + num2))
```