Fachhochschule
Nordwestschweiz

Functional Programming

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Input/Output

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Learning Targets

You understand the problem of impure functions

You appreciate the simplicity of pure functions

You can perform console, file and network I/O

You understand Haskell's I/O system and how it supports pure functional programming

Content

- **Example**
- **Terminal I/O**
  - Read type class
- **Concept**
  - Evaluate vs Execute
  - Pure vs Impure
- **File I/O**
- **Network I/O**

IO by Example

- **Program (FirstIO.hs)**

```
main = do putStrLn "Please enter your name:"
          name <- getLine
          let msg = "Welcome to the real world " ++ name
          putStrLn msg
```

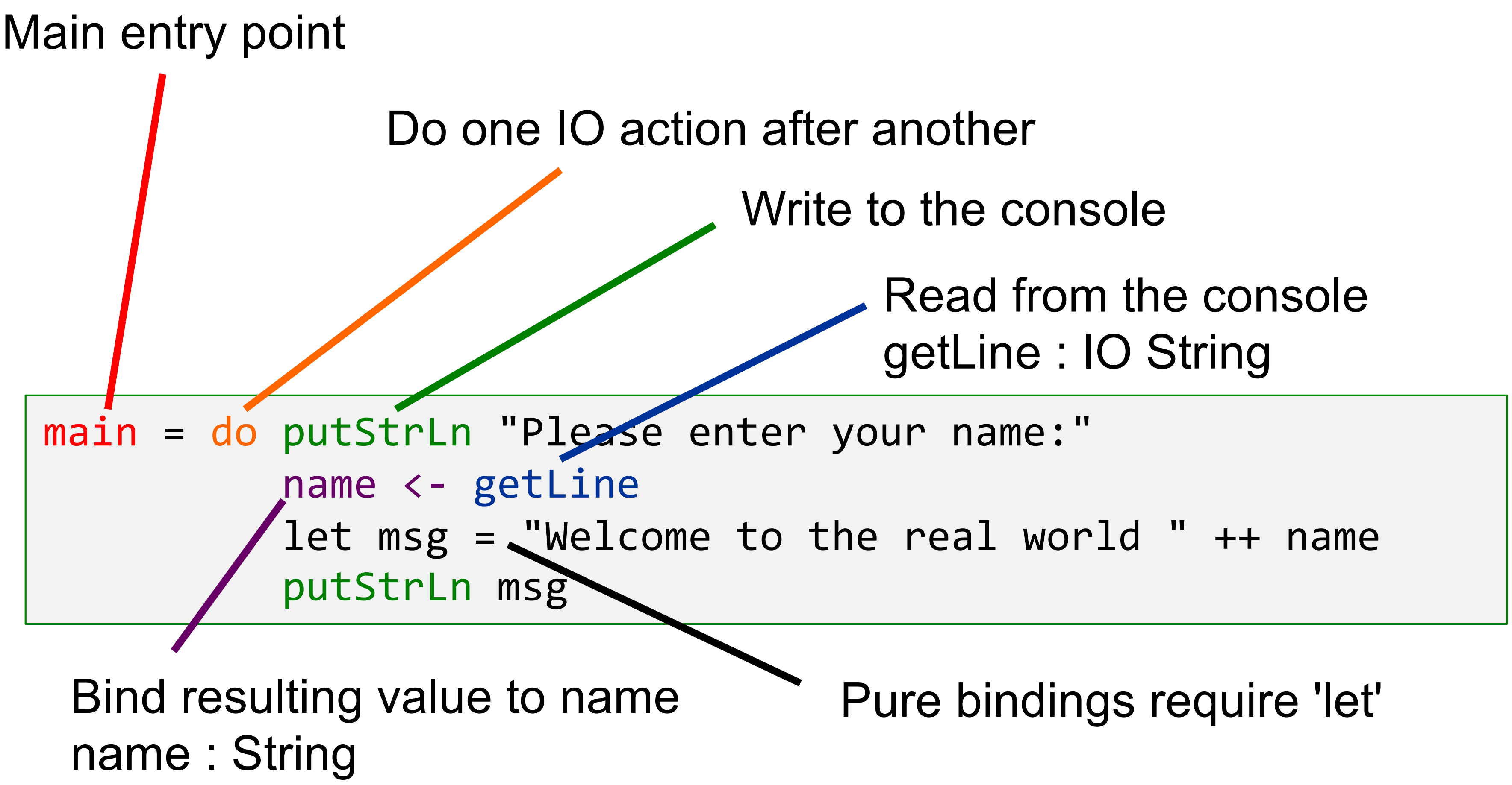
- **Compile**

```
> ghc FirstIO.hs
```

- **Run**

```
> ./FirstIO
Please enter your name:
Daniel
Welcome to the real world Daniel
```

IO by Example



Main entry point

Do one IO action after another

Write to the console

Read from the console
getLine : IO String

```
main = do putStrLn "Please enter your name:"
          name <- getLine
          let msg = "Welcome to the real world " ++ name
          putStrLn msg
```

Bind resulting value to name
name : String

Pure bindings require 'let'

Excursion: Read Typeclass

- **read is used to convert a String into a value of a member of Read**

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

- **Example**

```
> read "5"
<interactive>:2:1:
    No instance for (Read a0) arising from a use of `read'
    The type variable `a0' is ambiguous
    Possible fix: add a type signature that fixes these type
variable(s)
```

```
> (read "5") :: Int
5
```

Worksheet: MiniCalc

```
$ ./MiniCalc
Welcome to MiniCalc!
Please enter a first number:
12
Please enter a second number:
34
12 + 34 = 46
```

What is side effect free?

- **Haskell is a pure functional language**

  => Every function returns the same result if applied to the same parameters

```
func :: Int -> Int
func i = i + 1

constant :: Int
constant :: 42
```

now consider this use of the above functions:

```
let a = (func 3) - (func 3)
    b = constant - constant
```

  - What are the values of a and b?
  - In order to answer this question: What do you need to now about the functions definition?
  - Does it matter if the first or the second occurrence of func and constant respectively is evaluated first?

The Problem with IO

- **Side effect free means:**
  - Every function returns the same result if applied to the same parameters
  - But getLine which always returns the same string is meaningless!
- **Possible approach**
  - Provide *impure* functions like `inputInt :: Int` which read and return the users input
- **Problem**

```
inputDiff = inputInt - inputInt
```

  - What is the value of inputDiff?
  - In order to answer this question: What do you need to know about the definition of inputInt?
  - Does it help to know how inputInt is implemented?
  - Does the evaluation order of the two occurrences of inputInt matter?

The Problem with Side Effects cont.

- **Reasoning about the program's behavior becomes substantially more difficult with such a model.**
  - We can't understand the meaning of an expression anymore just by looking at the meaning of its parts. The environment of an expression becomes relevant.
- **This is because any function may be affected by IO:**

```
lookingPure :: Int -> Int
lookingPure i = inputInt + i
```

- **This is like programming in Java & Co. where every method call could potentially delete your disk or even launch a missile!**

NOT GOOD

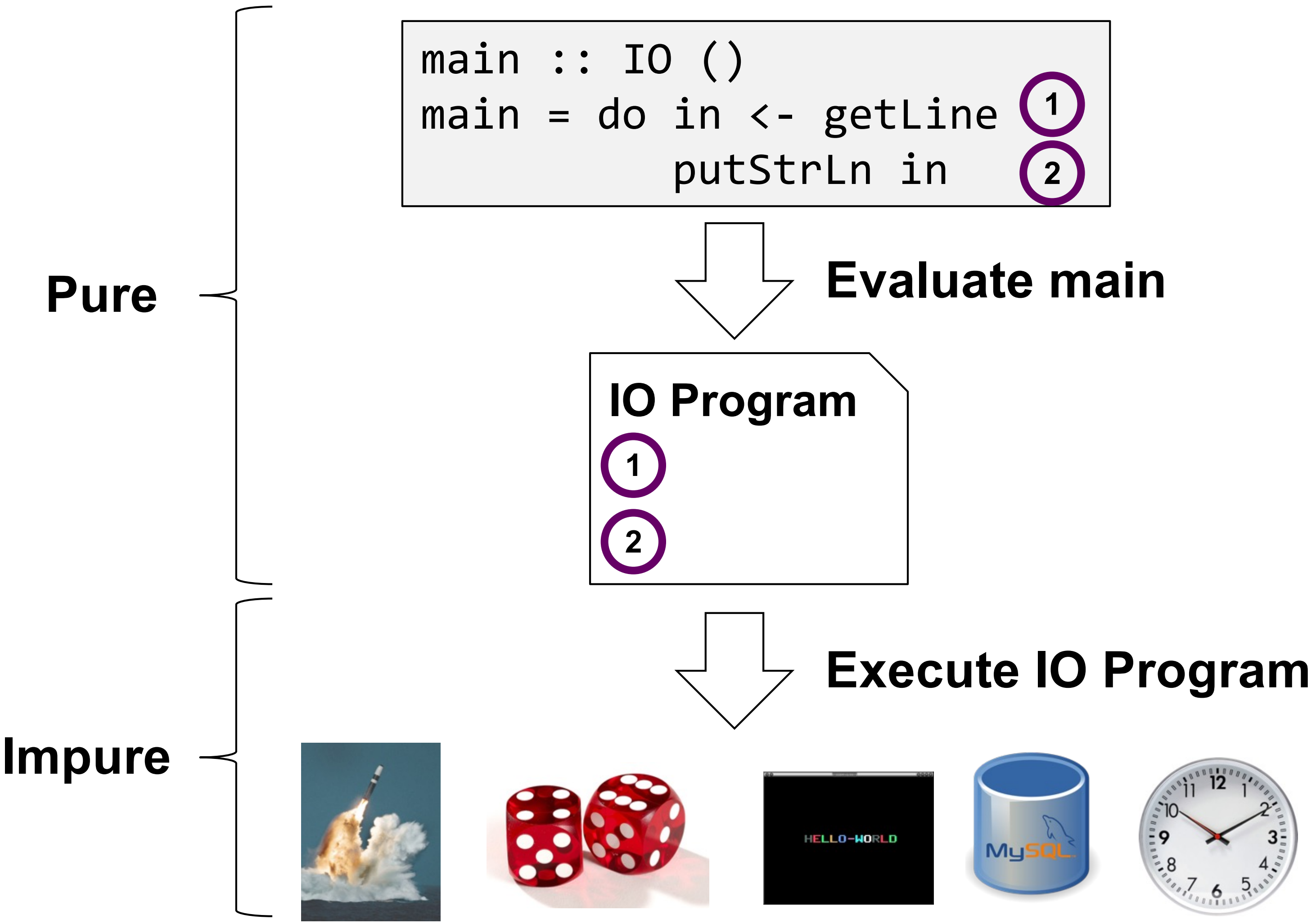
Haskell's Solution

- **I/O is best described as actions happening in sequence**
  - Example: Read an input then write to a file
- **Haskell provides the type** `IO a` **which is an I/O action of type** `a` **or an I/O program of type** `a`**.**
- **A value belonging to** `IO a` **is a program which could do some I/O and then returns a value of type** `a`**.**
- **Haskell provides some primitive I/O programs as well as a mechanism to sequence these I/O operations.**
- **I/O is not performed until the I/O programs are executed:**

```
main :: IO ()
main = do in <- getLine
          putStrLn in
```

main returns an I/O program which is then executed by the Haskell runtime system.

Haskell IO Illustrated



```
main :: IO ()
main = do in <- getLine
          putStrLn in
```

Evaluate main

IO Program

Execute IO Program

Basic IO: Reading Input, Writing Output

- **Reading a line from the standard input**

```
getLine :: IO String
```

  - A line is terminated by hitting Enter in a shell

- **Reading a single character**

```
getChar :: IO Char
```

- **Writing a string**

```
putStr :: String -> IO ()
```

- **Writing a string followed by a newline**

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

Unit – The One-Element Type

- **All IO actions must return a value:**

```
getChar :: IO Char
```

returns a Char

```
getLine :: IO String
```

returns a String

- **What should we do if you have nothing useful to return?**

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

  - The IO action created by putStrLn does not return an interesting value
    It is performed for its I/O-effect only
- **Haskell defines the type `()` called Unit which has only one single value which is also written `()` like the empty tuple**
- **Not often used since it can't transport any information**
- **We use it only in IO to denote that the returned value is not of interest but only the effect of the action**

Return

- **return creates an IO action which returns its argument when executed without any other effect**

```
return :: a -> IO a
```

- **Example**

```
main :: IO ()
main = do input    <- getLine
          putStrLn (reverse input)
          continue <- getChar
          if continue == 'y' then main else return ()
```

- **Return has nothing to do with Java's return statement!**

Simple File IO

- **Identifying a file by a path**

```
type FilePath = String
```

- **Reading content from a file**

```
readFile :: FilePath -> IO String
```

- **Writing content to a file**

```
writeFile :: FilePath -> String -> IO ()
```

- **Example: Copy a text file**

```
main = do content <- readFile "in.txt"
          writeFile "out.txt" content
```

Command Line Arguments

- **Most command line tools take arguments**

```
$ copy file1.txt file2.txt
```

- **getArgs from Module System.Environment**

```
getArgs :: IO [String]
```

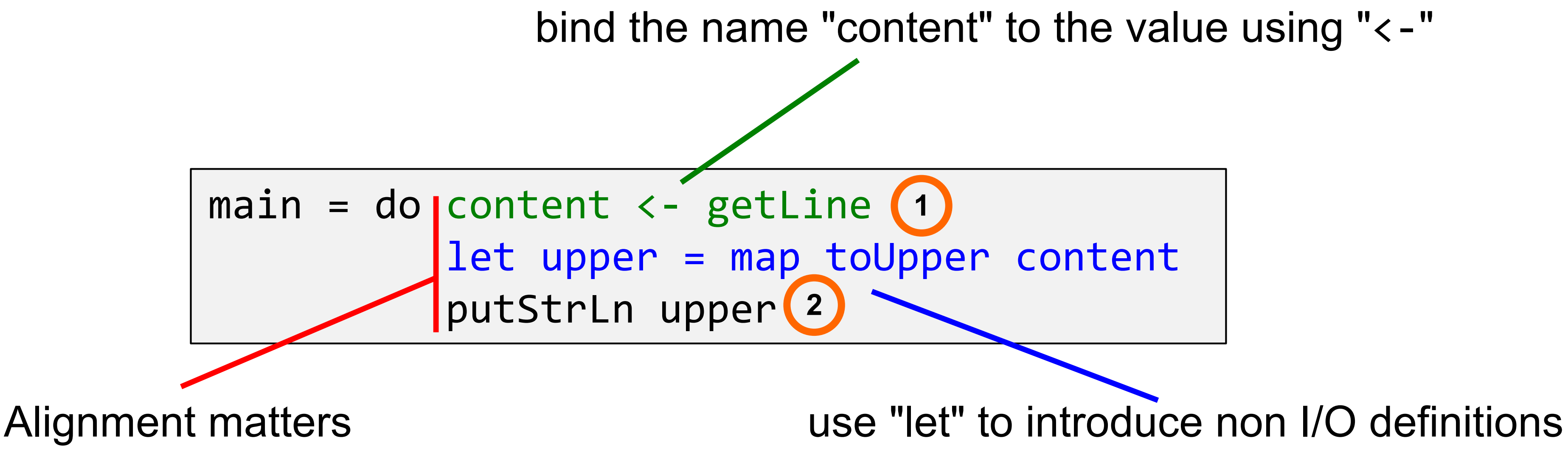
  - `getArgs` creates an IO action which returns a list of the command line arguments when executed

- **Example**

```
import System.Environment
import Data.List
main = do args <- getArgs
          putStrLn (intercalate "\n" args)
```

do Notation

- **do notation gives us a means to**
  - sequence I/O programs
  - bind names to the returned values



bind the name "content" to the value using "<-"

```
main = do content <- getLine
          let upper = map toUpper content
          putStrLn upper
```

Alignment matters

use "let" to introduce non I/O definitions

I/O programs are put in sequence: First 1 and then 2

do Notation Desugared

- **do notation is syntactic sugar for sequencing actions**
  - Original example

```
do putStr "Hi"
   name <- getLine
   putStrLn name
```

  - Rewritten using braces and semicolons

```
do { putStr "Hi" ;
     name <- getLine ;
     putStrLn name }
```

  - Desugared to applications of >> and >>=

```
(putStr "Hi") >>
getLine >>= \name ->
putStrLn name
```

do Notation Desugared cont.

- **(>>=) and (>>)**
  - describe what happens when effectful computations are sequenced
  - dubbed "programmable semicolons"

```
do {putStr "Hi" ;
    name <- getLine ;
    putStrLn name }
```

```
putStr "Hi" >> getLine >>= \name -> putStrLn name
```

- **`(>>) :: IO a -> IO b -> IO b`**
  - Sequencing actions, ignoring result of first action
- **`(>>=) :: IO a -> (a -> IO b) -> IO b`**
  - Sequencing actions, using result of first action to obtain second action

Preparations for Worksheet: Webclient

- **Start the build**

```
> cd WS_Webclient
> cabal build
```

```
On Windows use
"git bash" or "wsl"
```

```
cabal-version: >=1.10
name: WS-Webclient
version: 0.1.0.0
author: Daniel Kröni
build-type: Simple

executable webclient
  main-is: Main.hs
  build-depends: base >=4.13
                ,http-client-tls
                ,http-client
                ,bytestring
default-language: Haskell2010
```

`WS-Webclient.cabal` contains build related information

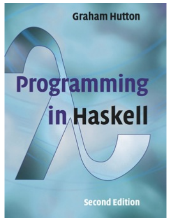
Name of the executable

Dependencies

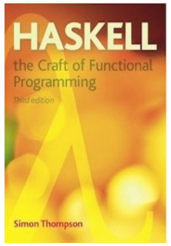
Worksheet: Webclient

```
$ ./webclient Brugg
Brugg: ⛅  +13°C
```

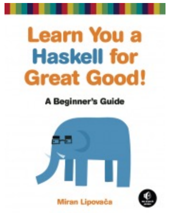
Further Reading



Chapter 10



Chapter 8



Book: Chapter 8

Web: http://learnyouahaskell.com/input-and-output