# Haskell WorkShop

## Writing your first Haskell programm

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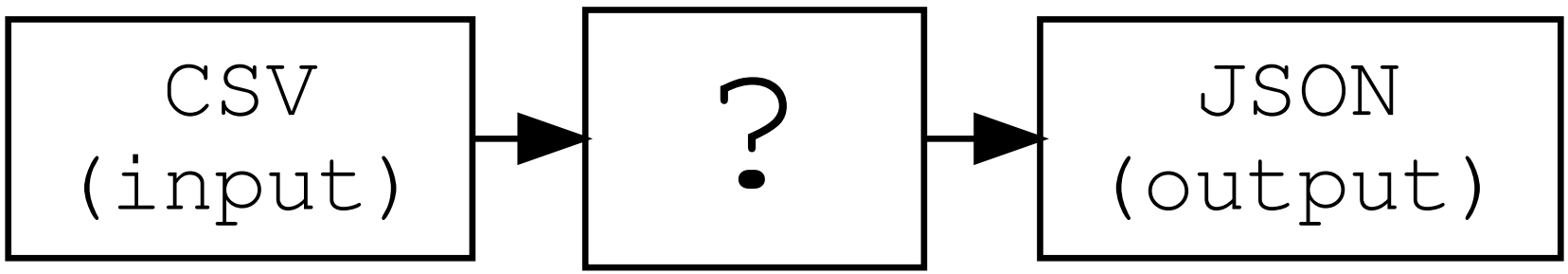
# The Goal

Develop a complete Haskell program that converts CSV data to JSON.



```
"Constituency","Party","Sex","Average age"
"Helsinki constituency","KOK","Men",47.6
"Helsinki constituency","KOK","Women",49.4
"Helsinki constituency","SDP","Men",48.0
"Helsinki constituency","SDP","Women",46.1
"Helsinki constituency","PS","Men",46.9
"Helsinki constituency","PS","Women",43.1
"Helsinki constituency","KESK","Men",44.0
"Helsinki constituency","KESK","Women",46.8
"Helsinki constituency","VAS","Men",40.3
"Helsinki constituency","VAS","Women",37.0
"Helsinki constituency","VIHR","Men",41.8
"Helsinki constituency","VIHR","Women",40.5
"Helsinki constituency","RKP","Men",39.7
"Helsinki constituency","RKP","Women",42.3
"Helsinki constituency","KD","Men",42.8
"Helsinki constituency","KD","Women",47.1
```

# The Plan

1) Haskell Development Environment
2) Hello World and some Syntax
3) The Data Model
4) Data Transformation
5) Connecting to the Outside

# The Haskell Development Environment

# Setting up your environment

- Go to the Github repo for the workshop (https://github.com/relex/haskell-workshop)
- Clone it locally
- Go to workshop1/Exercise.md
- Complete “Set up tooling” section

# Stack

- One of Haskell's build tools.
- To build a project: `stack build`
- To access the REPL: `stack repl`

```
I ~/D/haskell-workshop  presentation …  workshop1/slides  stack repl
Note: Enabling Nix integration, as it is required under NixOS
Note: Enabling Nix integration, as it is required under NixOS
Building all executables for `workshop1' once. After a successful build of all of them, only specifi
ed executables will be rebuilt.
workshop1-0.1.0.0: initial-build-steps (exe)
The following GHC options are incompatible with GHCi and have not been passed to it: -threaded
Configuring GHCi with the following packages: workshop1
Using main module: 1. Package `workshop1' component exe:workshop1-exe with main-is file: /home/nic/D
ocuments/haskell-workshop/workshop1/src/Main.hs
GHCi, version 8.4.4: http://www.haskell.org/ghc/  :? for help
[1 of 1] Compiling Main             ( /home/nic/Documents/haskell-workshop/workshop1/src/Main.hs, in
terpreted )
Ok, one module loaded.
Loaded GHCi configuration from /run/user/1000/haskell-stack-ghci/3a980dcd/ghci-script
*Main>
```

Figure 1: Basic repl

# Hello Syntax

# Playing with the REPL

- Useful tool to try things out parts of your program
- Extensively used in the workshop

# Hello World

- Open src/Main.hs
- Run in the REPL by typing `main`

```
main :: IO ()
main = putStrLn "Hello World!"
```

- `main` is special:
  - Present in every Haskell program
  - No arguments
  - Performs an IO action

# Functions and Types

- The primary way of defining computation is with **functions**
- **Types** describe the inputs and outputs of functions
- Working with two languages at once :)

```
identity :: Int -> Int
identity x = x

hello :: String -> String
hello name = "Hello, " ++ name

addInt :: Int -> Int -> Int
addInt x y = x + y
```

# A First Function

- A function that converts (some) integers to words
- Pattern matching

```
intToWord :: Int -> String
intToWord 1 = "one"
intToWord 2 = "two"
intToWord 3 = "three"
intToWord _ = "dunno"
```

# Polymorphic Types

- Some functions have the same behaviour for values of different types
  - E.g. the `identity` function
- Can generalise functions by using **type variables**

```
identity :: a -> a
identity x = x
```

- Can also **constrain** the type variables

```
add :: Num a => a -> a -> a
add x y = x + y
```

- These constraints can be defined using **type classes**

# Composition

- Using the output of one function as the input of another function: **“chaining functions together”**
- Use the dot operator for composition

```haskell
f :: Int -> Int
f x = x + 1

g :: Int -> Int
g x = x * 2

h :: Int -> Int
h = g . f

(.) :: (b -> c) -> (a -> b) -> a -> c
(.) f g x = g (f x)
```

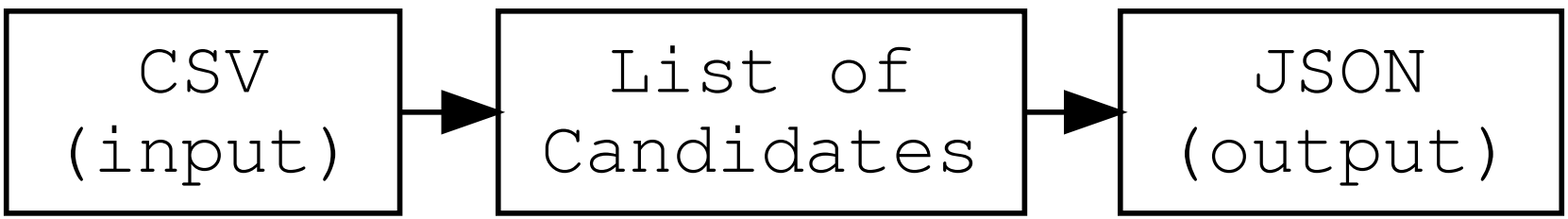
# The Data Model

# Goal

- Create a data structure that accurately models the data
- Introduce `Maybe`
- Introduce lists

## Approach

- Define a model for a single row of data (a candidate)
- Apply this model to all the rows



# A Single Candidate

```
1 "Constituency","Party","Sex","Average age"
2 "Helsinki constituency","KOK","Men",47.6
3 "Helsinki constituency","KOK","Women",49.4
4 "Helsinki constituency","SDP","Men",48.0
5 "Helsinki constituency","SDP","Women",46.1
6 "Helsinki constituency","PS","Men",46.9
7 "Helsinki constituency","PS","Women",43.1
8 "Helsinki constituency","KESK","Men",44.0
```

- A candidate has 4 attributes:
  - constituency
  - party
  - sex
  - average age
- Need a way of grouping these together

# Data Types

A simple data type:

```haskell
data Person = MakePerson
  { name :: String
  , age  :: Int
  } deriving Show
```

- `Person` is the type being defined
- `MakePerson` is the constructor function
- `name, age` are fields with associated types
- `deriving Show` allows the use of the `show` function
  - `show` converts structure to a string

# Working with Data Types

- Creating a new data type:

```
MakePerson :: String -> String -> Person
```

- Accessing the data type:

```
name :: Person -> String
age :: Person -> Int
```

```
*Main> let neo = MakePerson "Neo (The One)" 34
*Main> neo
MakePerson {name = "Neo (The One)", age = 34}
*Main> name neo
"Neo (The One)"
*Main> age neo
34
*Main>
```

# The Maybe Type

- What happens if we cannot parse a candidate?
- Need some way to represent the failure case:

```
data Maybe a = Nothing | Just a
```

- `Maybe` is the type being defined
- `a` is a **type variable** (could be any type)
- `Nothing, Just` are **both** constructors

# The List Type

- How do we represent a list of candidates?
- Use singly-linked lists:
  - `[]` is the empty list
  - `:` lets you append values to the front
  - `[a,b,c] == (a : b : c : [])`

```
*Main> (1 : 2 : 3 : [])
[1,2,3]
*Main> 10 : [1,2,3]
[10,1,2,3]
*Main> [1 .. 10]
[1,2,3,4,5,6,7,8,9,10]
*Main> ("I'm" : "in" : "a" : "list" : [])
["I'm","in","a","list"]
*Main>
```

# The Data Model

- Define our basic candidate type:

```haskell
data Candidate = Candidate
  { constituency :: String
  , party        :: String
  , sex          :: String
  , averageAge   :: Double
  } deriving Show
```

- Add a notion of failure: `Maybe Candidate`
- Create a list of candidates: `[Maybe Candidate]`

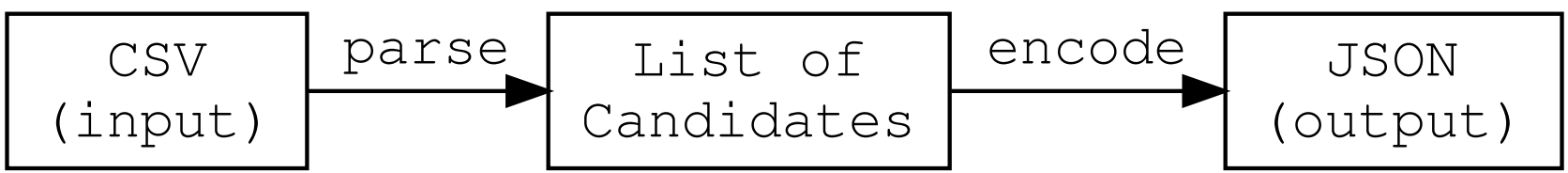
# Data Transformation

# Goal

- Write some functions to:
  - Convert CSV into data model
  - Convert data model into JSON
- Demonstrate power of `Generic`
- Introduce `map`

## Approach

- Write a function `parseLine :: CSV -> Candidate`
- Generate a function `encode :: Candidate -> JSON`
- Apply these to every row



# Writing `parseLine :: CSV -> Candidate`

```haskell
parseLine :: String -> Maybe Candidate
parseLine line =
  case splitOn ',' line of
    [c, p, s, a] ->
      case readMaybe a of
        Nothing -> Nothing
        Just a' -> Candidate c p s a'
    _ -> Nothing
```

- Use case statement to pattern match on possible outcomes
- _ means “for every other value”
- `splitOn` splits a string into a list of strings on a character
- `readMaybe` decodes a double from a string (may fail)

ps: there’s an error in the code above, try and find it!

# Stripping Quotes

```haskell
stripQ :: String -> String
stripQ = leftStrip . rightStrip
  where
    leftStrip :: String -> String
    leftStrip ('"' : xs) = xs
    leftStrip xs         = xs

    rightStrip :: String -> String
    rightStrip = undefined
```

- Use `leftStrip` and `reverse` to implement `rightStrip`
- A string is literally a list of characters (`Char`)
- `where` used to define local functions
- Point-free style
- composition FTW!

# parseLine v2

- Using `stripQ` to improve `parseLine`

```haskell
parseLine :: String -> Maybe Candidate
parseLine line =
  case splitOn ',' line of
    [c, p, s, a] ->
      case readMaybe a of
        Nothing -> Nothing
        Just a' ->
          let c' = stripQ c
              p' = stripQ p
              s' = stripQ s
          in Just (Candidate c' p' s' a')
    _ -> Nothing
```

# Generating `encode :: Candidate -> JSON`

```haskell
{-# LANGUAGE DeriveGeneric #-}
main Main where

import qualified Data.Aeson       as JSON
import qualified Data.ByteString as B

data Candidate =
  ...
  deriving (Show, Generic)

instance JSON.ToJSON Candidate
```

- Language extensions expand the Haskell language
- `Data.Aeson` provides encoding to and from JSON
- `Data.ByteString` provides efficient binary strings
- Ta-da! We can use JSON.encode now

# Using `JSON.encode`

- Try it out in the REPL!

```
> :set -XDeriveGeneric
> import qualified Data.Aeson as JSON
> import qualified Data.ByteString.Lazy as BL
> let candidate = Candidate "Helsinki" "KOK" "Women" 49.4
> B.putStr (JSON.encode candidate)
{"constituency":"Helsinki","averageAge":49.4,"party":"KOK","sex":"Women"}
```

# The `map` function

- How do we apply `parseLine` to every row?
- Use `map`, a **higher-order function**
- Takes a function and a list as input and applies the function to every item in the list

```
map :: (a -> b) -> [a] -> [b]
map f []     = []
map f (x:xs) = f x : map f xs
```

- Defined using **recursion**
- Can apply `parseLine` to structures of type `[String]`

# The Full Parser

- We are ready to write the full parser function:
- `lines` splits strings into lines
- `tail` removes the first item in a list

```haskell
parseFile :: String -> [Maybe Candidate]
parseFile = map parseLine . tail . lines
```

- We don't have to write this for encoding

# Connecting to the Outside

# Goal

- Write a complete program!
- Introduce IO and do notation

## Approach

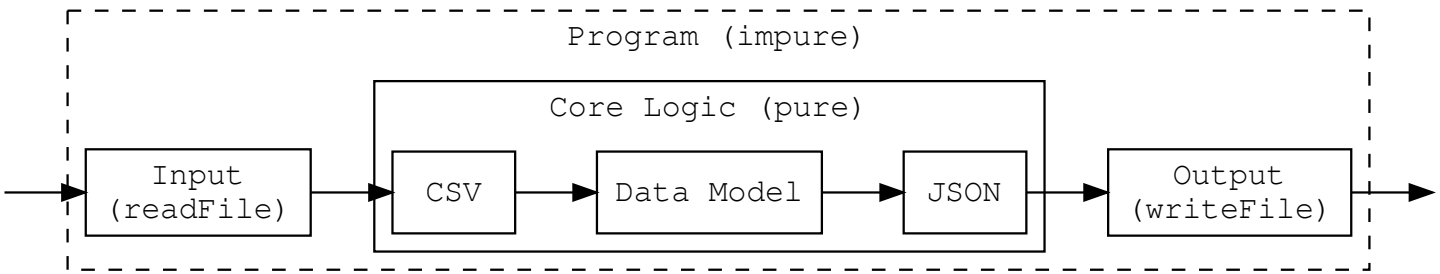
- Introduce purity and impurity
- Write main function

# Purity in Haskell

- All functions we have written in the previous section are **pure**
- A pure function **always** returns the same **output** when given the same **input**
- This behaviour is **enforced by the compiler**
- Why?
  - Code is easier to refactor and reason about
  - Interactions with the outside world are more explicit
  - Easy to test
- Pure functions cannot interact with the world
- So how do we communicate with the outside world?

# IO and do notation

- Communication with the outside handled through IO
- Impurity is always explicitly encoded in the types



# Read / Write

# The Complete App

# Conclusion

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# Challenges

# Further Reading


That's all Folks!