Haskell4Life:
Types and Typeclasses

Sergiu Ivanov

sergiu.ivanov@lacl.fr

Slides and code examples available online:

http://lacl.fr/~sivanov/doku.php?id=en:haskell_for_life

Warm Up

https://openclipart.org/

What is a class?

What is a type?

Outline

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Classes and Types

A class/type is a set of objects sharing a property.

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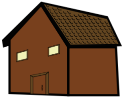
house = { , , , . . . }

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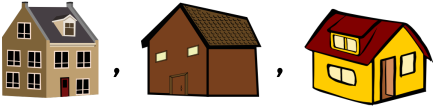
house = {  , . . . }

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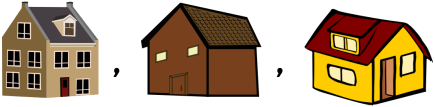
house = {  , ... }

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$\text{house} \subseteq \text{building}$

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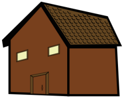
house = {  ,  ,  , $\ldots$ }

Inheritance = set inclusion

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Every house is a building, but not every building is a house.

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Typeclasses in Haskell: Vague Idea

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Typeclasses in Haskell $\neq$ classes in other languages.

Classes in other languages $\sim$ types in Haskell

The use of the word class to refer to different things is just a “coincidence”.

Outline

1. Vague Definitions
2. Algebraic Data Types
3. Parameterised and Recursive Data Types
4. Typeclasses

Defining a New Datatype

```
data BookInfo = Book Int String [String]
                deriving ( Show )
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data constructor

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Defining a New Datatype

data
constructor

first
field

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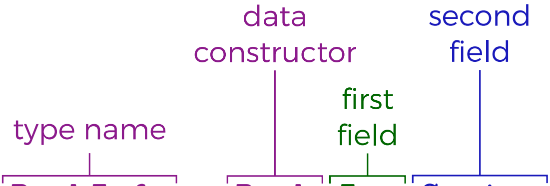


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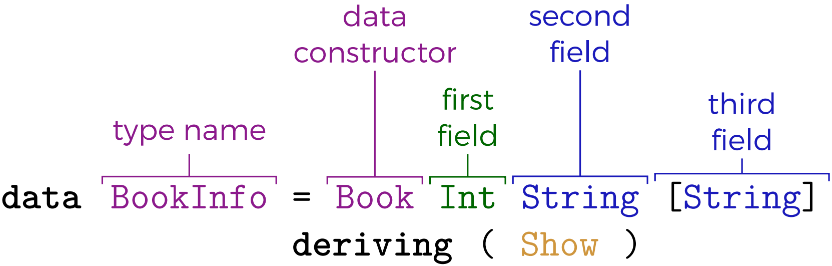
Defining a New Datatype



Defining a New Datatype

```
data BookInfo = Book Int String [String]
                deriving ( Show )
```

- type name: BookInfo
- data constructor: Book
- first field: Int
- second field: String
- third field: [String]
- automatically derive `show`: Show

Defining a New Datatype

data constructor

second field

first field

third field

type name

```
data BookInfo = Book Int String [String]
                deriving ( Show )
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automatically derive `show`

`show` converts “anything” to `String`.

Constructing and Deconstructing a Value

```
λ> let hp = Book 1997 "Harry Potter"
                ["J. K. Rowling"]
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λ> year
1997

λ> title
"Harry Potter"

λ> authors
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```

Naming Conventions

Type names start with capital letters.

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Function and variable names start with lowercase letters.

Type variables start with lowercase letters.

Often the same name is used for the type and the data constructor.

```
data IntPair = IntPair Int Int
```

Type Synonyms

```haskell
type Year = Int
```

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```haskell
type Year = Int
type Title = String
type Author = String
data BookInfo = BookInfo Year Title [Author]
```

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type Year = Int
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type Author = String
data BookInfo = BookInfo Year Title [Author]
```

Symbolic names are not enforced:

```
("J. K. Rowling" :: Author) :: String
```

is a valid expression.

Data Types vs. Tuples

```
type Cartesian2D = (Double,Double)
```

vs.

```
data Cartesian2D = Cartesian2D Double Double
```

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On the other hand,

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type Polar2D = Polar2D Double Double /= Cartesian2D
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Data types allow distinguishing at compile time between semantically different types which have the same syntactical structure.

Algebraic Data Types

Algebraic data types have ≥ 1 data constructor.

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data Bool = True | False
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```

```
type Mass = Double
type Volume = Double
data Cargo = Solid Mass | Liquid Volume
           | Gas Volume | Plasma Volume
```

Outline

Parameterised Data Types

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data Pair a = Pair a a
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```

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λ> let p1 = Pair True False
λ> :type p1
p1 :: Pair Bool
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Parameterised Data Types

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λ> let p1 = Pair True False
λ> :type p1
p1 :: Pair Bool

λ> let p2 = Pair "Hello" "World"
λ> :type p2
p2 :: Pair String
```

The `Maybe` Type

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

Very often used to represent a container which may transport a data item or may be empty.

The List Type

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```
data List a = Cons a (List a) | Nil
          deriving (Show)
```

```
Nil
```

The List Type

```
data List a = Cons a (List a) | Nil
            deriving (Show)
```

```
      Nil
Cons 3 Nil
```

The List Type

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data List a = Cons a (List a) | Nil
        deriving (Show)
```

```
                Nil
         Cons 3 Nil
Cons 2 (Cons 3 Nil)
```

The List Type

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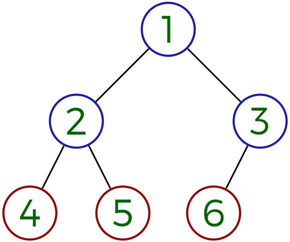
data List a = Cons a (List a) | Nil
            deriving (Show)
```

```
                    Nil
             Cons 3 Nil
      Cons 2 (Cons 3 Nil)
Cons 1 (Cons 2 (Cons 3 Nil))
```

The BinaryTree Type



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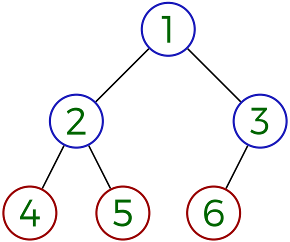
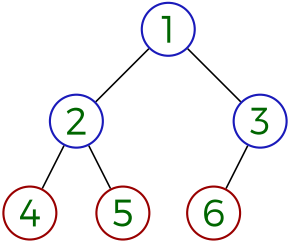



```
data Tree a = Node a (Tree a) (Tree a)
```

The BinaryTree Type




```
data Tree a = Node a (Tree a) (Tree a)
            | Empty
            deriving (Show)
```

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A typeclass specifies which functions should be defined for a type.

An Example of a Typeclass

```
class BasicEq foo where
  isEqual :: foo -> foo -> Bool
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A type `foo` belongs to the typeclass `BasicEq` if there exists a version of the function `isEqual` defined for it.

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A type `foo` belongs to the typeclass `BasicEq` if there exists a version of the function `isEqual` defined for it.

One can say that, to verify whether a value of type `a` appears in a list of `a`, we need to be able to compare values of type `a` in the following way:

```
isElement :: BasicEq a => a -> [a] -> Bool
```

Saying That a Type Belongs to a Typeclass

```
instance BasicEq Bool where
  isEqual True True = True
  isEqual False False = True
  isEqual _ _ = False
```

Typeclasses Show and Read (in a nutshell)

```
class Show a where
  show :: a -> String

class Read a where
  read :: String -> a
```

Automatic Derivation of Instances

Instances of `Show`, `Read`, `Eq`, `Ord`, `Bounded`, `Enum` can be derived automatically.

```
data Maybe a = Just a | Nothing
                 deriving (Show,Read,Eq)
```