

Tutorium 03: Typen und Typklassen

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09. November 2020

Tutorium Programmierparadigmen am KIT

Heutiges Programm

- Übungsblätter 1 und 2
- Wiederholung der Vorlesung: Typen und Typklassen
- Datentypen selbst definieren

Übungsblatt 1

1.2.{1,2} – Insertionsort

```
module Sort1 where

insert x [] = [x]
insert x (y:ys)
  | x <= y    = x : y : ys
  | otherwise = y : insert x ys

insertSort []      = []
insertSort (x:xs) = insert x (insertSort xs)

insertSort' :: Ord a => [a] -> [a]
insertSort' = foldr insert []
```

1.2.{3,4} – Mergesort

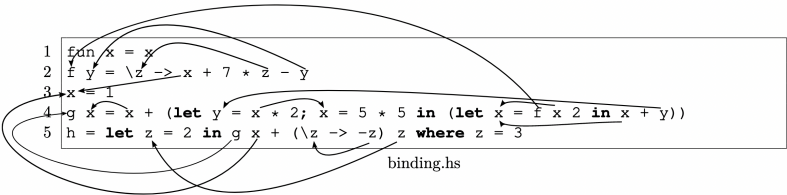
```
module MergeSort where

merge left@(x:xs) right@(y:ys)
  | x <= y      = x : merge xs    right
  | otherwise   = y : merge left  ys
merge left right = left ++ right

mergeSort []      = []
mergeSort [x]     = [x]
mergeSort list =
  merge (mergeSort left) (mergeSort right)
  where left  = take (length list `div` 2) list
        right = drop (length list `div` 2) list
```

Übungsblatt 2

2.1 – Bindung und Gültigkeitsbereiche



```
1 fun x = x
2 f y = \z -> x + 7 * z - y
3 x = 1
4 g x = x + (let y = x * 2; x = 5 * 5 in (let x = f x 2 in x + y))
5 h = let z = 2 in g x + (\z -> -z) z where z = 3
```

The diagram illustrates variable binding and scope resolution in the provided Haskell code. Arrows indicate the following:

- Line 1: `fun x = x`. An arrow points from `x` to its definition.
- Line 2: `f y = \z -> x + 7 * z - y`. Arrows point from `x` to line 1 and from `z` to the lambda parameter.
- Line 3: `x = 1`. An arrow points from `x` to its definition.
- Line 4: `g x = x + (let y = x * 2; x = 5 * 5 in (let x = f x 2 in x + y))`. Arrows show `x` binding to line 3, `y` binding to `x * 2`, the inner `x` binding to `f x 2`, and `f` binding to line 2.
- Line 5: `h = let z = 2 in g x + (\z -> -z) z where z = 3`. Arrows show `z` binding to `z = 2`, `g` binding to line 4, the lambda `\z` binding to its parameter, and the `where z = 3` binding to the `z` in the lambda body.

binding.hs

- Größte Fehlerquelle: `x * 2` und `f x 2` in Zeile 4
- Beide zeigen auf Definition im selben `let`-Block
- \leadsto Allgemein: Variablen zeigen möglicherweise auf eine Definition im selben `let`-Block, selbst wenn es ihre eigene ist.

2.2.{1,2,3} – Polynome

```
module Polynom where

type Polynom = [Double]

cmult polynom c = map (* c) polynom

eval polynom x = foldr go 0 polynom
  where go a_n acc = acc * x + a_n

deriv [] = []
deriv polynom = zipWith (*) [1..] $ tail polynom
```

$(\$)$:: $(a \rightarrow b) \rightarrow a \rightarrow b$ – Funktionsanwendung als Operator.

Wiederholung:

Typen und Typklassen

Cheatsheet: Typen

- Char, Int, Integer, ...
- String
- Typvariablen/Polymorphe Typen:
 - (a, b): Tupel
 - [a]: Listen
 - a -> b: Funktionen
 - Vgl. Java: List<A>, Function<A, B>
- Typsynonyme: type String = [Char]

Cheatsheet: Algebraische Datentypen in Haskell

- data-Definitionen, Datenkonstruktoren
- Algebraische Datentypen: Produkttypen und Summentypen
 - Produkttypen \approx structs in C
 - Summentypen \approx enums
- Typkonstruktoren, bspw. `[] :: * -> *`
- Polymorphe Datentypen, bspw. `[a]`, `Maybe a`
- Beispiel:

```
module Shape where

data Shape
  = Circle Double -- radius
  | Rectangle Double Double -- sides
  | Point -- technically equivalent to Circle 0
```

Cheatsheet: Typklassen 1

- Klasse, Operationen/Methoden, Instanzen
- Beispiele:
 - `Eq t, {(==), (/=)}`, `{Eq Bool, Eq Int, Eq Char, ...}`
 - `Show t, {show}`, `{Show Bool, Show Int, Show Char, ...}`
- Weitere Typklassen: `Ord`, `Num`, `Enum`
- Deklaration/Implementierung:

```
module Truthy where

class Truthy t where
  toBool :: t -> Bool

instance Truthy Int where
  toBool x = x /= 0
```

Cheatsheet: Typklassen 2

- Vererbung: Typklassen mit Voraussetzungen

```
module Truthy2 where

class Truthy t where
  toBool :: t -> Bool

instance Truthy Int where
  toBool x = x /= 0

instance Truthy t => Truthy (Maybe t) where
  toBool Nothing  = False
  toBool (Just x) = toBool x
```

Typen selbst definieren

Typen selbst definieren

Modelliert mit data:

- Führerschein
- Spielkarten
- Monopolykarten
- Boolesche Ausdrücke
- (Typen in Haskell)
- MiMa-Instruktionen

Vorlagen: codi.pbrinkmeier.de/s/wq88qbGYy


```
module DriversLicense where

data DriversLicense = DriversLicense
  [VehicleClass]
  String
  (Int, Int, Int)

data VehicleClass = A | B Bool | BE | C | D
```

- Klasse B kann Zusatzziffer B96 haben.
- Für Daten gibt es natürlich auch eigene Typen.
- Beispiel:

```
DriversLicense [A, B True] "Arthur" (1, 1, 1970)
```

```
module PlayingCard where

data PlayingCard = PlayingCard Suit Rank

data Suit = Hearts | Diamonds | Clubs | Spades
data Rank
    = Rank7 | Rank8 | Rank9 | Rank10
    | Jack  | Queen | King  | Ace
```

Monopolykarten

```
module Monopoly where

data MonopolyCard
  = Street String Rent Int Color
  | Station String
  | Utility String

data Rent = Rent Int Int Int Int Int Int

data Color
  = Brown | LightBlue | Pink | Orange
  | Red | Yellow | Green | Blue
```

Boolesche Logik

```
module BoolExpr where

data BoolExpr
  = Const Bool
  | Var String
  | Neg BoolExpr
  | BinaryOp BoolExpr BinaryOp BoolExpr

data BinaryOp = AND | OR | XOR | NOR
```

Beispiele:

- $a \wedge b$ entspricht `BinaryOp (Var "a") AND (Var "b")`
- $a \vee (b \wedge 0)$ entspricht
`BinaryOp (Var "a") AND (BinaryOp (Var "b") OR (Const False))`

```
module MiMa where
```

```
data MimaInst
```

```
  = LDC Int | LDV Int | STV Int  
  | ADD Int | AND Int | OR Int  
  | EQL Int | JMP Int | JMN Int  
  | HALT | NOT | RAR
```

```
-- Alternatively:
```

```
data MimaInst' =
```

```
  Nullary MimaNullary | Unary MimaUnary Int
```

```
data MimaUnary = LDC' | LDV' | STV' | ADD' -- ...
```

```
data MimaNullary = HALT' | NOT' | RAR'
```

Typklassen implementieren

Implementierung von Typklassen

Implementiert:

- Monopolykarten: `Eq MonopolyCard`, `Show MonopolyCard`
- Boolesche Ausdrücke: `Show BoolExpr`
- Typen in Haskell: `Show Type`
- MiMa-Instruktionen: `Show MiMaInst`
- Spielkarten: `Eq` und `Ord` für `Suit`, `Rank` und `PlayingCard`
 - `Ord PlayingCard`: Zuerst nach Farbe, dann nach Wert.

Aufgabe: Spielkarten + eine weitere

```
module PlayingCard2 where
import PlayingCard
instance Eq Suit where
    Hearts    == Hearts    = True
    Diamonds == Diamonds = True
    Clubs     == Clubs     = True
    Spades    == Spades    = True
    _         == _         = False
instance Ord Suit where
    s1 <= s2 = toInt s1 <= toInt s2
    where toInt Hearts    = 0
          toInt Diamonds = 1
          toInt Clubs     = 2
          toInt Spades    = 3
```



```
module PlayingCard3 where

data PlayingCard = PlayingCard Suit Rank
  deriving (Eq, Ord, Show)

data Suit = Hearts | Diamonds | Clubs | Spades
  deriving (Eq, Ord, Show, Enum)
data Rank
  = Rank7 | Rank8 | Rank9 | Rank10
  | Jack | Queen | King | Ace
  deriving (Eq, Ord, Show, Enum)
```

Enum ermöglicht es, bspw. [Hearts .. Spades] zu schreiben.