Haskell les 2

Functies zijn cool

door Pietervdn

Syntax

If then else

- Speciale syntax
- Geeft een waarde terug

```
if boolean then expressie else
expressie
```

If then else

```
fac :: Int -> Int
fac i = if i == 0 then 1
        else i * fac $ i - 1
```

Syntax met pattern matching is beter

Case

- Speciale syntax
- Geeft een waarde terug

```
case expressie of
   pattern match -> expressie
   pattern match -> expressie
   ...
```

Case

```
case list of
  [] -> 0
  (False:as) -> length as
  (True:True:_) -> 2
```

Tuple

Soms willen we verschillende waardes teruggeven/groeperen

```
(“Pieter”, 1993)
(“Ilion”, 1996)
```

Tuple

Soms willen we verschillende waardes teruggeven/groeperen

```
gegevensVan :: Int -> (String, Int)
gegevensVan id = ...
```

Tuple

```
sumTuple :: (Int, Int) -> Int
sumTuple (i,j) = i + j
```

Tuple

```
fst       :: (a,b) -> a
fst (a,_) = a

snd       :: (a,b) -> b
snd (_,b) = b
```

Tuple

```
fmap :: (b -> c) -> (a,b) -> (a,c)
fmap f (a,b) = (a, f b)
```

Lambda functie

- Anonieme functies

```
\ pattern match -> expressie
```

Lambda functie

```
map (\i -> i + 1) [1,2,3]
map (\(a:as) -> a:a:as) [[1,2],[3]]
```

Currying

Plus: twee implementaties

```
plus :: Int -> Int -> Int
plus i j   = i + j

plus :: Int -> (Int -> Int)
plus i     = \j -> i + j
```

Plus: twee implementaties

```
map (plus 5) [1,2,3]
```

Plus: drie implementaties

```
plus :: Int -> Int -> Int
plus i j   = i + j
plus i     = \j -> i + j
plus       = \i -> \ j -> i + j
```

Elke functie is zo opgebouwd

Zipwith

```
zipWith plus [1,2,3] [4,5,6]
zipWith (+) [1,2,3] [4,5,6]

map (plus 1) [1,2,3]
map (+1) [1,2,3]
```

Abstract Data Types

Sum types

ADT

Abstract Data Type

Volledig gedefinieerd door functies

Boolean

```
data Boolean  = Fls | Tr
   deriving (Show)
```

We maken een eigen type `Boolean` bestaande uit `{Fls, Tr}`

Boolean

We kunnen ons type `Boolean` nu gebruiken

```
and' :: Boolean -> Boolean -> Boolean
```

Boolean

We kunnen ons type `Boolean` nu gebruiken
En pattern matchen

```
and' :: Boolean -> Boolean -> Boolean
Tr Tr = Tr
Fls Fls = Fls
```

ADT

Wat zijn die `Fls` en `Tr` nu juist?

Het is een *functie* (zonder argumenten) die iets van het type *`Boolean`* geeft

```
:t Fls
      Fls :: Boolean
:t Tr
      Tr :: Boolean
```

Sum type

`Boolean` is een *sum type*

Het is *ofwel* `Tr`, *ofwel* `Fls`

```
Boolean = {Tr} + {Fls}
```

Abstract Data Types

Product types

Person

```
data Person  = P String Int
   deriving (Show)
```

We maken een eigen type `Person`

Person

We kunnen ons type `Person` nu gebruiken

```
name :: Person -> String
```

Person

We kunnen ons type `Person` nu gebruiken
En pattern matchen

```
name :: Person -> String
name (P n _) = n
```

Person

Wat is die `P` nu juist?

Het is een *functie* (die een string en een getal neemt) en er een *`Person`* van maakt

```
:t P
      P :: String -> Int -> Person
```

Person

```
P “Pieter” 1993  :: Person
P “Ilion” 1996   :: Person
```

Person

```
P “Pieter” 1993  :: Person
P “Ilion” 1996   :: Person
P “Eloïse” 1996  :: Person
```

`P` is een **constructor**

Person

Ook constructoren kan je curryen

```
P “Pieter” 1993  :: Person
P “Ilion”        :: Int -> Person
P                :: String -> Int -> Person
```

Person

Ook constructoren kan je curryen

```
map (P “Kenneth”) [1995, 1996]
  = [P “Kenneth” 1995, P “Kenneth” 1996]
zipWith P [“Pieter”, “Ilion”, “Kenneth”]
[1993,1996,1995]
   = [P “Pieter” 1993, P “Ilion” 1996,
         P “Ketnet” 1995]
```

Product type

`Person` is een *product type*

```
Person = {P} *
         {“”,”a”,”aa”,”ab”,...} *
         {0,1,2,3, ...}
```

Abstract Data Types

Sum-Product types

MaybeInt

```
data MaybeInt = Just Int
              | Nothing
```

MaybeInt

We kunnen ons type `MaybeInt` nu gebruiken

```
add :: Int -> MaybeInt -> MaybeInt
```

MaybeInt

We kunnen ons type `MaybeInt` nu gebruiken
En pattern matchen

```
add :: Int -> MaybeInt -> MaybeInt
add i (Just j) = Just $ i + j
add i Nothing  = Nothing
```

MaybeInt

Wat is die `Nothing` nu juist?

Het is een *functie* (zonder argumenten) die iets van het type `MaybeInt` geeft

```
:t Nothing
      Nothing :: MaybeInt
```

MaybeInt

Wat is die `Just` nu juist?

Het is een *functie* (met een getal als argument) die iets van het type `MaybeInt` geeft

```
:t Just
      Just :: Int -> MaybeInt
```

MaybeInt

```
Just 5
Nothing
```

MaybeInt

```
Just 5
Nothing
```

`Just` is een **constructor**

`Nothing` is een **constructor**

MaybeInt

Ook constructoren kan je curryen

```
Just 5          :: MaybeInt
Just            :: Int -> MaybeInt
Nothing         :: MaybeInt
```

MaybeInt

Ook constructoren kan je curryen

```
map Just [1995, 1996]
  = [Just 1995, Just 1996]
```

Sum - Product type

`MaybeInt` is een *sum-product type*

```
MaybeInt = {Nothing} +
                {Just} * {0,1,2,3, ...}
```

Polymorfe ADTs

MaybeInt

```
data MaybeInt = Just Int
              | Nothing
```

MaybeBool

```
data MaybeBool = Just Bool
               | Nothing
```

MaybeString

```
data MaybeString = Just String
                 | Nothing
```

Maybe a

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

(Kleine letter)

Maybe a

Wat is die `Just` nu juist?

Het is een *functie* (met een **a** als argument) die iets van het type `Maybe` **a** geeft

```
:t Just
      Just :: a -> Maybe a
```

Maybe a

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a)= Just $ f a
```

Maybe a

```
fmap (+1) (Just 5)
```

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a)= Just $ f a
```

Maybe a

```
fmap (+1) (Just 5)
```

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a) = Just $ f a
```

Maybe a

```
fmap (+1) (Just 5)
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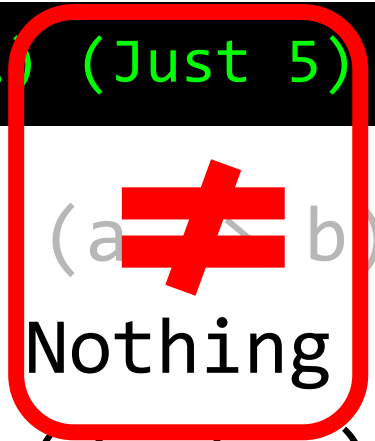


```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a) = Just $ f a
```

Maybe a

```
fmap (+1) (Just 5)
```

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a)= Just $ f a
```

Maybe a

```
fmap (+1) (Just 5)
```

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a) = Just $ f a
```

Maybe a

```
fmap (+1) (Just 5)
```

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a) = Just $ f a
```

Maybe a

```
Just $ (+1) 5
```

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a)= Just $ f a
```

Maybe a

```
Just 6
```

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a)= Just $ f a
```

Maybe a

```
Just 6
```

```
fmap :: (a -> b) -> Maybe a -> Maybe b
fmap _ Nothing = Nothing
fmap f (Just a)= Just $ f a
```

Fmap voert *f* uit op de `a` in de `Maybe`

Maybe a

```
join :: Maybe (Maybe a) -> Maybe a
join (Just (Just a))  = Just a
join _   = Nothing
```

Maybe a

```
join (Just (Just 5))
```

```
join :: Maybe (Maybe a) -> Maybe a
join (Just (Just a))  = Just a
join _    = Nothing
```

Maybe a

```
join (Just (Just 5))
```

```
join :: Maybe (Maybe a) -> Maybe a
join (Just (Just a)) = Just a
join _               = Nothing
```

Maybe a

```
join (Just (Just 5))
```

```
join :: Maybe (Maybe a) -> Maybe a
join (Just (Just a)) = Just a
join _               = Nothing
```

Maybe a

```
join (Just (Just 5))
```

```
join :: Maybe (Maybe a) -> Maybe a
join (Just (Just a)) = Just a
join _               = Nothing
```

Maybe a

```
Just 5
```

```
join :: Maybe (Maybe a) -> Maybe a
join (Just (Just a))  = Just a
join _    = Nothing
```

Recursieve ADTs

List a

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

List a

Wat is die `Nil` nu juist?

Het is een *functie* (zonder argumenten) die iets van het type `List a` geeft

```
:t Nil
      Nil :: List a
```

List a

Wat is die `Cons` nu juist?

Het is een *functie* (met twee argumenten) die iets van het type `List a` geeft

```
:t Cons
      Cons :: a -> List a -> List a
```

List a

```
Nil                   :: List a
Cons 5 Nil            :: List Int
Cons 6 (Cons 5 Nil)   :: List Int
```

Haskell's gewone lijsten hebben speciale syntax:

`(:)` ipv `Cons`

`[a]` ipv `List a`

List a

```
head :: List a -> a
head (Cons a _) = a

tail :: List a -> List a
tail (Cons _ as) = as
```

Higher order programming

List a vs Maybe a

- `map`, `doeElk` en `concatMap` ook definieerbaar op onze eigen `List`
- Equivalenten voor `Maybe a`?

DoeOp

Gegeven: `Maybe (a -> b), Maybe a`

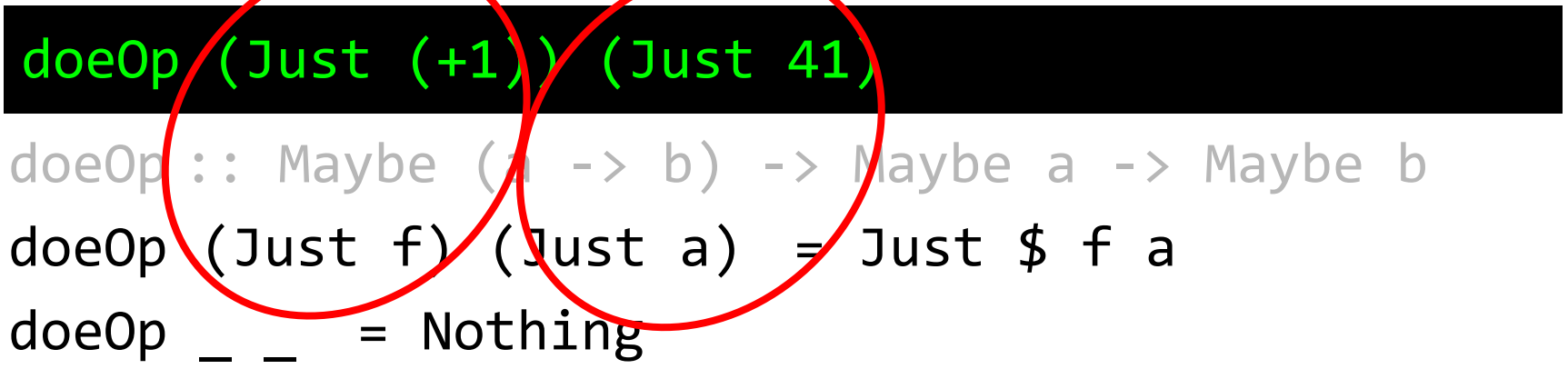
```
doeOp :: Maybe (a -> b) -> Maybe a -> Maybe b
doeOp (Just f) (Just a)  = Just $ f a
doeOp _ _  = Nothing
```

DoeOp

```
doeOp (Just (+1)) (Just 41)
```

```
doeOp :: Maybe (a -> b) -> Maybe a -> Maybe b
doeOp (Just f) (Just a)  = Just $ f a
doeOp _ _  = Nothing
```

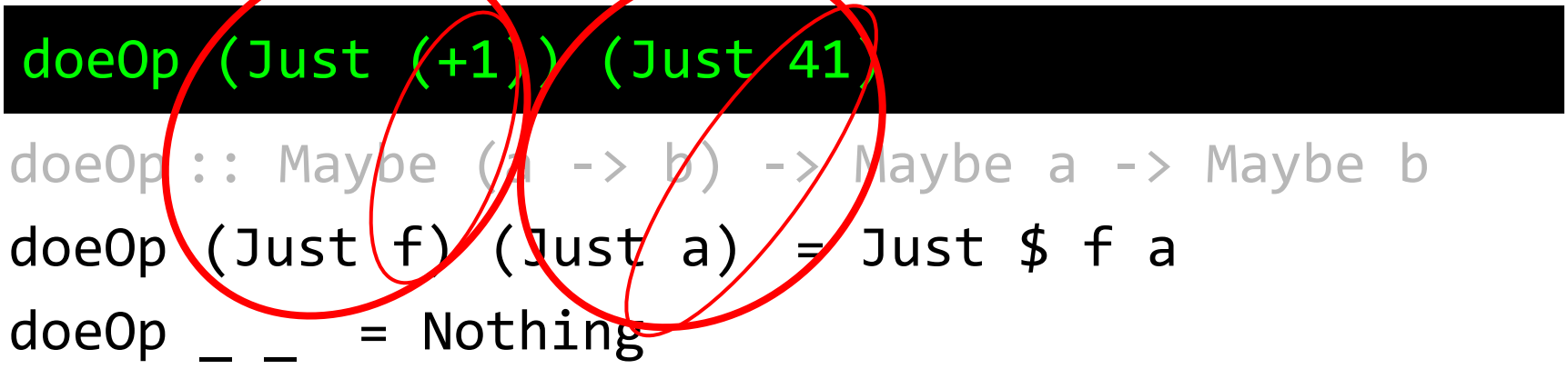
DoeOp



```
doeOp (Just (+1)) (Just 41)
```

```
doeOp :: Maybe (a -> b) -> Maybe a -> Maybe b
doeOp (Just f) (Just a)  = Just $ f a
doeOp _ _   = Nothing
```

DoeOp



```
doeOp (Just (+1)) (Just 41)
```

```
doeOp :: Maybe (a -> b) -> Maybe a -> Maybe b
doeOp (Just f) (Just a) = Just $ f a
doeOp _ _   = Nothing
```

DoeOp

```
Just $ (+1) 41
```

```
doeOp :: Maybe (a -> b) -> Maybe a -> Maybe b
doeOp (Just f) (Just a)  = Just $ f a
doeOp _ _  = Nothing
```

DoeOp

```
Just 42
```

```
doeOp :: Maybe (a -> b) -> Maybe a -> Maybe b
doeOp (Just f) (Just a)  = Just $ f a
doeOp _ _  = Nothing
```

Higher order programming

Databank lookups

```
data :: [(String, Int)]
data =[(“Pieter”,21),
       (“Ilion”,18),(“Kenneth”,19)]
```

Databank lookups

```
lookup :: a -> [(a,b)] -> Maybe a
lookup _ []  = Nothing
lookup k ((a,b):abs)
     = if k == a then Just b
                 else lookup k abs
```

Databank lookups

Gemeenschappelijke leeftijd van 3 gegeven personen?

Databank lookups

```
totLeeftijd   :: (String, String) ->
                    [(String, Int)] -> Maybe Int
totLeeftijd (p0,p1) db
   = lookup p0 db           :: Maybe Int
```

Databank lookups

```
totLeeftijd   :: (String, String) ->
                    [(String, Int)] -> Maybe Int
totLeeftijd (p0,p1) db
   = case lookup p0 db of
        Nothing -> Nothing
        Just i  -> case lookup p1 db of
                      Nothing -> Nothing
                      Just j  -> Just (i + j)
```

Databank lookups

Slechte stijl

- Nesting van cases
- “Staircase of doom”

We can do better!

Databank lookups

```
totLeeftijd   :: (String, String) ->
                    [(String, Int)] -> Maybe Int
totLeeftijd (p0,p1) db
    = case lookup p0 db of
        Nothing -> Nothing
        Just i  -> case lookup p1 db of
                     Nothing -> Nothing
                     Just j  -> Just (i + j)
```

Databank lookups

```
totLeeftijd   :: (String, String) ->
                    [(String, Int)] -> Maybe Int
totLeeftijd (p0,p1) db
   = case lookup p0 db of
        Nothing -> Nothing
        Just i  -> case lookup p1 db of
                     Nothing -> Nothing
                     Just j  -> Just (i + j)
```

Databank lookups

```
andThen :: Maybe a -> (a -> Maybe b) -> Maybe b
andThen maybeA f
   = case maybeA of
        Nothing -> Nothing
        (Just a)-> f a
```

Databank lookups

```
totLeeftijd   :: (String, String) ->
                        [(String, Int)] -> Maybe Int
totLeeftijd (p0,p1) db
   = lookup p0 db `andThen`
            (\i -> lookup p1 db `andThen`
            (\j -> Just (i + j) ))
```

Databank lookups

```
totLeeftijd   :: (String, String, String) ->
                        [(String, Int)] -> Maybe Int
totLeeftijd (p0,p1,p2) db
   = lookup p0 db `andThen`
            (\i -> lookup p1 db `andThen`
            (\j -> lookup p2 db `andThen`
            (\k -> Just (i + j + k) )))
```

Tooling
modules en imports

Module

Een module is stuk samenhorende code

Bestandsnaam = moduleNaam.hs

Module

```
module ModuleNaam where

... code ...
```

Module

```
module Boolean where

data Boolean = Tr | Fls


and' :: ...
```

Module

```
module AndereModule where

import Boolean
```

Module

```
module AndereModule where

import Boolean (Boolean, and')
```

Module

```
module AndereModule where

import Boolean (Boolean (Tr, Fls))
```

Module

```
module AndereModule where

import Boolean hiding (Boolean, and')
```

Module

```
module AndereModule where

import qualified Boolean as B

someFunction :: B.Boolean -> …
someFunction (B.Tr)
```

Module

```
module AndereModule where

import Prelude
```

Module

```
module AndereModule where

import Prelude hiding (...)
```

Tooling: hlint

Oefeningen

Oefeningen

github.com/pietervdvn/Haskell/les2

Slides en oplossingen komen online