
III. Funktionale Programmierung

- 1. Prinzipien der funktionalen Programmierung
- 2. Deklarationen
- 3. Ausdrücke
- 4. Muster (Patterns)
- 5. Typen und Datenstrukturen
- 6. Funktionale Programmiertechniken: Funktionen höherer Ordnung

Funktionen höherer Ordnung: `comp`

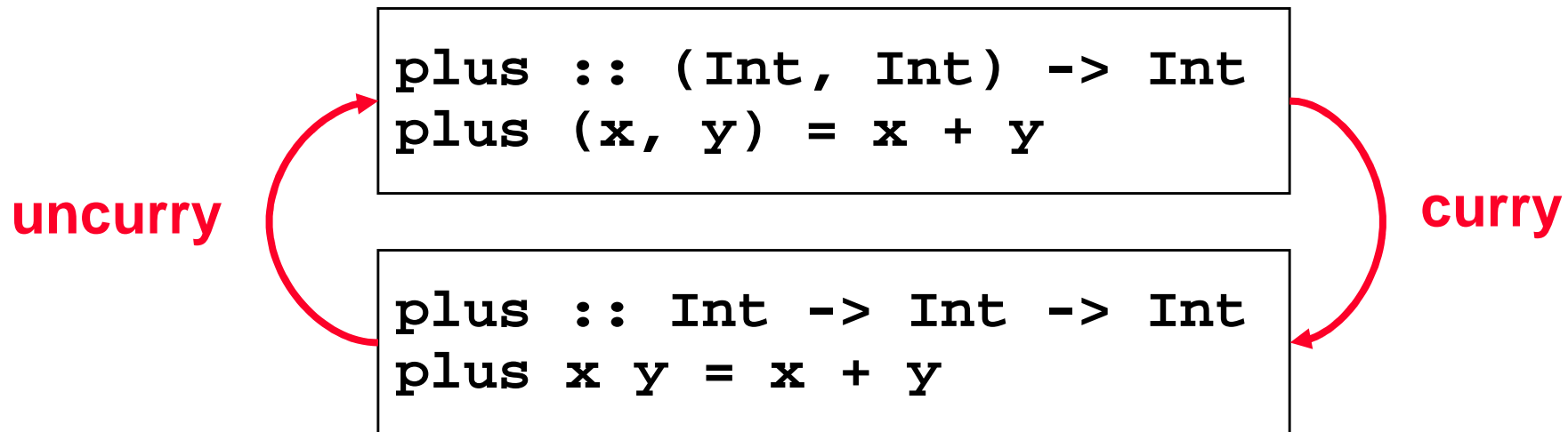
```
comp :: (b -> c) -> (a -> b) -> (a -> c)
```

```
comp f g = \x -> f (g x)
```

Argument vom Typ: `(b -> c)`

Ergebnis vom Typ: `(a -> b) -> (a -> c)`

Funktionen höherer Ordnung: curry



```
curry :: ((a,b) -> c) -> a -> b -> c
curry f = g
      where g x y = f (x,y)
```

```
uncurry :: (a -> b -> c) -> (a,b) -> c
uncurry g = f
      where f (x,y) = g x y
```

Funktionen höherer Ordnung: map

```
suclist :: [Int] -> [Int]
suclist [] = []
suclist (x:xs) = suc x : suclist xs
```

```
sqrtdlist :: [Float] -> [Float]
sqrtdlist [] = []
sqrtdlist (x:xs) = sqrt x : sqrtdlist xs
```

```
suclist [x1, ..., xn] = [suc x1, ..., suc xn]
sqrtdlist [x1, ..., xn] = [sqrt x1, ..., sqrt xn]
map g [x1, ..., xn] = [g x1, ..., g xn]
```

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

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

Funktionen höherer Ordnung: map

```
suclist :: [Int] -> [Int]
suclist = map suc
```

```
sqrtlist :: [Float] -> [Float]
sqrtlist = map sqrt
```

```
suclist [x1, ..., xn] = [suc x1, ..., suc xn]
sqrtlist [x1, ..., xn] = [sqrt x1, ..., sqrt xn]
map g [x1, ..., xn] = [g x1, ..., g xn]
```

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

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

Funktionen höherer Ordnung: filter

```
dropEven :: [ Int ] -> [ Int ]
dropEven [] = []
dropEven (x:xs) | odd x = x : dropEven xs
                | otherwise = dropEven xs
```

```
dropUpper :: [ Char ] -> [ Char ]
dropUpper [] = []
dropUpper (x:xs) | isLower x = x : dropUpper xs
                 | otherwise = dropUpper xs
```

```
f :: [ a ] -> [ a ]
f [] = []
f (x:xs) | g x = x : f xs
         | otherwise = f xs
```

vordefiniert im
Modul Char:
import Char

```
filter :: (a -> Bool) -> [a] -> [a]
filter g [] = []
filter g (x:xs) | g x = x : filter g xs
                | otherwise = filter g xs
```

Funktionen höherer Ordnung: filter

```
dropEven :: [ Int ] -> [ Int ]  
dropEven = filter odd
```

```
dropUpper :: [ Char ] -> [ Char ]  
dropUpper = filter isLower
```

```
f :: [ a ] -> [ a ]  
f [] = []  
f (x:xs) | g x = x : f xs  
         | otherwise = f xs
```

```
filter :: (a -> Bool) -> [a] -> [a]  
filter g [] = []  
filter g (x:xs) | g x = x : filter g xs  
                | otherwise = filter g xs
```

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Unendliche Datenobjekte

```
from :: Int -> [Int]
from x = x : from (x+1)
```

```
take :: Int -> [a] -> [a]
take 0 _ = []
take n (x:xs) = x : take (n-1) xs
```

```
take 1 (from 5)
= take 1 (5 : from (5+1))
= 5 : take (1-1) (from (5+1))
= 5 : take 0 (from (5+1))
= 5 : []
= [5]
```

Sieb des Eratosthenes

1. Erstelle Liste aller natürlichen Zahlen ab 2.
2. Markiere die erste unmarkierte Zahl in der Liste.
3. Streiche alle Vielfachen der letzten markierten Zahl.
4. Gehe zurück zu Schritt 2.

```
drop_mult :: Int -> [Int] -> [Int]
drop_mult x xs = filter (\y -> mod y x /= 0) xs
```

```
dropall :: [Int] -> [Int]
dropall (x:xs) = x : dropall (drop_mult x xs)
```

```
primes :: [Int]
primes = dropall (from 2)
```

Sieb des Eratosthenes

```
primes = [2,3,5,7,11,13,17,19,23,29,31,...
```

```
take 5 primes = [2,3,5,7,11]
```

```
drop_mult :: Int -> [Int] -> [Int]
drop_mult x xs = filter (\y -> mod y x /= 0) xs
```

```
dropall :: [Int] -> [Int]
dropall (x:xs) = x : dropall (drop_mult x xs)
```

```
primes :: [Int]
primes = dropall (from 2)
```