A Syntax for Composable Data Types in Haskell

A User-friendly Syntax for Solving the Expression Problem

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Introduction

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data Expr = Const Int | Add Expr Expr | Mul Expr Expr
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eval :: Expr -> Int
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- Extend both data types and set of functions without recompiling old code

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- Extend both data types and set of functions without recompiling old code
- The expression problem

This Project

- Designed syntax components for a solution to the expression problem

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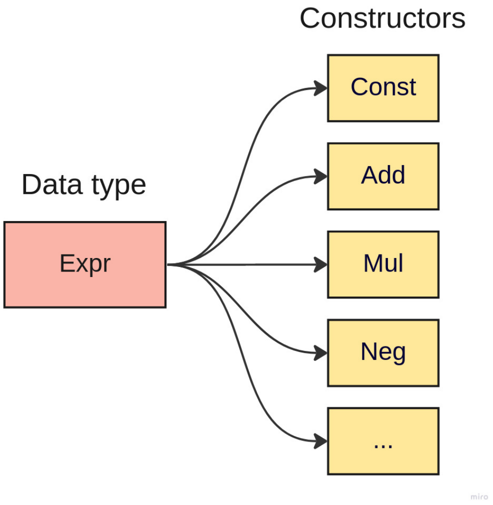
- A transformation into standard Haskell with `compdata`

Background

Automatic Extension of Data Types



Open Data Types

Automatic extension of data types

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Add :: Expr -> Expr -> Expr
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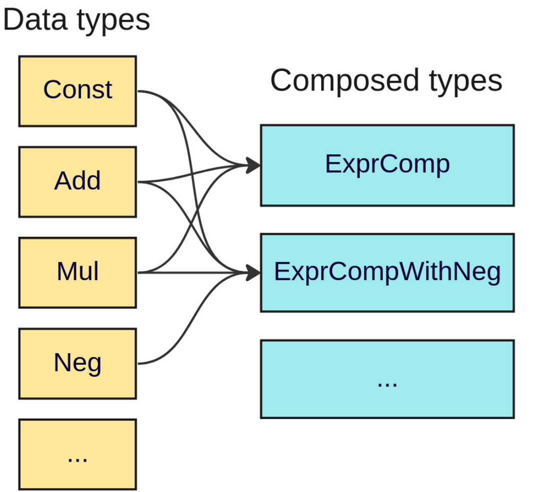
Simple syntax, but limited in expressive power

Composable Data Types



Data Types in compdata

Composable data types

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data Term f = In (f (Term f))

data (f :+: g) e = Inl (f e) | Inr (g e)
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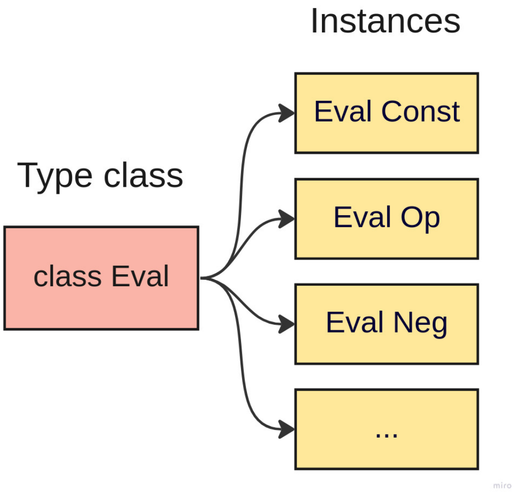
Complex syntax, but higher expressive power

Automatic Extension of Functions



Extensible Functions in compdata

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class Eval f where
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instance (Eval f, Eval g) => Eval (f :+: g) where
    eval' (Inl a) = eval' a
    eval' (Inr b) = eval' b
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instance Eval Neg where
    eval' (Neg e) = (-1) * eval e
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Constructors in compdata

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threePlusFive :: ExprComp
threePlusFive = In (Inr (Add (In (Inl (Const 3)))
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Subsumption

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inject :: (g :<: f) => g (Term f) -> Term f
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Smart constructors

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iAdd :: (Op :<: f) => Term f -> Term f -> Term f
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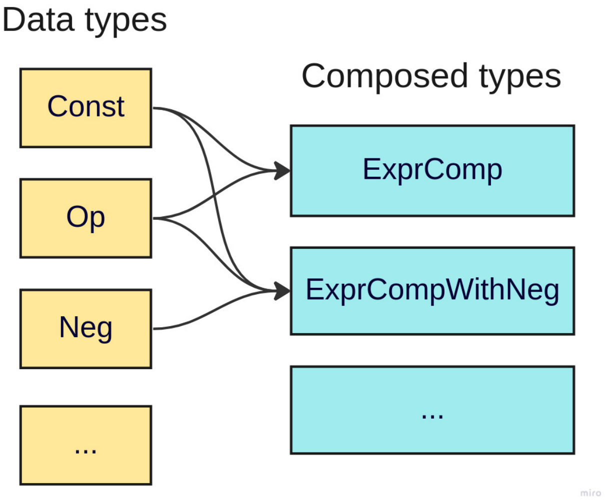
threePlusFive' :: ExprComp
threePlusFive' = iConst 3 `iAdd` iConst 5
```

Our syntax and transformation

Data Types


Data types
Composed types
Const
Op
Neg
...
ExprComp
ExprCompWithNeg
...
miro

Data Types

```
data piece Const = Const Int
data piece Op = Add Expr Expr
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type ExprComp = (Const | Op)
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piececategory Expr

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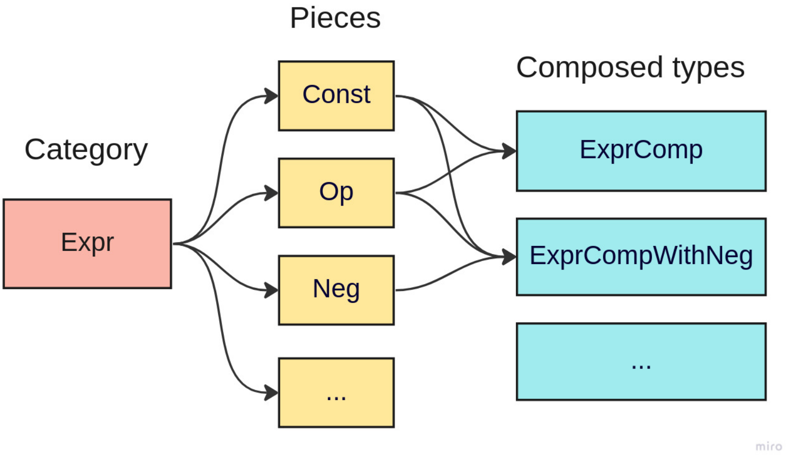
Data Types


Pieces
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Category
Expr
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Transformation of Data Types

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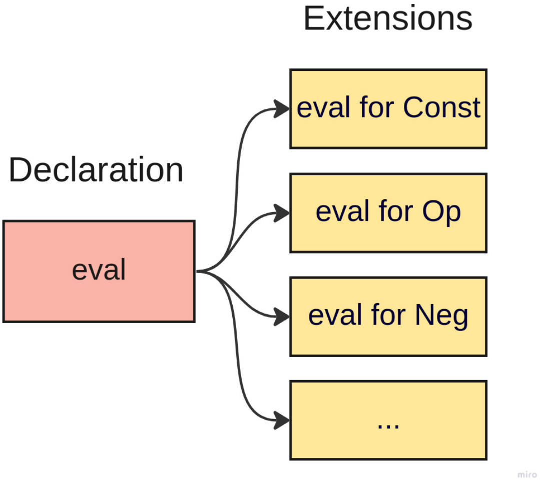
Extensible Functions



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    eval (Const i) = i

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Transformation of Function Declaration

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class Eval f where
    eval' :: Eval g => f (Term g) -> Int
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```
$(derive [liftSum] [''Eval])
```

```
class Eval_outer t where
    eval :: t -> Int
instance Eval g => Eval_outer (Term g) where
    eval = eval' . unTerm
```

Transformation of Function Extensions

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ext eval for Const where
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threePlusFive :: ExprComp
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Piece Constraints

```
constTwo :: Expr ==> (Const)
constTwo = Const 2

twoMulThreePlusFive ::
    Expr ==> (Const | Op)
twoMulThreePlusFive = constTwo `Mul`
    (Const 3 `Add` Const 5)
```

Piece Constraints

```
constTwo :: Const partof e => e
constTwo = Const 2

twoMulThreePlusFive ::
    (Const partof e, Op partof e) => e
twoMulThreePlusFive = constTwo `Mul`
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```
constTwo :: Const :<: f => Term f
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twoMulThreePlusFive ::
    (Const :<: f, Op :<: f) => Term f
```

Transforming `e` to `Term f` is difficult!

Piece Constraints with PartOf

```haskell
class PartOf f e where
    inject' :: f e -> e
instance f :<: g => PartOf f (Term g) where
    inject' = inject
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constTwo :: PartOf Const e => e
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    (PartOf Const e, PartOf Op e) => e
```

Smart Constructors with PartOf

```haskell
iConst :: (PartOf Const e) => Int -> e
iConst i = inject' (Const i)
```

```haskell
iAdd :: (PartOf Op e) => e -> e -> e
iAdd e1 e2 = inject' (Add e1 e2)
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```haskell
iMul :: (PartOf Op e) => e -> e -> e
iMul e1 e2 = inject' (Mul e1 e2)
```

Function Constraints

```
evalCond -: Expr -> Bool -> Int

evalFalse :: Expr ==> (Const | Op) -> Int
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    evalCond :: t -> Bool -> Int
instance EvalCond g => EvalCond_outer (Term g) where
    evalCond = evalCond' . unTerm
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Discussion and Conclusion

Multi-Variant Pieces

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data piece Expr ==> Op = Add Expr Expr | Mul Expr Expr
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Should a piece have several constructors?

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But more piece constraints, larger composed types,
no way to group constructors

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- Characterizing some solutions to the expression problem

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- Characterizing some solutions to the expression problem
- A syntax for composable data types
- A working transformation into standard Haskell
- Combined concepts of composable data types and automatically extended data types

The End

Thank you for your attention!