Fixing Records in Haskell

Neil Mitchell et al, ndmitchell.com

an in-your-face, glaring weakness telling you there is something wrong with Haskell
- Greg Weber

What is your least favorite thing about Haskell? Records are still tedious -
2018 State of Haskell Survey

Haskell's record system is a cruel joke - Scrive

The record system is a continual source of pain
- Stephen Diehl

Records' syntax sucks
- Bitcheese

myPerson.name

Which language is this?

It can be Haskell!

- Using record-dot-preprocessor
  - github.com/ndmitchell/record-dot-preprocessor
  - Available as a textual preprocessor and plugin
- Using DAML – a Haskell derivative
  - daml.com
- If the latest GHC proposal gets accepted and implemented
  - tinyurl.com/ghc-records

Forbidden Questions (until later)

What I want to do

```
data Company = Company {
    name :: String,
    owner :: Person}
data Person = Person {
    name :: String,
    age :: Int}
```

ERROR: Multiple declarations of ‘name’

Automatic selectors

- Haskell helpfully generates

```
name :: Company -> String
owner :: Company -> Person
name :: Person -> String
age :: Person -> Int
```

ERROR: Multiple declarations of ‘name’

What I actually do #1

```
data Company = Company {
   companyName :: String,
   companyOwner :: Person}
data Person = Person {
   personName :: String,
   personAge :: Int}


personName (companyOwner x)
```

What I actually do #2

```
import qualified Company(Company(..)) as C
import qualified Person(Person(..)) as P

P.name (C.owner x)
```

What I actually do #3

Especially when explaining this to Haskell beginners…
Especially experienced programmers…

With RecordDotSyntax

```
data Company = Company {
    name :: String,
    owner :: Person}
data Person = Person {
    name :: String,
    age :: Int}


x.owner.name
```

This change is a BIG deal

- DAML is a Haskell inspired DSL for smart contracts on a Distributed Ledger
  - Written by Digital Asset, a company that is hiring, that I used to work for: digitalasset.com
- Wanted to move from *Haskell inspired* to *GHC based implementation*
- Records stopped us, until we implemented this extension (in use ~18 months)

How does it work?

- Step 1: Don’t generate the selectors
  - Already part of the NoFieldSelectors proposal
  - But now how do I get at the fields?
  - Record puns to the rescue

```
case x of
    Company{owner} -> case owner of
        Person{name} -> name
```

Sugar that up #1

a.B.c => case a of B{c} -> c

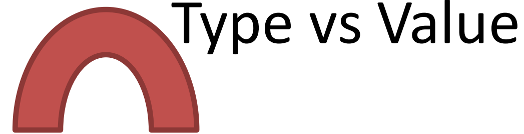
x.Company.owner.Person.name

- Ugly! Company should be inferred from the type of ‘a’.

Sugar that up #2

x.owner.name

a.b => getField a b



getField :: r -> String -> *F* r String

"b" :: String -- a *value* of *type* String

@"b" :: Label -- a *type* of *kind* Label

Implement that sugar

```
class HasField x r a | x r -> a where
  getField :: r -> a

instance HasField "name" Person String where
  getField Person{name} = name

x.owner.name
getField @"name" (getField @"owner" x)
```

Appreciate the Magic

- NoFieldSelectors
- HasField type class
- Automatic instances
- Minor syntax sugar

= records solved

Pairs of labels

```
instance (HasField l1 a b, HasField l2 b c) =>
    HasField (l1, l2) a c where
        getField = getField @l2 . getField @l1
```

- Since type is either a Label (lifted String) or pair (lifted pair)

```
getField @("owner", "name") x
```

Standalone selectors

- Old world

```
map name people
```

- New world

```
map (getField @"name") people
map (.name) people
```

Record Updates

Step 1: Make them work

```
a{b=c}  =>  setField @"b" a c
```

```
class HasField x r a | x r -> a where
    setField :: r -> a -> r
```

Step 2: Multiple field updates

- a{b=c, d=e}

```
setField @"d" (setField @"b" a c) e
```

Real updates are more powerful.
Where did I cheat?

Type changing updates!

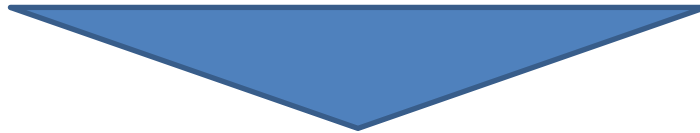
```
data Foo a = Foo {foo :: [a], bar :: Int}

(x :: Foo Int){foo = [True]} :: Foo Bool

setField :: Label -> r -> v -> F Label r v
```

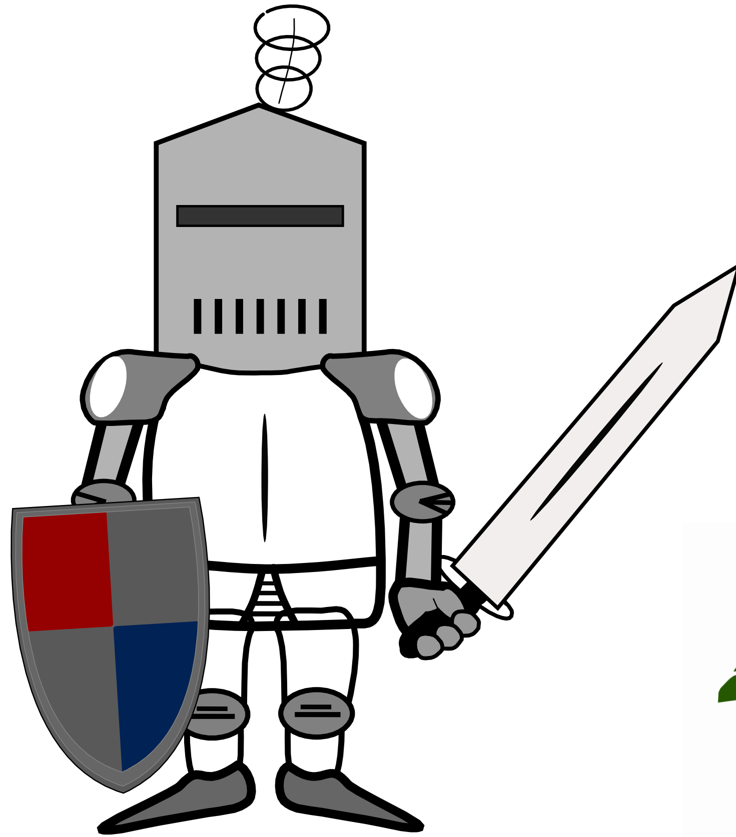
Type inference issues

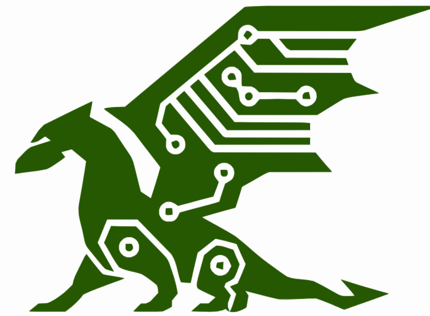
```
x{foo = [], bar = 2}
setField @"bar" (setField @"foo" x []) 2
```



:: Foo ???

There are complex solutions, but…





Powerful idea

Complex and rarely used feature

Easily emulated

```
let Foo{..} = x in Foo{foo=[], bar=2, ...}
```

Deep updates still suck

- Set the age of the owner to 42

```
x{owner = x.owner{age=42}}
```

Repeated owner twice. Gets much worse as we nest further.

Deep updates fixed

- Set the age of the owner to 42

```
x{owner.age = 42}
```

```
setField @("owner","age") x 42
```

Field modification still sucks

- Increment the age of the owner

```
x{owner.age = x.owner.age + 1}
```

Not terrible, but not beautiful.

Field modification fixed

- Increment the age of the owner

```
x{owner.age + 1}

modifyField @("owner","age") x (+ (1))
```

Field modification with lambda

- Do something weird

```
x{owner.age & \i -> floor $ sqrt (i * 57) + 21}

modifyField @("owner","age") x (& (\i -> …))

Data.Function.(&) = flip ($)
```

Is modifyField expensive?

```
-- Traversing the structure twice is bad (maybe?)
modifyField @l x f =
    setField @l x $ f $ getField @l x

instance HasField x r a | x r -> a where
    hasField :: r -> (a, a -> r)

modifyField @l x f = u $ f v
    where (v, u) = hasField @l x
```

HasField FAQ

- Can I define my own HasField instance, e.g. to pretend my structure has a virtual field
  - Yes, you can. Let’s not do one for Map though, please…

- Can I access non-exported fields now?
  - No. HasField is magic. GHC manufactures it locally only if the field/constructor are in scope.

Hmm, DuplicateRecordFields?

- An extension in GHC that let's you write:

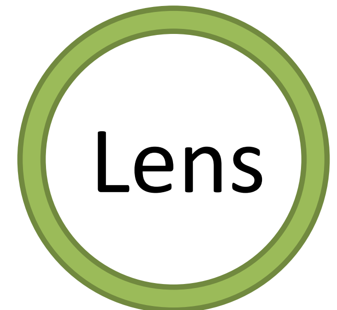
name (owner c :: Person)

- name's arg must be *a locally known type*:
  - f c = name (owner (c :: Company)) -- bad
  - f c = name (owner c :: Person) -- good
  - f (p :: Person) = name p -- bad
- We use real constraints for better power

Did you just reinvent lenses?

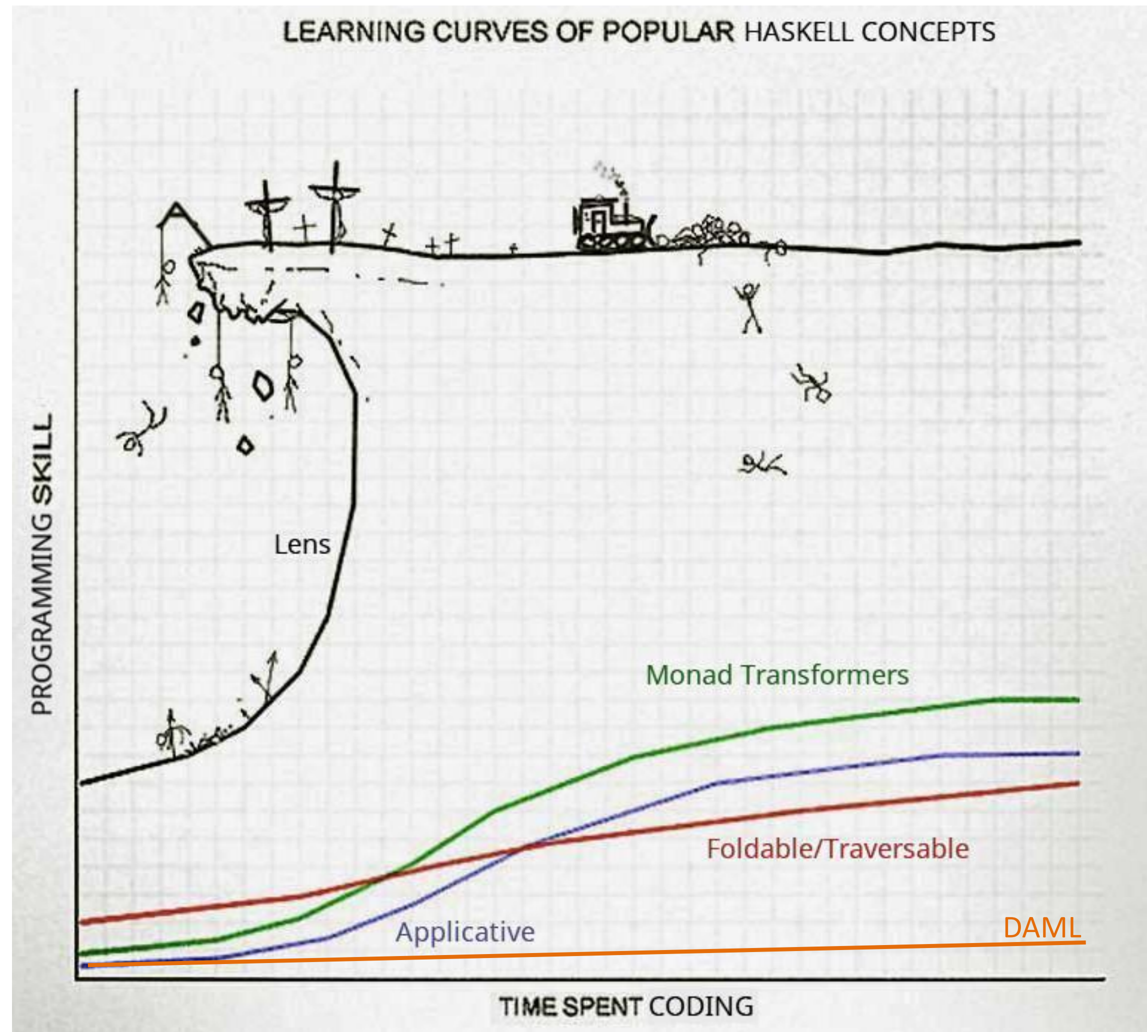
- There's definitely overlap!
- Lenses are record fields as first-class values, which is awesome. Powerful. Scary. These records are concrete.

- It does conflict with the lens c^.companyOwner.personName style.



Remember the original motivation

For the domain of DAML, lens is not a feasible solution.



Syntactic extensions

Expression	**Equivalent**
e.lbl	getField @"lbl" e
e{lbl = val}	setField @"lbl" e val
(.lbl)	(\x -> x.lbl)
e{lbl1.lbl2 = val}	e{lbl1 = (e.lbl1){lbl2 = val}}
e{lbl * val}	e{lbl = e.lbl * val}
e{lbl1.lbl2}	e{lbl1.lbl2 = lbl2}

Combinations

Expression	**Equivalent**
e.lbl1.lbl2	(e.lbl1).lbl2
(.lbl1.lbl2)	(\x -> x.lbl1.lbl2)
e.lbl1{lbl2 = val}	(e.lbl1){lbl2 = val}
e{lbl1 = val}.lbl2	(e{lbl1 = val}).lbl2
e{lbl1.lbl2 * val}	e{lbl1.lbl2 = e.lbl1.lbl2 * val}
e{lbl1 = val1, lbl2 = val2}	(e{lbl1 = val1}){lbl2 = val2}
e{lbl1.lbl2, ..}	e{lbl2=lbl1.lbl2, ..}

Acknowledgements: DAML Team, incl Shayne Fletcher. Adam Gundry.
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Coming to a GHC near you! (Maybe)