The Next Great Functional Programming Language

(OK, not really.)

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ML - 1973

Haskell - 1990[1]

OCaml - 1996[2]

[1] Or 1985 if you count Miranda.

[2] Or 1987 if you count Caml.

verlappingInstances
rrows
enerics
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elaxedPolyRec
ADTs
onoLocalBinds
angPatterns
iewPatterns
ewQualifiedOperators
ank2Types
xistentialQuantification
arallelListComp
beralTypeSynonyms
Arr
isambiguateRecordFields
eriveDataTypeable
exibleContexts
ultiParamTypeClasses

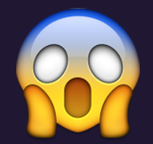
XIncoherentInstances
XDisambiguateRecordFields
XImplicitParams
XNoNPlusKPatterns
XExtendedDefaultRules
XTypeFamilies
XTemplateHaskell
XCPP
XUnicodeSyntax
XExplicitForAll
XRankNTypes
XKindSignatures
XTransformListComp
XTypeOperators
XRecordWildCards
XUnboxedTuples
XGeneralizedNewtypeDeriving
XFlexibleInstances
XFunctionalDependencies

Haskell

XUndecidableInstances
XForeignFunctionInterfa
XNoImplicitPrelude
XNoMonoPatBinds
XOverloadedStrings
XScopedTypeVariables
XQuasiQuotes
XPatternGuards
XMagicHash
XPolymorphicCompone
XImpredicativeTypes
XEmptyDataDecls
XUnliftedFFITypes
XRecursiveDo
XNamedFieldPuns
XStandaloneDeriving
XTypeSynonymInstance
XConstrainedClassMeth
XPackageImports

Haskellz

144 quadrillion flavors.



Our Best FPLs Suffer from Decades Worth of Accretion

Individual Features were Designed, but the FPLs Came Into Existence

What Would a Designed FPL Look Like Today?


Idris
?


Idris

[This Slide Intentionally Left Blank]

My Ideal FPL

- ~~Pattern Matching~~
- ~~Records~~
- ~~Modules~~
- ~~Syntax~~
- ~~Type Classes~~
- ~~Nominative Typing~~
- ~~Data~~
- ~~Recursion~~

👎 Pattern Matching

Pattern Matching

```haskell
import Lens.Family.Total
import Lens.Family.Stock

total :: Either Char Int -> String        -- Same as:
total = _case                             -- total = \case
    & on _Left  (\c -> replicate 3  c )   --     Left  c -> replicate 3 c
    & on _Right (\n -> replicate n '!')   --     Right n -> replicate n '!'
```

👎 Records

Records

```
val book =
  ("author" ->> "Benjamin Pierce") ::
  ("title"  ->> "Types and Programming Languages") ::
  ("id"     ->>  262162091) ::
  ("price"  ->>  44.11) ::
  HNil

scala> book("author")  // Note result type ...
res0: String = Benjamin Pierce

scala> val extended = book + ("inPrint" ->> true)  // Add a new field
extended: ... complex type elided ... =
  Benjamin Pierce :: Types and Programming Languages :: 262162091 :: 46.11 :: true :: HNil

scala> val noId = extended - "id"  // Removed a field
noId: ... complex type elided ... =
  Benjamin Pierce :: Types and Programming Languages :: 46.11 :: true :: HNil
```

Modules

Modules

```
structure ListStack :> STACK =
struct
  type t = 'a list
  [...]
end
```

Modules

```
data Stack f = Stack
  { makeNew :: forall a. f a,
    push    :: forall a. a -> f a -> f a,
    pop     :: forall a. f a -> Maybe (Tuple a (f a)) }


doSomeStackStuff :: forall f. Stack f -> Thing
```

Modules

```
data Stack f = Stack
  { makeNew :: forall a. f a,
    push    :: forall a. a -> f a -> f a,
    pop     :: forall a. f a -> Maybe (Tuple a (f a)) }

data ReservationSystem f = ReservationSystem
  (forall g. Stack g -> { ... })
```

👎 Syntax

Syntax

Let's stop pretending programs are strings of ASCII characters.

- ~~implicits~~
- ~~order of function parameters / application~~
- ~~compiler errors~~
- ~~funky looking operators~~
- ~~scopes~~
- ~~Haskell-style (fake) modules & imports~~
- ~~name clashes~~
- ~~information elision~~
- ...

👎 Type Classes

Type Classes

Just 'records' with compiler-enforced laws.[3]

[3] Type classes also add an implicitly applied `(a : Type) -> TypeClass a` function that's piecewise-defined, but that's just syntax.

Partiality

Partiality

If it's partial, it's not a &^@#% function.

👎 Nominative Typing

Nominative Typing

```
data Email = Email String

data DOMId = DOMId String

data Positive = Positive Float

data Negative = Negative Float

data DressSize = DressSize Float
```

Nominative Typing

```
data ??? = ??? String

data ??? = ??? String

data ??? = ??? Float

data ??? = ??? Float

data ??? = ??? Float
```

Let's Stop Pretending Differences in Names Actually Matter

Nominative Typing

Let's play a guessing game.

```
data ??? = ??? -- {v: Float | v > 0}

data ??? = ??? -- {v: Float | v < 0}
```

Data

Data

Data: Bits-based description.

```
data Either a b = Left a | Right b
```

```
struct either {
  int tag;
  union {
    void *left;
    void *right;
  };
};
```

Data

Newbies: addicted to pattern matching.

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

doSomething :: forall a. List a -> Int
doSomething Nil          = 0
doSomething (Cons _ l) = 1 + doSomething l
```

Data

Pros: addicted to folds.

```
fold :: forall z a. z -> (z -> a -> z) -> List a -> z
fold z _ Nil = z
fold z f (Cons a l) = fold (f z a) l
```

Data

Folds: Capability-based description.

```
fold :: forall z a. z -> (z -> a -> z) -> List a -> z
```

```
data List a = List (forall z. z -> (z -> a -> z) -> z)
```

Data

```
data List a = List (forall z. z -> (z -> a -> z) -> z)

nil                   = \z f -> z
cons a (List as) = \z f -> as (f a z) f
```

Array? Linked List? Vector? Skip List?[4]

[4] Strictly more powerful than a `data List` (pros & cons).

👎 Recursion

Recursion

Goto of functional programming.[5]

```
f x = if x / 2 > x then g (2 * x) else 42
g x = if x % 1 == 0 then f (g (x + 1)) else h (x - 1)
h x = if x % 1 == 1 then f (x * 2 + 1) else g (x + 1)
```

[5] What's hard for a machine|human to understand is also hard for a human|machine to understand.

Recursion

Induction -> Folds.

Recursion

Coinduction -> State Machines.

```
type Machine s a b = (s, (s, a) -> (s, b))
```

6

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[6] Except this is too weakly typed.

My Ideal FPL

My Ideal FPL

Layered like an onion.

- Turing incomplete for 99% of program
  - Prove / optimize more
- Turing complete 'driver'
  - Prove / optimize less
  - Possibly in a different language (e.g. Haskell)

My Ideal FPL

Structured editor.

- → Friendly FP
- → Destroys motivation for most language 'features'

My Ideal FPL

All the things are values.

- Math functions
- Abolish incidental complexity
- Abolish artificial distinctions

My Ideal FPL

Proof search.

- Turing complete
- Levels of proof
  1. Proven true
  2. Evidence for truth but not proven true
  3. Proven false (in general or by counterexample)
- Massive, persistent proof databases
- *Cross-disciplinary* research
  - e.g. deep learning to accelerate proof search

My Ideal FPL

Zero cost abstraction.

- As long as we're shooting for the moon
  - (But genuinely easier w/o recursion/data)

Inspirations

- Unison Programming Language[7]
- LiquidHaskell[8]
- Morte[9]

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[7] http://unisonweb.org

[8] http://goto.ucsd.edu/~rjhala/liquid/haskell/blog/

[9] http://www.haskellforall.com/2014/09/morte-intermediate-language-for-super.html

THANK YOU

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