The HERMIT in the Tree

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- Alternative: GHC Core, GHC's intermediate language

GHC Core

```
type CoreProg = [CoreBind]
data CoreBind = NonRec Var CoreExpr
              | Rec [(Var, CoreExpr)]
data CoreExpr = Var Var
              | Lit Literal
              | App CoreExpr CoreExpr
              | Lam Var CoreExpr
              | Let CoreBind CoreExpr
              | Case CoreExpr Var Type [CoreAlt]
              | Cast CoreExpr Coercion
              | Tick CoreTickish CoreExpr
              | Type Type
              | Coercion Coercion
type CoreAlt  = (AltCon, [Var], CoreExpr)
data AltCon   = DataAlt DataCon | LitAlt Literal | DEFAULT
```

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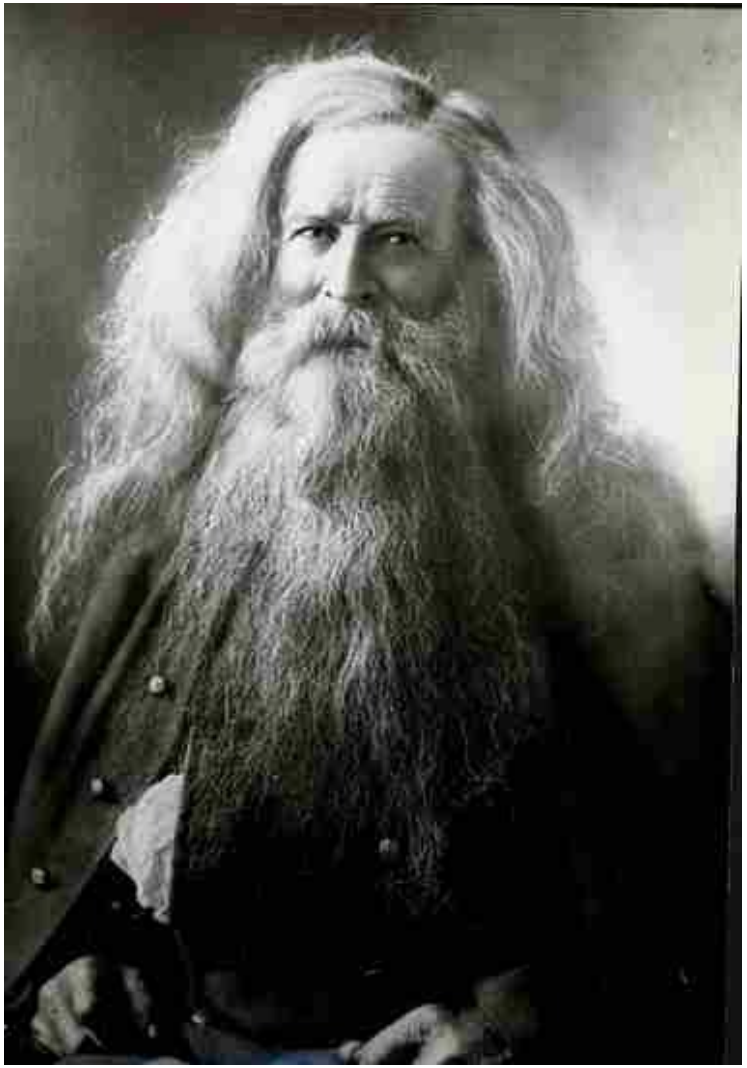
- Under development at the University of Kansas, Lawrence.
- Not to be confused with: The Kansas Hermit (1826–1909), also from Lawrence.



(image from `http://www.angelfire.com/ks/larrycarter/LC/OldGuardCameron.html`)

Downloading and Running HERMIT

HERMIT requires GHC 7.4 or 7.6 (7.6 recommended)

1. `cabal update`
2. `cabal install hermit`
3. `hermit Main.hs`

The `hermit` command just invokes GHC with some default flags:

```
% hermit Main.hs
ghc Main.hs -fforce-recomp -O2 -dcore-lint
            -fsimple-list-literals -fplugin=HERMIT
            -fplugin-opt=HERMIT:main:Main:
```

Demonstration: Unrolling Fibonacci

As a first demonstration, let's transform the *fib* function by unrolling the recursive calls once.

$$\textbf{data}\ Nat = \mathrm{Zero} \mid \mathrm{Succ}\ Nat$$

$$\begin{aligned}
&fib :: Nat \to Nat \\
&fib\ \mathrm{Zero} &&= \mathrm{Zero} \\
&fib\ (\mathrm{Succ}\ \mathrm{Zero}) &&= \mathrm{Succ}\ \mathrm{Zero} \\
&fib\ (\mathrm{Succ}\ (\mathrm{Succ}\ \mathrm{n})) &&= fib\ (\mathrm{Succ}\ \mathrm{n}) + fib\ \mathrm{n}
\end{aligned}$$

Demonstration: Unrolling Fibonacci

As a first demonstration, let's transform the *fib* function by unrolling the recursive calls once.

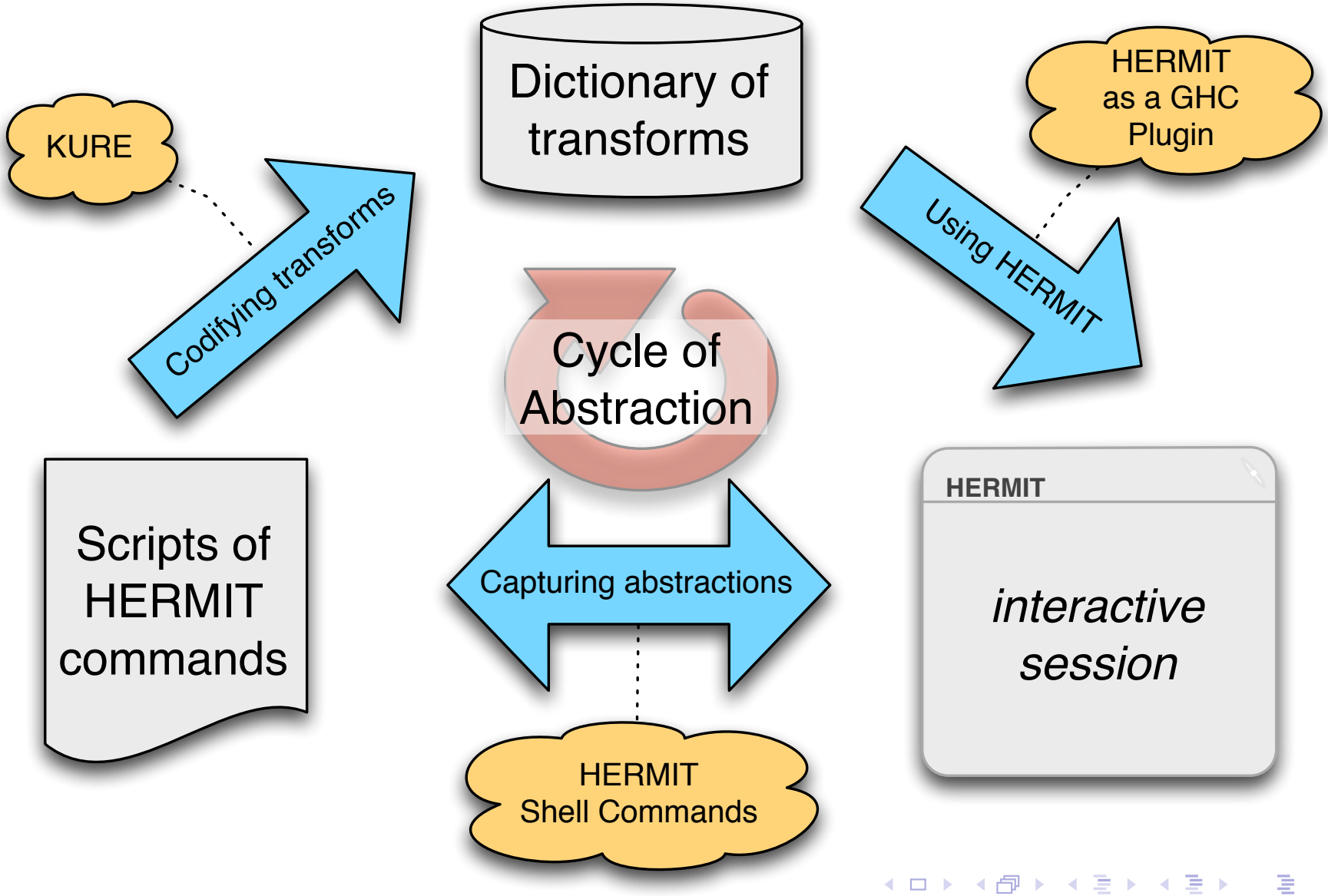
```
data Nat = Zero | Succ Nat

fib :: Nat → Nat
fib Zero              = Zero
fib (Succ Zero)       = Succ Zero
fib (Succ (Succ n))   = (case Succ n of
                           Zero          → Zero
                           Succ Zero     → Succ Zero
                           Succ (Succ m) → fib (Succ m) + fib m)
                         +
                         (case n of
                           Zero          → Zero
                           Succ Zero     → Succ Zero
                           Succ (Succ m) → fib (Succ m) + fib m)
```

HERMIT Commands

- Core-specific rewrites, e.g.
  - beta-reduce
  - eta-expand '*x*
  - case-split '*x*
  - inline
- Strategic traversal combinators (from KURE), e.g.
  - any-td *r*
  - repeat *r*
  - innermost *r*
- Navigation, e.g.
  - up, down, left, right, top
  - consider '*foo*
  - 0, 1, 2, ...
- Version control, e.g.
  - log
  - back
  - step
  - save "myscript.hss"

Developing Transformations



Transformations Mechanised

We've been using HERMIT to mechanise some established program transformations:

- Concatenate Vanishes [Wad89]
- Tupling Transformation [Pet84]
- Worker/Wrapper [GH09]

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In the process we've discovered that concatenate vanishes and tupling transformation can be expressed as instances of worker/wrapper.

Tupling Transformation: Fib

$$
\begin{aligned}
&\mathit{fib} :: \mathit{Nat} \to \mathit{Nat} \\
&\mathit{fib}\ \mathsf{Zero} &&= \mathsf{Zero} \\
&\mathit{fib}\ (\mathsf{Succ}\ \mathsf{Zero}) &&= \mathsf{Succ}\ \mathsf{Zero} \\
&\mathit{fib}\ (\mathsf{Succ}\ (\mathsf{Succ}\ \mathsf{n})) &&= \mathit{fib}\ (\mathsf{Succ}\ \mathsf{n}) + \mathit{fib}\ \mathsf{n}
\end{aligned}
$$

$$
\begin{aligned}
&\mathit{fib} :: \mathit{Nat} \to \mathit{Nat} \\
&\mathit{fib}\ \mathsf{n} = \textbf{let}\ \mathit{work} :: \mathit{Nat} \to (\mathit{Nat}, \mathit{Nat}) \\
&\qquad\qquad \mathit{work}\ \mathsf{Zero} \qquad = (\mathsf{Zero}, \mathsf{Succ}\ \mathsf{Zero}) \\
&\qquad\qquad \mathit{work}\ (\mathsf{Succ}\ \mathsf{m}) = \textbf{let}\ (\mathsf{x}, \mathsf{y}) = \mathit{work}\ \mathsf{m} \\
&\qquad\qquad\qquad\qquad\qquad\qquad\quad \textbf{in}\ (\mathsf{y}, \mathsf{x} + \mathsf{y}) \\
&\qquad \textbf{in} \\
&\qquad\qquad \mathit{fst}\ (\mathit{work}\ \mathsf{n})
\end{aligned}
$$

Summary

- HERMIT is a GHC plugin for interactive transformation of GHC Core programs
- Currently we're using it to mechanise known program transformations
- Next step: an equational reasoning framework that only allows correctness preserving transformations
- For HERMIT implementation details, see:
  - "The HERMIT in the Machine" (Haskell '12) [FGKS12]

References

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