The Structure of the Essential Haskell Compiler
Coping with Compiler Complexity

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IFL, September 27–29, 2007

The structure of the Essential Haskell Compiler. . .

We are writing a Haskell compiler
that by design *evolves*

- from *lambda calculus* to *full Haskell*
- from *essential* to *syntactically sugared*
- from *common constructs* to *extensions*

. . . or: Coping with Compiler Complexity

When writing a compiler we face

- Implementation complexity
- Description/Coding complexity
- Design complexity
- Maintenance complexity

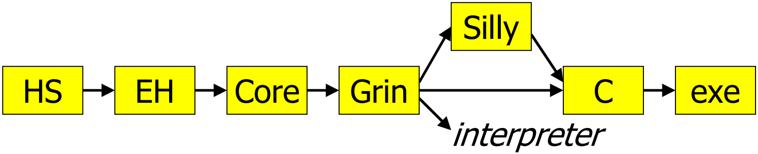
. . . or: Coping with Compiler Complexity

When writing a compiler we face

- Implementation complexity
  a compiler is a *large program*
- Description/Coding complexity
  translation involves *complicated abstract syntax trees*
- Design complexity
  a language has *many features*
- Maintenance complexity
  evolving projects must *remain consistent*

Coping with *Implementation* Complexity

Transform!



Many intermediate languages, *7 transformations*

- Haskell
- Essential Haskell
- Core
- Grin
- Silly
- C

Coping with *Implementation* Complexity

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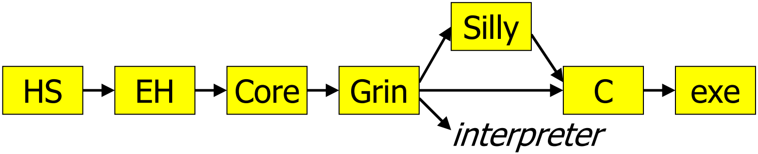
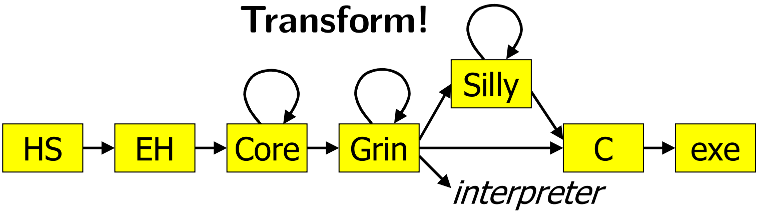


Many intermediate languages, *7 transformations*

- Haskell
- Essential Haskell (desugared)
- Core (type erased)
- Grin (sequential)
- Silly (imperative)
- C

Coping with *Implementation* Complexity



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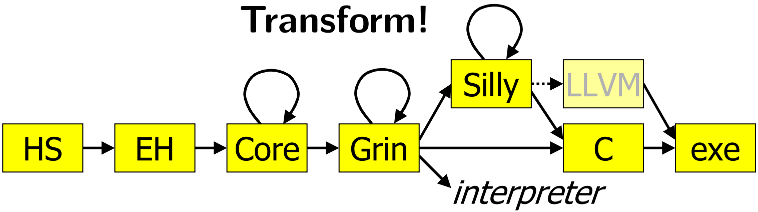

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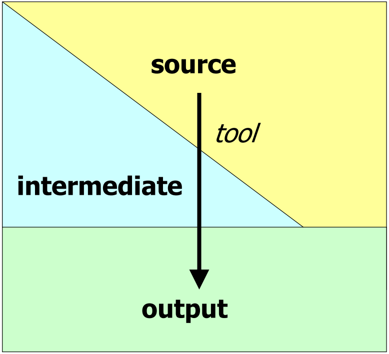
Use tools!



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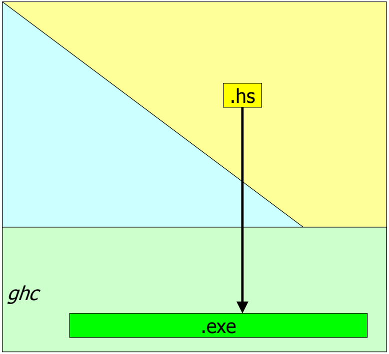

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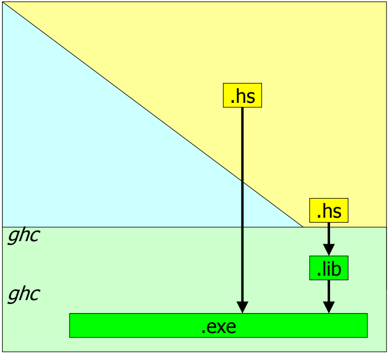

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- *Utrecht University* Attribute Grammar Compiler
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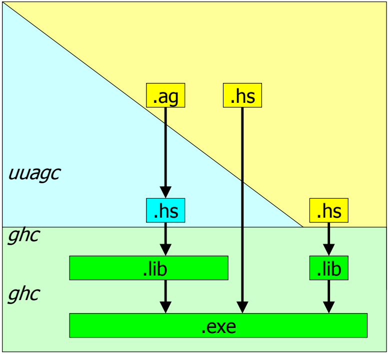

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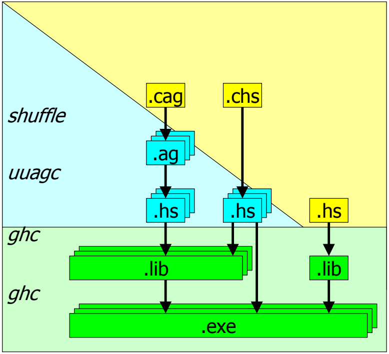

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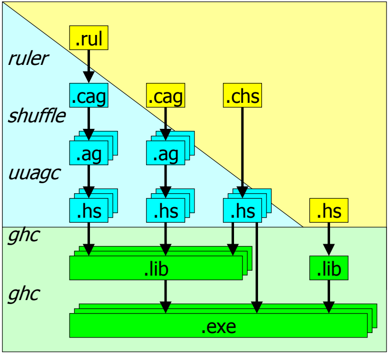

Coping with *Design* Complexity

Grow stepwise!

1. λ-calculus, type checking
2. type inference
3. polymorphism
4.
5. data types

Coping with *Design* Complexity

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	plain Haskell	experiments
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7	records	tuples as records
8	code generation	full program analysis
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20	modules	
95	'deriving'	exceptions
99	prelude, I/O	

Coping with *Maintenance* Complexity

Generate, generate, generate...

Domain specific languages
and tools to transform them:

- Attribute Grammar Compiler
- Ruler
- Shuffle

Tools: Attribute Grammar Compiler

write recursive functions

$$
\begin{aligned}
&\mathit{sum}\ [\,] &&= 0\\
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$$\mathit{catamorphism} = \mathit{foldr}_T\ \mathit{algebra}_T$$

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If *programming by writing algebras* is a Good Thing
why does nobody do it when processing parse trees?

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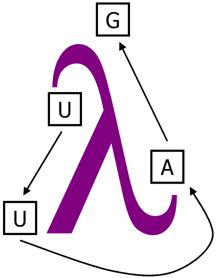

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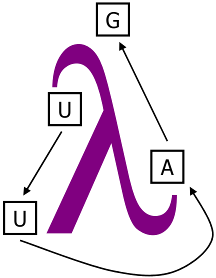

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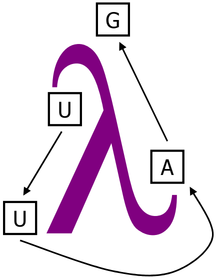

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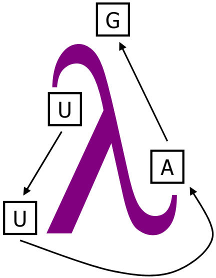

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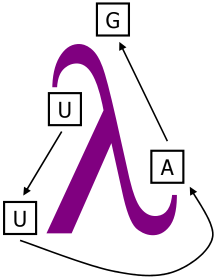
  defaulting mechanism



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Tools: Ruler

```
sem_Expr_App func_ arg_ =
  (λ_lhsIknTy
    _lhsIopts
    _lhsItyGam
    _lhsIvalGam →
      (case (_lhsIvalGam) of
        { _argOvalGam →
        (case (_lhsItyGam) of
          { _argOtyGam →
          (case (_lhsIopts) of
            { _argOopts →
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                  { _funcOopts →
                  (case ([Ty_Any] `mkArrow` _lhsIknTy) of
                    { _funcOknTy →
                    (case ((func_ _funcOknTy _funcOopts _funcOtyGam _funcOvalGam)) of
                      { (_funcIappArgPPL, _funcIappFunNm, _funcIappFunPP, _funcIerrSq, _funcIpp, _funcIppAST, _f
                      (case (tyArrowArgRes _funcIty) of
                        { __tup2 →
                        (case (__tup2) of
                          { (_ty_a_, _) →
                          (case (_ty_a_) of
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data Expr
    | App func : Expr
          arg  : Expr
attr AllExpr [knTy : Ty || ty : Ty]
sem Expr
    | App func.knTy             = [Ty_Any] `mkArrow` @lhs.knTy
          (loc.ty_a_, loc.ty_)  = tyArrowArgRes @func.ty
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pAST , _f
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$$\frac{\Gamma; \square \rightarrow \sigma^k \vdash^e e_1 : \sigma_a \rightarrow \sigma \qquad \Gamma; \sigma_a \vdash^e e_2 : \_}{\Gamma; \sigma^k \vdash^e e_1\ e_2 : \sigma} \mathrm{E.APP}_K$$

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Tools: Ruler

Now that things are acceptably simple...

$$\frac{\begin{array}{c}\Gamma; \Box \rightarrow \sigma^{k} \vdash^{e} e_1 : \sigma_a \rightarrow \sigma \\ \Gamma; \sigma_a \vdash^{e} e_2 : \_\end{array}}{\Gamma; \sigma^{k} \vdash^{e} e_1\ e_2 : \sigma}\ \text{E.APP}_K$$

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...we can start to introduce new ideas:

$$\frac{v \text{ fresh} \qquad \Gamma; \mathcal{C}^k; v \rightarrow \sigma^k \vdash^e e_1 : \sigma_a \rightarrow \sigma \leadsto \mathcal{C}_f \qquad \Gamma; \mathcal{C}_f; \sigma_a \vdash^e e_2 : \_ \leadsto \mathcal{C}_a}{\Gamma; \mathcal{C}^k; \sigma^k \vdash^e e_1\ e_2 : \mathcal{C}_a\sigma \leadsto \mathcal{C}_a} \ \mathrm{E.APP}_{HM}$$

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APP_{HM}

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- 20 language variants of increasing complexity
- code, documentation, test sets, publications, presentations

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Shuffle

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Shuffle shuffles the chunks,
to extract the input for the compiler and text formatter

Tools: Shuffle

Shuffle combines the best of:

- *#define / #ifdef*
- *#include*
- Literate programming
- Version management

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  Shuffle can combine *multiple sources* and *re-use* code
- Version management
  Shuffle does *variant* management
  versions are historically grown
  variants are *didactically chosen*

Project status

Status of the Essential Haskell Compiler

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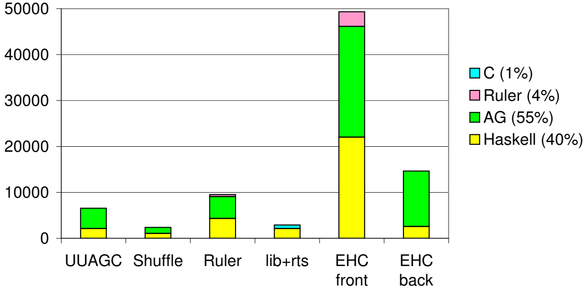
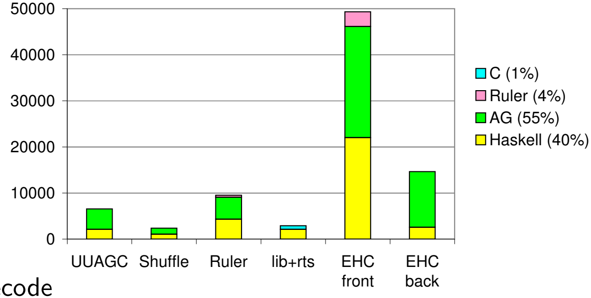


Project status

Status of the Essential Haskell Compiler

- Available on `www.cs.uu.nl/wiki/Ehc`
- 85000 lines of code, half of which in AG
- Working towards full Haskell with full prelude
- Simple programs compile and run
  - as interpreted bytecode
  - as compiled code



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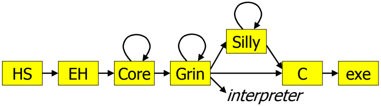

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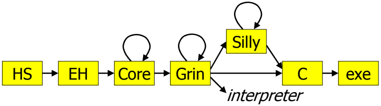
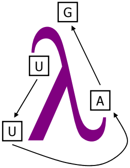


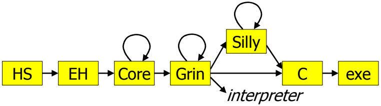


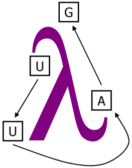
in the Essential Haskell Compiler

Summary

Coping with Compiler Complexity

- Implementation complexity
  Transform!
- Description complexity
  Use tools!
- Design complexity
  Grow stepwise!
- Maintenance complexity





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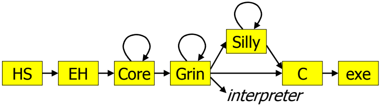

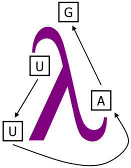

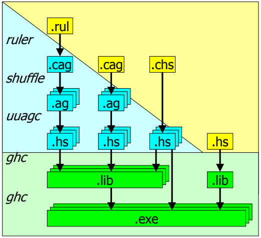

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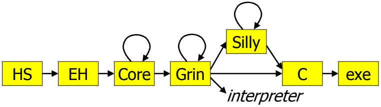

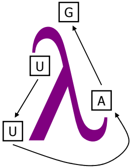

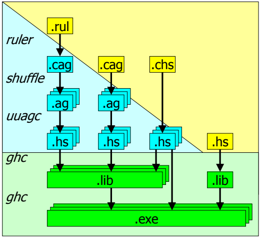

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`www.cs.uu.nl/wiki/Ehc`