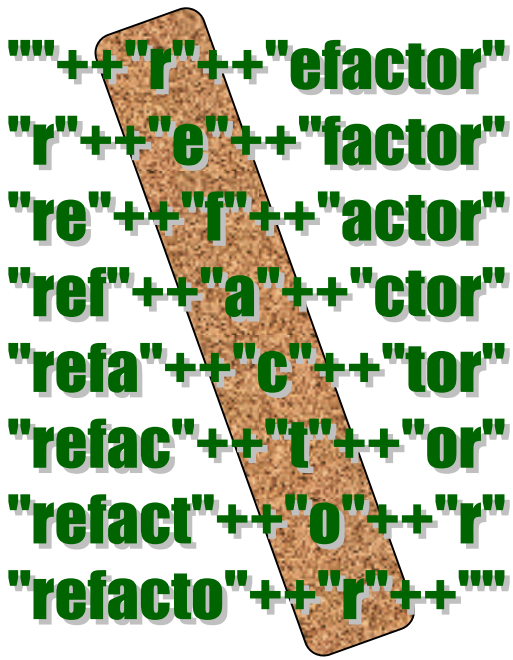
Tool Support for Refactoring Functional Programs

http://www.cs.kent.ac.uk/projects/refactor-fp/



Huiqing Li

Claus Reinke

Simon Thompson

Computing Lab, University of Kent

Refactoring Functional Programs

- 3 year EPSRC-funded project at the University of Kent:
  - explore the prospects for refactoring in functional languages
  - catalogue useful refactorings and prototype tool support
  - look into differences between OO and FP refactoring
  - ***concrete focus: Haskell refactoring*** (would like to add Erlang)
  - collect and document Haskell design patterns (each refactoring changes from one design option to an alternative, implicitly documenting the pros and cons for both)
  - ***we'd like a real life refactoring tool for Haskell programming***
- Now at end of year one; have focussed on:
  1. refactoring case studies, initial catalogue
  2. securing suitable infra-structure for building a refactorer for H98
  3. first prototype exists (simple, local refactorings to stress-test 2)

http://www.cs.kent.ac.uk/projects/refactor-fp/

btw, what is this “Refactoring”?

- Refactoring, the process:
  - is about *“improving the design of existing code” (Fowler)*
  - ***systematically changing program structure, without changing program functionality***
  - representation-level implementation of design changes

δBug = δ Feature = 0

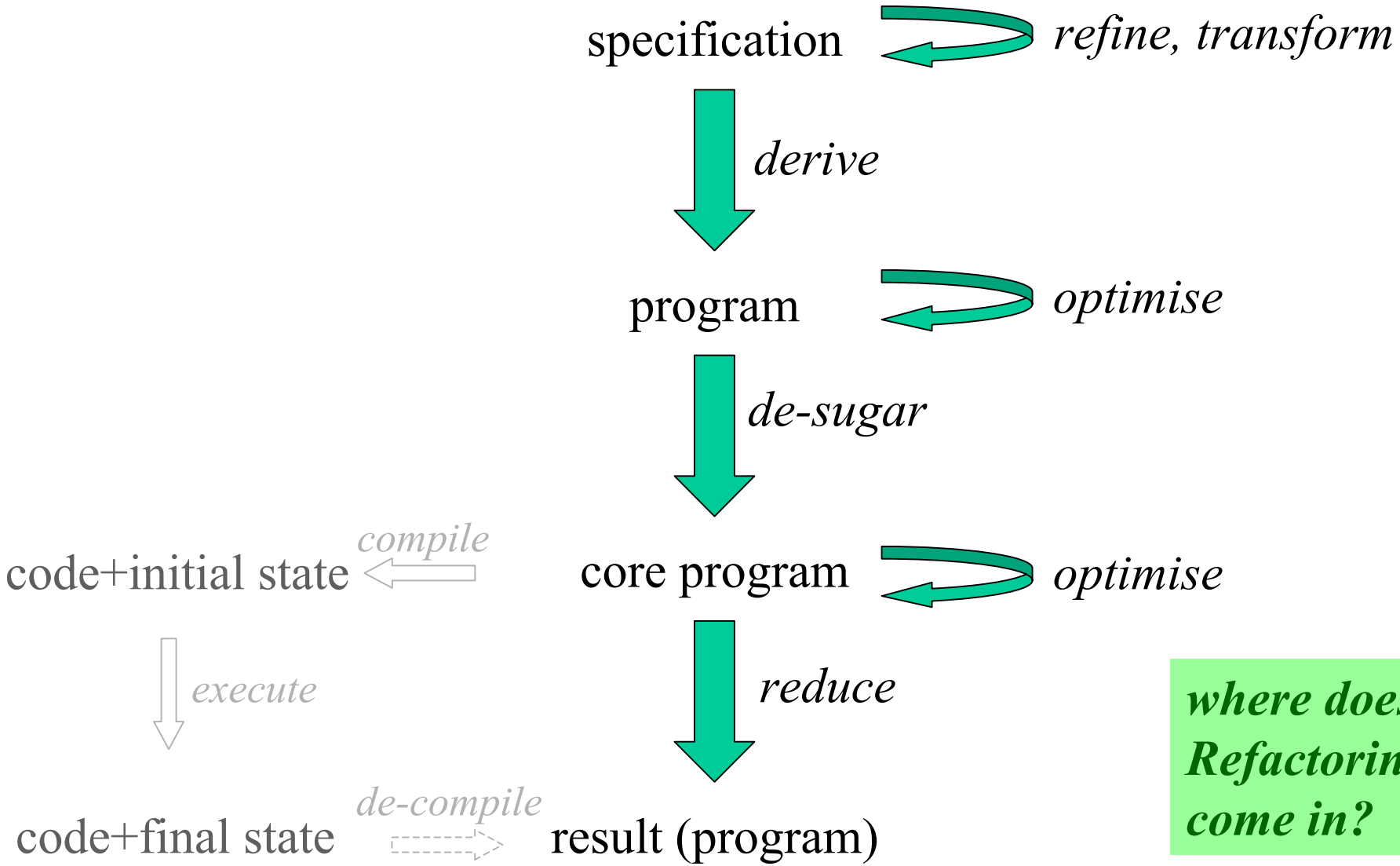
- Refactorings, individual steps:
  - meaning-preserving program transformations ..
- Refactoring, context:
  - software maintenance (*separate functional and structural changes,* simplify the former by supporting the latter)
  - agile development processes: continuous design improvement and adaptation favoured over monolithic upfront design

Transformations, transformations,..

- *operational semantics*, reduction to whnf
- *program optimisation,* source-to-source transformations to get more efficient code
- *program derivation,* calculating efficient code from obviously correct specifications
- *refactoring,* transforming code structure
- ..

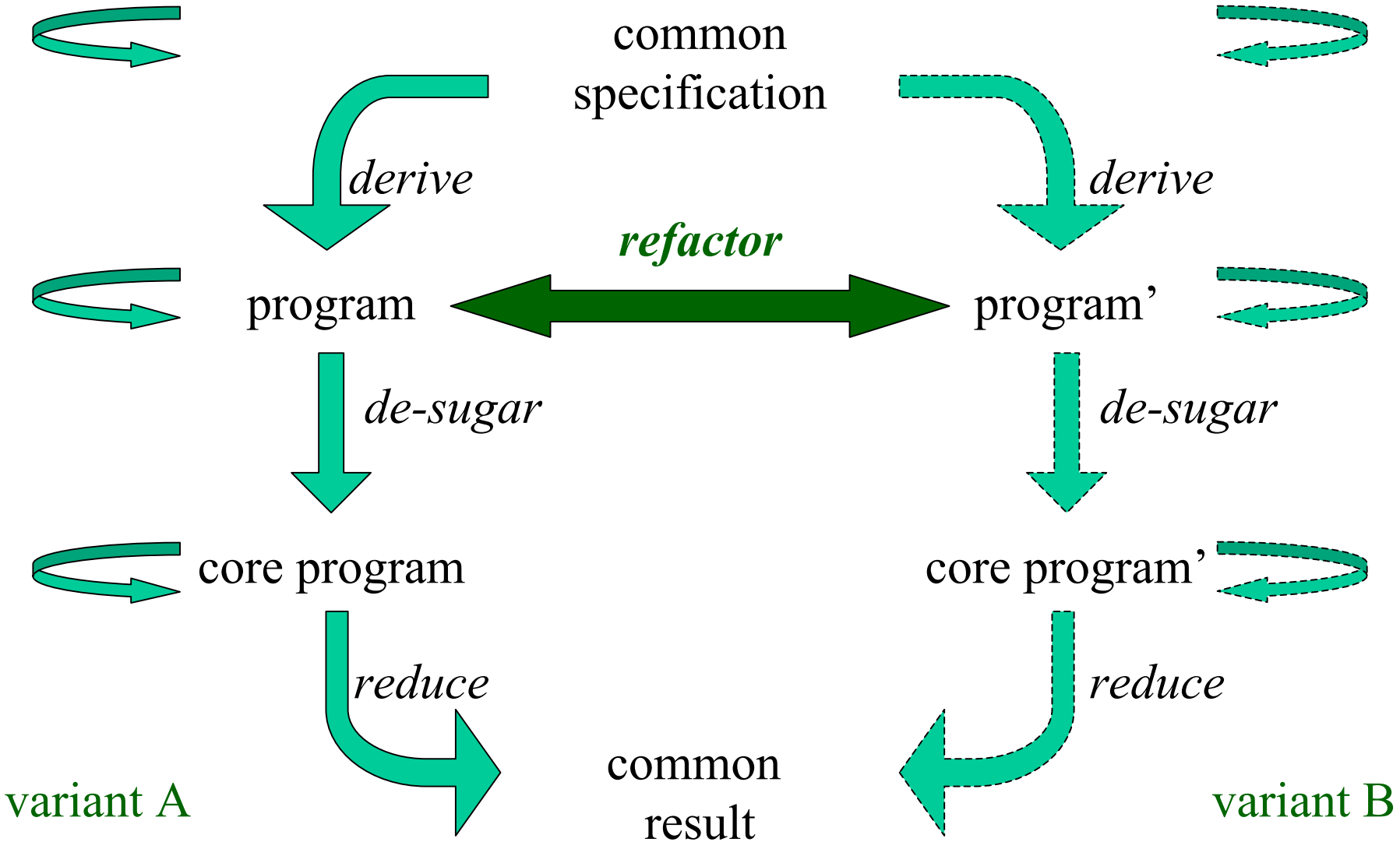
related themes, with substantial overlap, and common theory, but with different intentions

Development by transformation

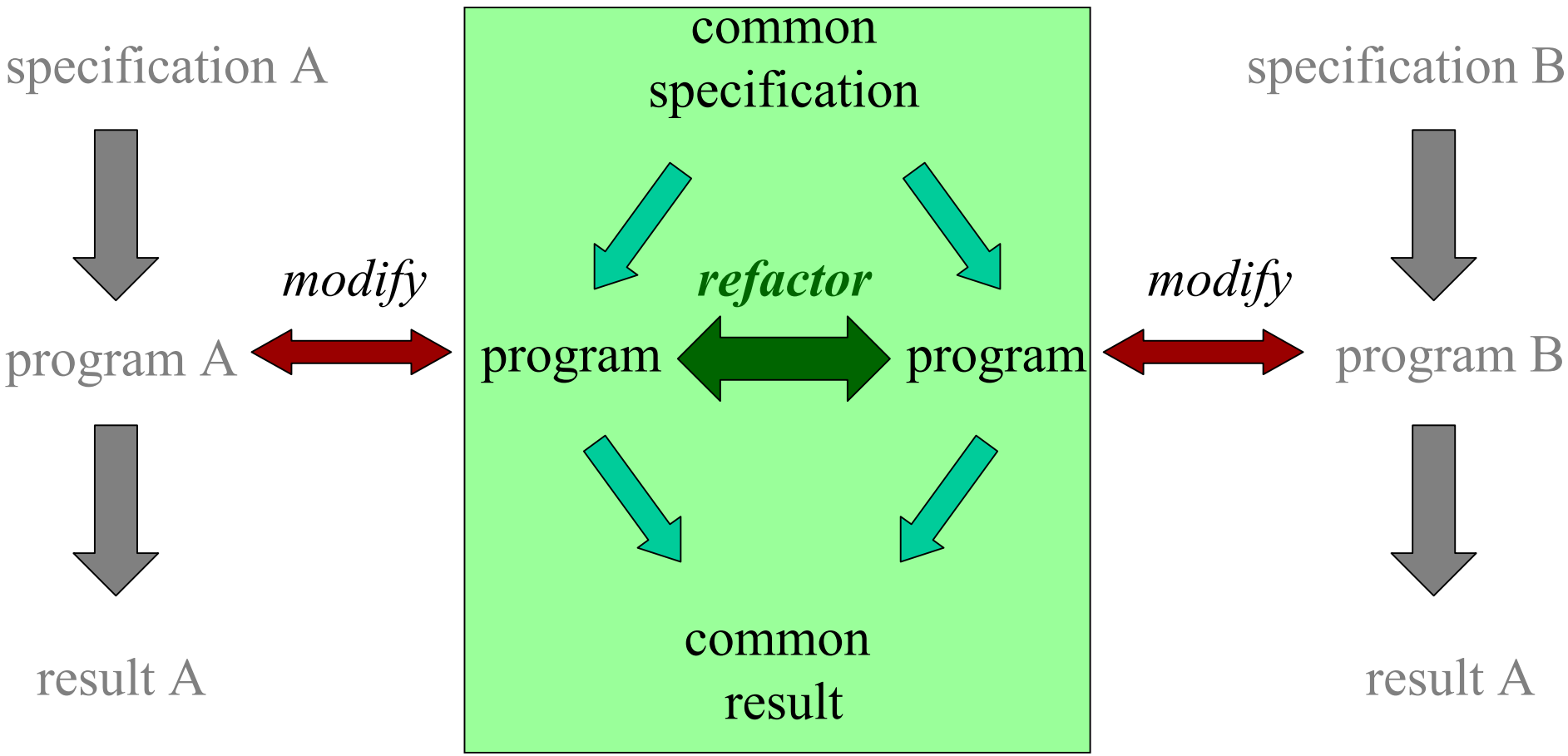


where does Refactoring come in?

Between development variants



Refactoring vs modification



The better the support for refactoring,
The less look-ahead guess-work needed to anticipate functional changes

A harmless little program

```
sum []     = 0
sum (h:t) = h + sum t

main = print $ sum [1..4]
```

But: shouldn't you write it like this?

```
fold c n []    = n
fold c n (h:t) = h `c` fold c n t

sum = fold (+) 0

main = print $ sum [1..4]
```

```
sum []    = 0
sum (h:t) = h + sum t

main = print $ sum [1..4]
```

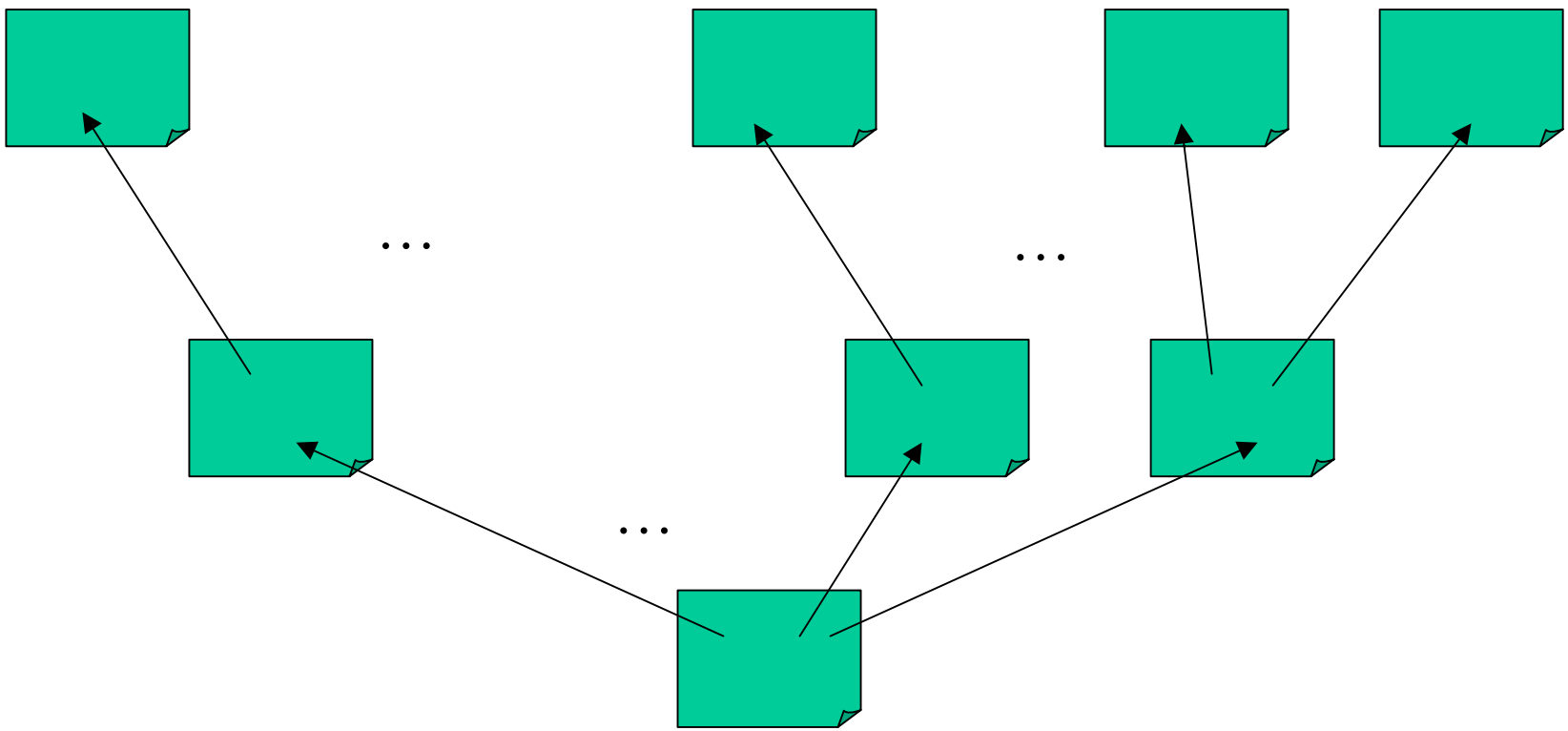
Or like this?

```
fold c n l | null l    = n
fold c n l | otherwise = head l `c` fold c n (tail l)

sum = fold (+) 0

main = print $ sum (cons 1 (cons 2 (cons 3 (cons 4 nil))))
```

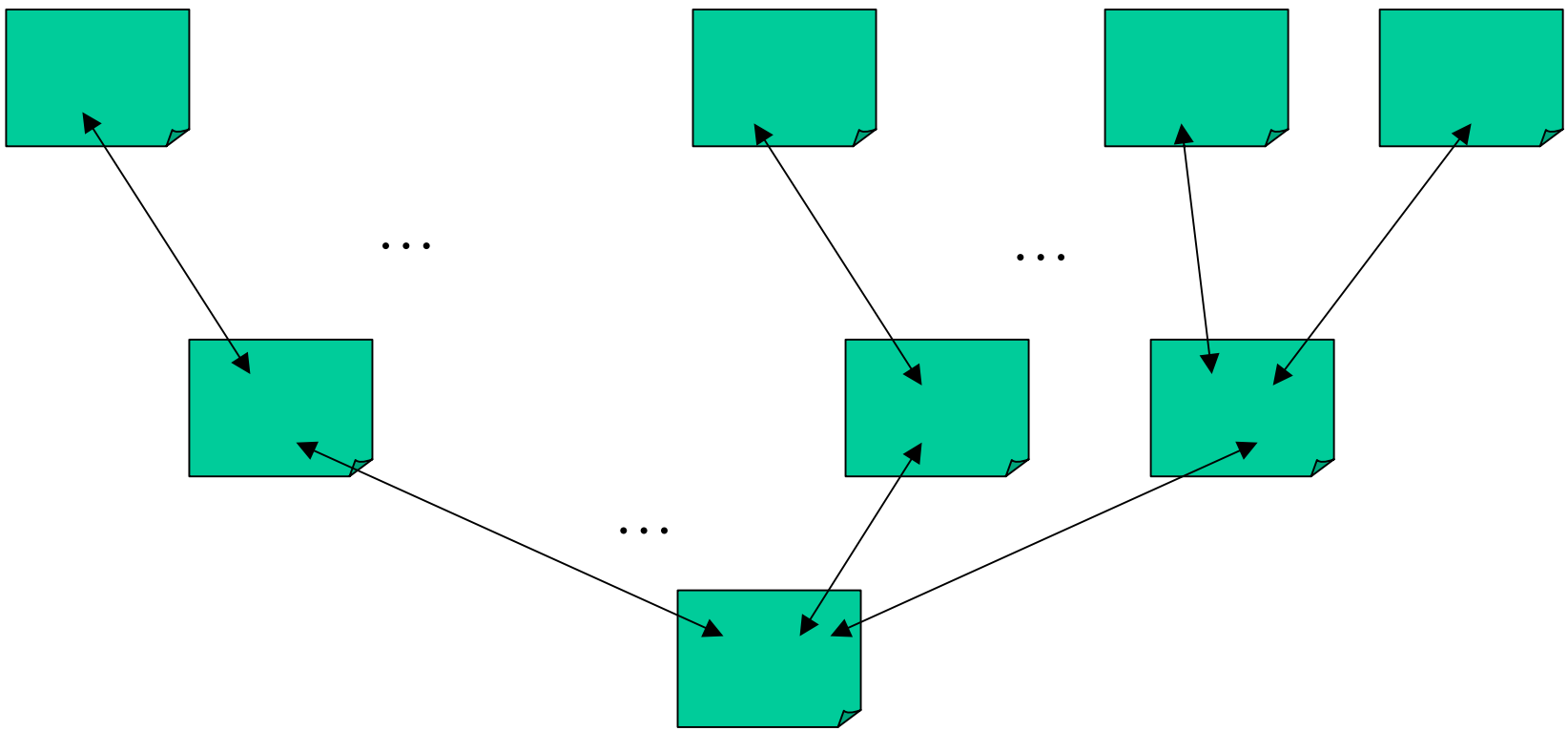
```
fold c n []    = n
fold c n (h:t) = h `c` fold c n t

sum = fold (+) 0

main = print $ sum [1..4]
```

```
sum []    = 0
sum (h:t) = h + sum t

main = print $ sum [1..4]
```

Or like what?



Or like what?



Do not try to guess ahead:
design minimally now, refactor if neccessary

Soft Ware

design for now, refactor later (if necessary)

- traditional assumptions:
  - code freezes into first form
  - any change is expensive and error prone
  - you have to get everything right first time

  ➔*substantial investment in upfront analysis & design needed*
- refactoring changes those assumptions:
  - ***code remains malleable***
  - ***structural changes can be inexpensive and safe***
  - functional changes can be less expensive and safer
  - what is “right” can emerge and evolve after coding has started

  ➔*incremental analysis & continuous adaptive redesign*

Sounds nice, but can that work?

mini demo

```
module Sum where

sum []     = 0
sum (h:t) = h + sum t

main = sum [1..4]
```

generalise definition

```
module Sum where

sum []     = 0
sum (h:t) = h + sum t

main = sum [1..4]
```

generalise definition

```
module Sum where

sum []     = 0
sum (h:t) = h + sum t

main = sum [1..4]
```

name for new parameter?

generalise definition

```
module Sum where

sum []     = 0
sum (h:t) = h + sum t

main = sum [1..4]

name for new parameter? n
```

generalise definition

```
module Sum where

sum n []     = n
sum n (h:t) = h + sum n t

main = sum 0 [1..4]
```

generalise definition

```
module Sum where

sum n []     = n
sum n (h:t) = h + sum n t

main = sum 0 [1..4]
```

generalise definition

```
module Sum where

sum n []     = n
sum n (h:t) = h + sum n t

main = sum 0 [1..4]
```

name for new parameter?

generalise definition

```
module Sum where

sum n []     = n
sum n (h:t) = h + sum n t

main = sum 0 [1..4]

name for new parameter? c
```

generalise definition

```
module Sum where

sum c n []     = n
sum c n (h:t) = h `c` sum c n t

main = sum (+) 0 [1..4]
```

rename definition

```
module Sum where

sum c n []     = n
sum c n (h:t) = h `c` sum c n t

main = sum (+) 0 [1..4]
```

rename definition

```
module Sum where

sum c n []     = n
sum c n (h:t) = h `c` sum c n t

main = sum (+) 0 [1..4]
```

new name?

rename definition

```
module Sum where

sum c n []     = n
sum c n (h:t) = h `c` sum c n t

main = sum (+) 0 [1..4]
```

new name? fold

rename definition

```
module Sum where

fold c n []     = n
fold c n (h:t) = h `c` fold c n t

main = fold (+) 0 [1..4]
```

introduce definition

```
module Sum where

fold c n []     = n
fold c n (h:t) = h `c` fold c n t

main = fold (+) 0 [1..4]
```

introduce definition

```
module Sum where

fold c n []     = n
fold c n (h:t) = h `c` fold c n t

main = fold (+) 0 [1..4]

name of new definition?
```

introduce definition

```
module Sum where

fold c n []     = n
fold c n (h:t) = h `c` fold c n t

main = fold (+) 0 [1..4]

name of new definition? sum
```

introduce definition

```
module Sum where

fold c n []     = n
fold c n (h:t) = h `c` fold c n t

main = sum [1..4]
  where
     sum = fold (+) 0
```

lift definition

```
module Sum where

fold c n []     = n
fold c n (h:t) = h `c` fold c n t

main = sum [1..4]
  where
     sum = fold (+) 0
```

lift definition

```
module Sum where

fold c n []     = n
fold c n (h:t) = h `c` fold c n t

main = sum [1..4]

sum = fold (+) 0
```

demo end

Tool support for refactoring

recap:

- source-level representation of design changes
- meaning-preserving program transformations

➔***need to manipulate source-code, but not as text (semantic editing)***

1. Gathering semantic info
   - lexical/syntactic/static/type analyses
2. Editing I: analyses/program transformations
   - conditional rewrite rules + rewrite strategies
3. Editing II: interaction/integration
   - retranslation/faithful presentation at source-level
   - navigation/interaction/simple editing

Tool support for Haskell Tools (1)

gathering semantic information

- *Ideal: standard interface to semantic info* in your favourite Haskell implementation? ☹☹ not there yet..
- Reuse code from one of the implementations/hack your own *tool-specific frontend*? ☹ common practice
- Write or find *reusable Haskell-in-Haskell frontend* for meta-programming and Haskell tool development
  - parser/pretty printer: hsparser ☺ (haskell 98)
  - Type analysis: thih ☺ (haskell 98 + some variations)
  - p/pp+ta: hatchet ☺☺ (haskell 98, somewhat in limbo)
  - p/pp+ta+static analysis: programatica frontend ☺☺☺ (haskell 98 + some first extensions, under active development; see Thomas' demo this afternoon)

Tool support for Haskell Tools (2)

program analyses/transformation

- you've got your annotated AST (scopes,types,..)
- what about tool-specific analyses/transformations?
  - idea from optimiser implementations: combine rewrite rules and rewrite strategies in *strategic programming* dsl; implement your own traversals on top ☺ Stratego, Strafunski (the latter provides a Haskell library)
  - abstract Haskell grammar is complex and many-typed: if handwritten, the essence of traversals disappears in an unmaintainable deluge of boilerplate code ☹
  - ☺ Strafunski already addresses this problem, providing a *generic strategy library* as well as pre-processor support to instantiate it

Tool support for Haskell Tools (3)

user interaction/integration in development environment

- Refactoring is a form of semantic editing, and needs to be integrated with standard development tools and processes
- Write-your-own Haskell editor/browser:
  - full control
  - zero acceptance
  - substantial extra work
- Interface to standard editor (Emacs/Vim):
  - restricted control, divergent standards
  - easier acceptance
  - reduced extra work

Tool support for Haskell Refactorer

1. Gathering semantic info
   - Programatica's Haskell-in-Haskell frontend
2. Editing I: program transformations/analyses
   - Strafunski: strategy library and generic programming support (currently pre-processor-based)
3. Editing II: interaction/integration
   - Text interface to refactorer proper, used via shallow script bindings/GUI elements from Emacs and Vim

…

retranslation/faithful presentation at source-level

Theory vs practice, an example

retranslation/faithful presentation at source-level

- initial (bad) idea: *no problem*
  - parse/analyse→transform→pretty print
  - most frontends throw away aspects of your code that you'd find quite essential (comments, layout)
- revised idea: *that needs some thinking*
  - preserve layout in annotated AST?
  - extract layout "style" and imitate that in pretty-printer?

  ➔use abstract syntax for abstract tasks, concrete syntax for concrete tasks; AST auxiliary, not intermediate representation; concrete updates on token stream

Conclusions

- Refactoring Functional Programs:
  - 3-year project at U of Kent; at the end of first year http://www.cs.kent.ac.uk/projects/refactor-fp/
  - Prototype ***Haskell Refactorer***, initial release after PLI (don't use on production sources just yet, but try it out and give us feedback)
  - *Over the next 2 years, prototype should develop into real-life tool* – neither perfect, nor complete, but in daily use
  - ***Think about refactoring: it'll change your programming***, and we'd welcome your suggestions (we have our own unbounded list of more complex refactoring candidates, though;-)
  - Practice makes the difference (implementing ideas is important!)
- Connections to non-refactoring transformations
  - Should we provide an API for extensions (so you can extend our tool for program derivation, optimisation, or ...)?
- Infrastructure for Haskell tool development is improving
  - time to undust your good ideas and implement them?