Tock: 18 Months On
(this was originally “One Year On”,
but it's been a while since the last CPA...)

Adam T. Sampson
Neil C. C. Brown
Computing Laboratory, University of Kent
What's Tock?

- A new compiler for concurrent languages
- Provide a solid basis for future work
- Makes experimenting with new features easy
- Compiles into C or C++
  - Highly portable (e.g. embedded devices, supercomputers)
  - Can use existing C compiler as backend
  - Decent performance for straightline code
Implementation

- Written in Haskell
  - Statically-typed, lazy, purely-functional language
  - Seems to have lots of users interested in compilers and concurrency already (see other presentations)
  - Our undergrads have to learn Haskell anyway
Nanopasses

- Uses “nanopass” approach
  - Lots of small passes
  - Easy to extend and to test
Overview

- We've done various things with Tock lately:
  - Rain frontend
  - C++CSP backend
  - Usage checking
  - Automated testing
  - Smart pattern-matching
  - Performance improvements

- Some of these may be of use to you...
Rain

- Tock supports multiple source languages
- We've implemented a frontend for Rain
  - Neil's new concurrent language
- We reused most of the existing code
  - A few Rain-specific bits
  - Other parts have been refactored to be more general
C++CSP

- Added a backend for C++CSP – process-oriented runtime library for C++
  - A bit more portable than CCSP (but also slower)
- We developed some useful Haskell techniques to share a lot of code between the C and C++ backends
  - e.g. “WHILE” is the same; “PAR” isn't
Usage checking, from alpha...

- The existing occ21 parallel usage checker has several problems
  - Works by expanding out PAR blocks and checking each case individually
  - No dynamic PAR replication counts
  - Very slow for large programs
- We need a better solution
... to Omega

- We use Pugh's Omega test algorithm
  - Very efficient integer constraint solver
  - Designed for this sort of application (e.g. SPoC)
- Extended algorithm to support occam's remainder operator
- Translate code to constraints, then solve
  - e.g. “P writes to i[n], Q reads from i[n+1]”
  - If there's a solution, it's not safe!
Automated testing

• Tock now has a large automated test suite
• HUnit: unit tests for functions and passes
• QuickCheck: test passes with randomly-generated data, and ensure properties hold
  – Works best for mathsy stuff (e.g. Omega test)
• Full-toolchain tests: real applications, and code fragments that test particular cases
  – ... including the existing occam-pi test suite
Smart pattern-matching

- Pattern-matching is very common in compilers
- Good ways of doing this in dynamically-typed languages like Scheme... but not Haskell yet
- We've developed a generics-based pattern matching library for Haskell
  - Reusable pattern fragments
  - Fuzzy matching
Performance improvements

• When we presented Tock at CPA2007, we were a bit concerned about the compiler's performance

• It turns out that while lots of people have written compilers in Haskell...
  – ... not many had written compilers with 50+ passes and over a million data values in the AST of a large program

• So we had some scalability problems to solve
Making passes faster

• We've developed a new generics system for writing transformation/analysis passes
  – Also useful for other generic programming problems
• Dynamically prunes the AST search based on what it's looking for
  – e.g. you aren't going to find a PAR inside a type
• Avoids runtime type introspection by using typeclasses to do more work at compile time
Making Tock less lazy

- Haskell is a lazy language
  - Defer calculations until they're actually needed
- Allows some cool tricks (e.g. infinite lists), but has memory usage problems
- We found some common Haskell standard library features were excessively lazy...
  - ... but we've fixed the problems
  - Tock now uses less memory than occ21!
Where next?

- Full occam-pi support
  - The infrastructure is there now
- Bytecode backend for very small devices
That's all, folks

• All the above work has been written up...
  – ... although not all of it has been published yet
  – Ask us if you're interested in reading more!
• See: http://offog.org/tock
• Any questions?