



UG3 Compiling Techniques Overview of the Course

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Critical Facts



Welcome to UG3 Compiling Techniques

<u>Topics</u> in the design of programming language translators, including parsing, run-time storage management, error recovery, code generation, and optimization

- Instructor: Dr. Björn Franke (bfranke@inf.ed.ac.uk)
- Office Hours: Monday 2 PM to 3 PM, JCMB 2414
- Text: Keith Cooper & Linda Torczon Engineering a Compiler
 → Morgan-Kaufmann, ISBN 1-55860-698-X
 - \rightarrow Textbook can be reused in UG4 Compiler Optimisation course
- Web Site: http://www.inf.ed.ac.uk/teaching/courses/ct/
 - \rightarrow Coursework, slides (2 per page), practice exams, ...
 - \rightarrow I will not have handouts in class; get them from the web
- Slides: Closely based on Keith Cooper's slides
 - \rightarrow Selection of approx. 15 out of >35 lectures
 - → Dropped optimisation, smaller amount of in-depth material

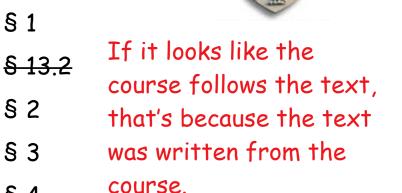
Basis for Grading

- Exams
 - \rightarrow Final 75%
- Coursework
 - \rightarrow Lexer & Parser 12.5%
 - \rightarrow Dataflow Analysis 12.5%



Rough Syllabus

- Overview
- Local Register Allocation
- Scanning
- Parsing
- Context Sensitive Analysis
- Inner Workings of Compiled Code §6,7
- Introduction to Optimization § 8
- Code Selection § 11
- **Instruction Scheduling**
- **Register Allocation**
- More Optimization (*time permitting*)



§ 1

§ 2

§ 3

§ 4

§ 12

§ 13

- What about the missing chapters? 5 : We'll fit it in
 - 9, 10: see UG4 Compiler Optimisation



Class-taking technique for Compiling Techniques

- I will use projected material extensively

 → I will moderate my speed, you sometimes need to say "STOP"
- You should read the book
 - \rightarrow Not all material will be covered in class
 - \rightarrow Book complements the lectures
- You are responsible for material from class
 - \rightarrow The exam will cover both lecture and reading
 - \rightarrow I will probably hint at good test questions in class
- "Compiling Techniques" is not a programming course
 - → Coursework is graded on functionality and documentation more than style (*results matter*)



• What is a compiler?



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 - → A program that translates an *executable* program in one language into an *executable* program in another language
 - \rightarrow The compiler should improve the program, in some way
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- C is typically compiled, Scheme is typically interpreted
- Java is compiled to bytecodes (code for the Java VM)
 - \rightarrow which are then interpreted
 - \rightarrow Or a hybrid strategy is used
 - Just-in-time compilation

Taking a Broader View



- Compiler Technology = Off-Line Processing
 - \rightarrow Goals: improved performance and language usability
 - Making it practical to use the full power of the language
 - \rightarrow Trade-off: preprocessing time versus execution time (or space)
 - → Rule: performance of both compiler and application must be acceptable to the end user
- Examples
 - \rightarrow Macro expansion
 - PL/I macro facility 10x improvement with compilation

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 - \rightarrow Database query optimization
 - \rightarrow Emulation acceleration
 - TransMeta "code morphing"

Why Study Compilation?



- Compilers are important system software components
 - → They are intimately interconnected with architecture, systems, programming methodology, and language design
- Compilers include many applications of theory to practice
 - \rightarrow Scanning, parsing, static analysis, instruction selection
- Many practical applications have embedded languages

 → Commands, macros, formatting tags ...
- Many applications have input formats that look like languages,
 - \rightarrow Matlab, Mathematica
- Writing a compiler exposes practical algorithmic & engineering issues
 - → Approximating hard problems; efficiency & scalability



Compiler construction involves ideas from many different parts of computer science

Artificial intelligence	Greedy algorithms Heuristic search techniques
Algorithms	Graph algorithms, union-find Dynamic programming
Theory	DFAs & PDAs, pattern matching Fixed-point algorithms
Systems	Allocation & naming, Synchronization, locality
Architecture	Pipeline & hierarchy management Instruction set use



- Compiler construction poses challenging and interesting problems:
 - \rightarrow Compilers must do a lot but also run fast
 - → Compilers have primary responsibility for run-time performance
 - → Compilers are responsible for making it acceptable to use the full power of the programming language
 - → Computer architects perpetually create new challenges for the compiler by building more complex machines
 - \rightarrow Compilers must hide that complexity from the programmer
 - \rightarrow Success requires mastery of complex interactions



It was our belief that if FORTRAN, during its first months, were to translate any reasonable "scientific" source program into an object program only half as fast as its hand-coded counterpart, then acceptance of our system would be in serious danger... I believe that had we failed to produce efficient programs, the widespread use of languages like FORTRAN would have been seriously delayed.

— John Backus

About the instructor

- My own research
 - \rightarrow Compiling for embedded processors
 - Optimisation for embedded systems (space, power, speed)
 - Source-level transformation
 - Adaptive compilation
 - Parallelisation for multi-core embedded systems
 - Homogeneous targets, e.g. Multi-DSP
 - Heterogeneous targets, e.g. Systems-on-Chip
 - \rightarrow Design Space Exploration
 - Architecture & Compiler Synthesis
- Thus, my interests lie in
 - \rightarrow Quality of generated code
 - \rightarrow Interplay between application, compiler and architecture



Next class

- The view from 35,000 feet
 - \rightarrow How a compiler works
 - \rightarrow What I think is important
 - \rightarrow What is hard and what is easy

