Adminstrivia

• Instructor:  
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• Course home page  
  [http://user.it.uu.se/~kostis/Teaching/KT2-06/](http://user.it.uu.se/~kostis/Teaching/KT2-06/)

• If you want to be enrolled in the course, you have to send, by January 27, a mail with your name and your UU e-mail address to:  
  kostis@it.uu.se

Course Goals

• Familiarize you with the theoretical basis of advanced compiler optimizations
• Give you a general orientation on compiler optimization techniques
• Give you a general understanding of
  - how some modern programming language features and constructs are implemented
  - the tradeoffs that are involved in including some feature in a programming language

Course Goals and Requirements

Non-Goals:

• Overview all possible optimizations
• Cover compilation techniques for parallelism

Requirements:

• You are supposed to be familiar with basic programming language implementation concepts
  - In particular, with semantic analysis and code generation
  - However, these topics will not be needed in this course!
• You are supposed to know how to program in Erlang
  - Do not panic: You will learn that in the next hour!

Course Content

• Static analysis and optimization
  - Theory for Static Analysis
  - Optimization Algorithms
• Implementation techniques for high-level languages
  - Memory Management (aka Garbage Collection)
  - Virtual Machines & Bytecode Interpreters
  - Just-in-time (JIT) Compilers
  - Feedback-Directed Compilation

Course Structure

• Course has theoretical and practical aspects
  - Need both in modern optimizing compilers!
• Lectures get you up-to-date with various topics and the state-of-the-art in programming language implementation.
• Project (can be done in groups of 2)
  - get you exposed with the real issues that need to be addressed when implementing a compiler optimization
  - teach you how to plan the development and testing of a non-trivial piece of software
  - teach you how to perform a serious performance evaluation.
Course’s Literature

- In addition to lecture slides, various papers from the recent research on programming language design and implementation will be available at the course’s homepage.
- These handouts are required reading.

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Introduction to Global Optimization

- The most important aspect of a compiler optimization is that the program remains correct.
- The terminology is confusing and misleading:
  - Global means function-local
  - Optimization means improvement
  - Compilation time vs. runtime speedup is often a factor to take into account

- The next slides try to give you a taxonomy of some common compiler optimization techniques

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Course Syllabus (Tentative)

- Introduction to advanced compiler design
- Foundations of static analysis and abstract interpretation
- Using static analysis for global optimization
- Static Single Assignment (SSA) form
- Optimizations based on SSA form
  - dead code elimination + sparse conditional constant propagation
  - Partial redundancy elimination and lazy code motion
  - Loop optimizations
  - Global register allocation
  - Code scheduling
  - Automatic memory management
  - Virtual machines and interpretation techniques
  - Just-in-time (JIT) compilers
  - Dynamic and feedback-directed compilation

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Taxonomy of Global Compiler Optimizations

Machine Independent
  - Redundancy
  - Code motion
  - Useless code
  - Create opportunities
  - Specialization

Machine Dependent
  - Redundancy Elimination
  - Partial Reduc.
  - Global Reduc.
  - Constant Propagation
  - Algorithmic Simplification
  - Dead Code Elimination
  - Partial D.L.C.
  - Global Reduc.
  - Constant Propagation
  - Algorithmic Simplification
  - Reassociation
  - Dead Code Elimination
  - Partial D.L.C.
  - Global Reduc.
  - Constant Propagation
  - Algorithmic Simplification

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Taxonomy of Global Compiler Optimizations

Machine Dependent
  - High Memory
  - Manage Resources
  - Special Features

- Scheduling
  - Regular tabulation
  - Data packing
- Instruction selection
  - Register allocation
  - Function optimization

- Inline expansion
  - Heap allocation
  - Stack allocation

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Why is this course interesting?

- Optimization is a very challenging problem — you can not write an ideal compiler; there is always room for improvements.
- The course will teach you many techniques and tools that you can use in other areas.
- You will gain a better understanding of how a compiler works and what to expect of the code generated by compilers.
- It is fun!