Overview of the Class

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Critical Facts

Welcome to Compilers — *Compiler Design and Implementation*

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

- **Instructor:** Dr. Pedro C. Diniz (pedro@isi.edu)
- **Office Hours:** Thursday, 11.00 – 12.00 (noon), SAL 216
- **Textbook:** “*Engineering a Compiler*” by Cooper and Torczon
- **Web Site:** http://www.isi.edu/~pedro/Teaching/CSCI565-Spring14
  - Projects, homework, slides, sample solved exercises …
  - I will not have handouts in class; get them from the web in electronic format
Basics of Grading

• Exams
  – Midterm (in class) 15%
  – Final (in class) 20%

• Homeworks (4) 20%

• Programming Projects
  – Developing Your Own Compiler/Language
    • Syntactic & Semantic Analysis 10%
    • Translation and Code Generation 25%
  – Website has a lot of info and code!
    • How to Get Started.
    • Links to Lex, Yacc.
    • Basic Data Structures (linked-list, arrays, graphs, …)
Homeworks & Projects

• Homeworks
  – Individual
  – Designed to prepare you for the Midterm and Final exams

• Projects
  – Building a compiler that generates 3-address code for a toy C-like language
  – Individual effort
  – Some programming but not much.
  – Plenty of auxiliary code basis so that you can focus on the concepts
  – Use Lex/Flex and Yacc/Bison tools (you are welcome to use other tools such as JavaCC)
  – You can develop it on your machine but need to demo on UNIX @ USC
  – Increasing difficulty at Grade Weight
    • First project focus on semantic checking (grammar provided)
    • Second project focus on code generation. You can use a simulator we provide to validate your compilation.
Tentative Syllabus

• Introduction & Overview
• Lexical Analysis: Scanning
• Syntactic Analysis: Parsing
• Syntax-Directed Translation & Parse Tree
• Intermediate Code Generation
• Control-Flow Analysis
• Semantic Analysis and Error Checking
• Run-Time Environment & Storage Organization
• Data-Flow Analysis
• Code Generation
• Instruction Scheduling
• Register Allocation
• More Optimizations (*time permitting* )

Lecture 1
Lecture 2
Lecture 3
Lecture 4
Lecture 5
Lecture 6
Lecture 7
Lecture 8
Lecture 9
Lecture 10
HW 1
HW 2
HW 2
Project 1
Project 2
HW 4
Class-Taking Technique for Compilers

• I will use projected material extensively
  – I will moderate my speed, you sometimes need to say “STOP”

• You should read the notes before coming to class
  – Not all material will be covered in class
  – Book complements the lectures

• You are responsible for material from class
  – The tests will cover both lecture and reading
  – I will probably hint at good test questions in class

• Compilers is a programming course (but not much)
  – Projects are graded on functionality, documentation, and lab reports more than style (results do matter)
On-line Material for the Class

- Class Web Site
  - http://www.isi.edu/~pedro/Teaching/CSCI565-Spring14

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Compilers - Compiler Design

Spring 2014

Contents

- Documents:
  - Syllabus (updated Feb. 24, 2008)

- Lecture Notes:
  - Lecture 1: Introduction; Overview and Lexical Analysis (month day, 2008)
    - Class Introduction [Zipped]
    - Overview of a Compiler [Zipped]
    - Lexical Analysis (part 1) [Zipped]
    - Lexical Analysis (part 2) [Zipped]
    - Lexical Analysis (part 3) [Zipped]
    - Lexical Analysis (part 4) [Zipped]
  - Lecture 2: Syntactic Analysis (month day, 2008)
    - Syntactic Analysis (part 1) [Zipped]
    - Syntactic Analysis (part 2) [Zipped]
    - Syntactic Analysis (part 3) [Zipped]
    - Syntactic Analysis (part 4) [Zipped]
    - Syntactic Analysis (part 5) [Zipped]
    - Syntactic Analysis (part 6) [Zipped]
    - Syntactic Analysis (part 7) [Zipped]
    - Syntactic Analysis (part 8) [Zipped]
  - Lecture 3: Syntactic-Directed Translation (month day, 2008)
    - Syntactic Directed Translation (part 1) [Zipped]
    - Syntactic Directed Translation (part 2) [Zipped]
  - Lecture 4: Intermediate Code Generation (month day, 2008)
    - Intermediate Code Generation (part 1) [Zipped]
    - Intermediate Code Generation (part 2) [Zipped]
    - Intermediate Code Generation (part 3) [Zipped]

- Class Forum on DEN
# Schedule of the Class

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Lectures
Office Hours
Unsolicited Advise

• This is a tough Class…
  – Structured in packets of material
  – Study regularly each subject

• We are here to Help
  – Just drop by the office during any of my office hours
  – Whenever I’m around

• Do not Cheat!
  – I get upset (that is not good!)
  – Later you might need a letter of reference from me…
Compilers

• What is a Compiler?
Compilers

• What is a Compiler?
  – A program that translates an *executable* program in one language into an *executable* program in another language
  – The compiler should improve the program, *in some way*

• What is an Interpreter?
Compilers

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• C is typically compiled, Scheme is typically interpreted

• Java is compiled to bytecodes (code for the Java VM)
  – which are then interpreted
  – Or a hybrid strategy is used
    • Just-in-time compilation
Taking a Broader View

• Compiler Technology = Off-Line Processing
  – Goals: improved performance and language usability
    • Making it practical to use the full power of the language
  – Trade-off: preprocessing time versus execution time (or space)
  – Rule: performance of both compiler and application must be acceptable to the end user

• Examples
  – Macro expansion
    • PL/I macro facility — 10x improvement with compilation
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• Examples
  – Macro expansion
    • PL/I macro facility — 10x improvement with compilation
  – Database query optimization
  – 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
  - 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,
  - MATLAB, Mathematica

- Writing a compiler exposes practical algorithmic & engineering issues
  - Approximating hard problems; efficiency & scalability
Intrinsic Interest

- Compiler Construction involves Ideas from many different parts of Computer Science

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Intrinsic Merit

Compiler Construction poses Challenging and Interesting Problems:

- 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
- Compilers must hide that complexity from the programmer
- Success requires mastery of complex interactions
About the Instructor

• My own Research
  – Compiling for Advanced Architectures Systems
  – Optimization for Embedded Systems (*space, power, speed*)
  – Program Analysis and Optimization
  – Reliability and Distributed Embedded Systems
  – Rethinking the fundamental structure of optimizing compilers

• Thus, my Interests lie in
  – Interplay between Compiler and Architecture
  – Static Analysis to discern Program Behavior
  – Run-time Performance Analysis