CS5810: Compiler Design and Implementation

Overview of the Course

Basic Information

- Course home page:
  http://www.cs.wmich.edu/~zijiang/CS5810/index.html
  Or follow the link at
  http://www.cs.wmich.edu/~zijiang
  - Slides, assignments, etc
  - I will not have handouts in class; get them from the web
- Textbook:
  - Dragon book
- Instructor: James Yang, zijiang.yang@wmich.edu
- Class time: 600-830pm, Monday @ C136
- Office hours: 400-500pm, Monday @ B-257

Project, Homework, Final Exam & Others

- Project-based course:
  - Project: 70%
  - Final: 20%
  - Class Participation 10%
- Project Grading:
  - No syntax error: 50%
  - Open test data: 35%
  - Close test data: 5%
  - Additional requirements: 10%

The Course Project

- A big project
- … in 4 not difficult but also not easy parts
- Start early!

Project Cheating Policy & Others

- Your program cannot print out the output directly from an input according to an open test data. (cheating violation)
- Later project/homework Policy: 4 late days policy.

  Start a project as early as you can!!! Don't wait until the open test data are available!!!

Grading

- Graduate class model
  - No memorizing facts, algorithms, formulas, etc. (but you need to understand)
  - You will have to be independent in this class and write your PAs by yourself

  (***You can discuss PAs with some other students but cannot sit together to write PAs***)

Class-taking Technique

- Read the book
  - Not all material will be covered in class
  - The tests will cover both lecture and reading
- Come to class
  - I take test questions from low-attendance classes
  - Pop quizzes
- Do the programming assignments
  - Good practice for the tests
  - 70%!

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?
  - A program that reads an executable program and produces the results of executing that program
- 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

Why Study Compilation?

- Compilers are important
  - Responsible for many aspects of system performance
- Compilers are interesting
  - Compilers include many applications of theory to practice
  - Writing a compiler exposes practical algorithmic & engineering issues
- Compilers are everywhere
  - Many practical applications have embedded languages
    - Commands, macros, formatting tags …
  - Many applications have input formats that look like languages

Intrinsic Merit

- Compiler construction poses challenging and interesting problems:
  - Compilers must do a lot but also run quickly
  - Compilers have primary responsibility for run-time performance
- Computer architects perpetually create new challenges for the compiler by building more complex machines
  - Compilers must hide that complexity from the programmer
- A successful compiler requires mastery of the many complex interactions between its constituent parts

Intrinsic Interest

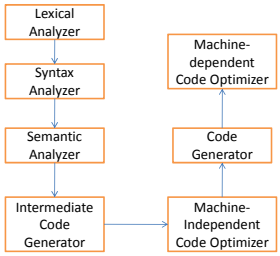
- Compiler construction involves ideas from many different parts of computer science
- Artificial intelligence
  - Greedy algorithms, Heuristic search techniques
- Algorithms
  - Graph algorithms, union-find Dynamic programming
- Theory
  - DFAs & PDAs, pattern matching, Fixed-point algorithms
- Systems
  - Allocation & naming, Synchronization, locality
- Architecture
  - Pipeline & hierarchy management, Instruction set use

Why Does This Matter Today?

In the last 2 years, most processors have gone multicore

- The era of clock-speed improvements is drawing to an end
  - Faster clock speeds mean higher power (n^2 effect)
  - Smaller wires mean higher resistance for on-chip wires
- For the near term, performance improvement will come from placing multiple copies of the processor (core) on a single die
  - Classic programs, written in old languages, are not well suited to capitalize on this kind of multiprocessor parallelism
    - Parallel languages, some kinds of OO systems, functional languages
- Parallel programs require sophisticated compilers

The Structure of a Compiler



Lexical Analysis (Scanning)

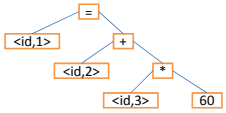
*position = initial + rate * 60*

- Reads the stream of characters and groups the characters into meaningful sequences called lexemes
  - Produces tokens of the form
    - <token-name, attribute-value>
    - <id,1> <=> <id,2> <+> <id,3> <*> <60>

Syntax Analysis (Parsing)

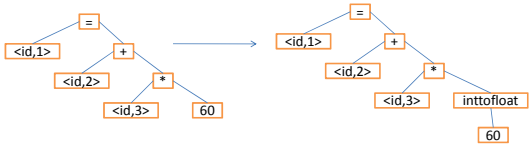
<id,1> <=> <id,2> <+> <id,3> <> <60>*

- Create a tree-like representation that depicts the grammatical structure of the token stream
- Syntax tree
  - Interior node represents an operation
  - Children represent the arguments



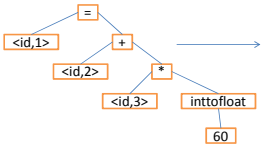
Semantic Analysis

- Use syntax tree and symbol table to check the source program for semantic consistency with the language definition
  - Type checking



Intermediate Code Generation

- Many compiler generate an explicit machine-like intermediate representation
  - Easy to produce
  - Easy to translate into the target machine
  - Three-address code




```
t1=intoffloat(60)
t2=id3 * t1
t3 = id2 + t2
id1 = t3
```

Code Optimization

- Improve the intermediate code so that better target code will result
  - Faster
  - Shorter
  - Consumes less power

```
t1=intoffloat(60)
t2=id3 * t1
t3 = id2 + t2
id1 = t3
```

→

```
t1=id3 * 60.0
id1 = id2 + t1
```

Code Generation

- Maps an intermediate representation into the target language