

CMSC 430— “Theory of Language Translation”

Topics in the design of programming language translators, including scanning, parsing, error recovery, code generation, and code improvement.

Prerequisite: CMSC 330

Important facts:

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Textbook is *Modern Compiler Implementation* by Andrew Appel

Course Overview

Basis for grades:

- 30% midterms, 20% final exam, 50% 5 programming projects

Programming Projects

- scanner construction (REs to minimal DFAs)
- scanner/parser using **JLex** and **CUP**
- simple type checker
- Java byte code generation
- advanced code generation, optimizations

Policies

- no collaboration (code sharing) allowed
- 1-week late policy, no incompletes

Lecture notes

- all lectures are on the Web, you should still take notes & read textbook

Compiler Overview

What is a compiler?

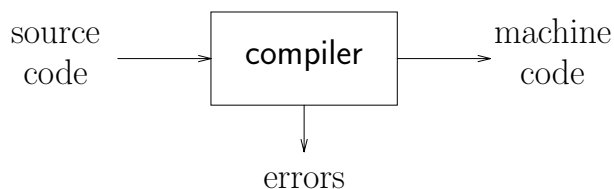
- a program that translates an *executable* program in one language into an *executable* program in another language
- the compiler typically *lowers* the level of abstraction of the program
- for “optimizing” compilers, we also expect the program produced to be *better*, in some way, than the original

Compilers are large, complex pieces of software. By working on compilers, you’ll learn to use

- programming tools (compilers, debuggers)
- program-generation tools (JLex, CUP)
- software libraries (Java class libraries)

Hopefully you will also improve your programming and software engineering skills.

Abstract view of compiler

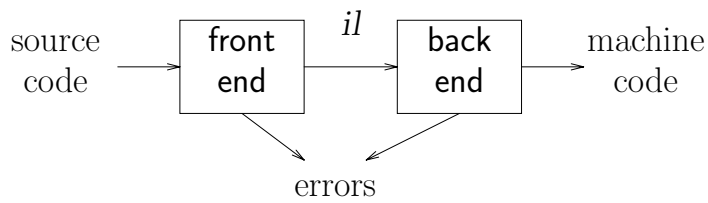


Implications:

- recognize legal (and illegal) programs
- generate correct code
- manage storage of all variables and code
- need format for object (or assembly) code

Big step up from assembler – higher level notations

Traditional two pass compiler



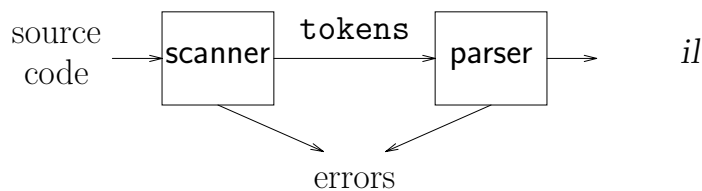
Implications:

- intermediate language (*il*)
- front end maps legal code into *il*
- back end maps *il* onto target machine
- simplify retargeting
- allows multiple front ends
- multiple passes \Rightarrow better code

Front end is $O(n)$ or $O(n \log n)$

Back end is NP-Complete

Front end

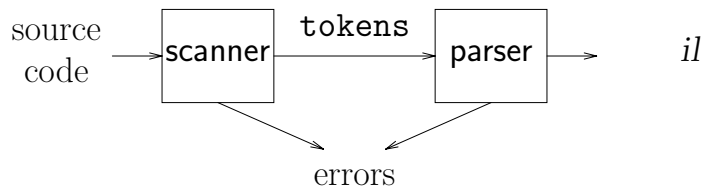


Responsibilities:

- recognize legal procedure
- report errors
- produce *il*
- preliminary storage map
- shape the code for the back end

Much of front end construction can be automated

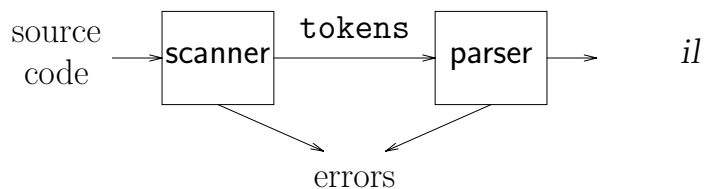
Scanner



Scanner

- maps characters into *tokens* – the basic unit of syntax
 $x = x + y;$
becomes
 $\langle \text{id}, x \rangle = \langle \text{id}, x \rangle + \langle \text{id}, y \rangle ;$
- character string for a *token* is a *lexeme*
- typical tokens: *number, id, +, -, *, /, do, end*
- eliminates white space (*tabs, blanks, comments*)
- a key issue is speed
⇒ use specialized recognizer (**lex**)

Parser



Parser:

- recognize context-free syntax
- guide context-sensitive analysis
- construct $il(s)$
- produce meaningful error messages
- attempt error correction

Parser generators mechanize much of the work

Back end

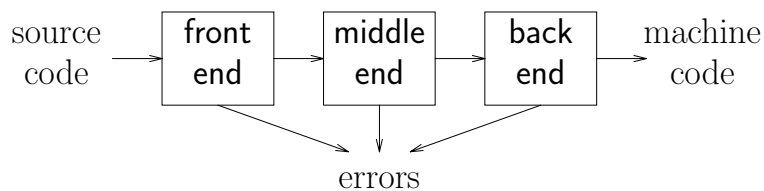


Responsibilities

- translate *il* into target machine code
- choose instructions for each *il* operation
- decide what to keep in registers at each point
- ensure conformance with system interfaces

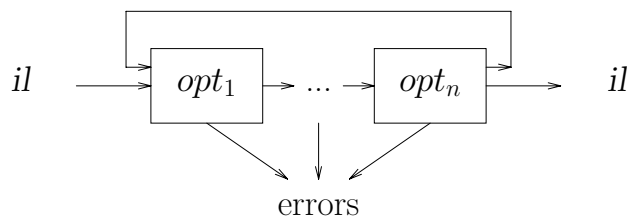
Automation has been less successful here

Optimizing compilers



Code Improvement

- analyzes and changes *il*
- goal is to reduce runtime
- must preserve values



Modern optimizers are usually built as a set of passes.