Introduction to Compiler Construction

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Syllabus

- Prerequisites: COP4020 or equivalent
- Textbook: "*Compilers: Principles, Techniques, and Tools*" by Aho, Sethi, and Ullman, 2nd edition
- Other material: "*The Java™ Virtual Machine Specification*" SE 8 and class handouts
- Grade breakdown:
  - Exams (three midterm, one final) (60%)
  - Four project assignments (40%)
  - Homework for extra credit (at most 4%)

Syllabus, Assignments, and Schedule

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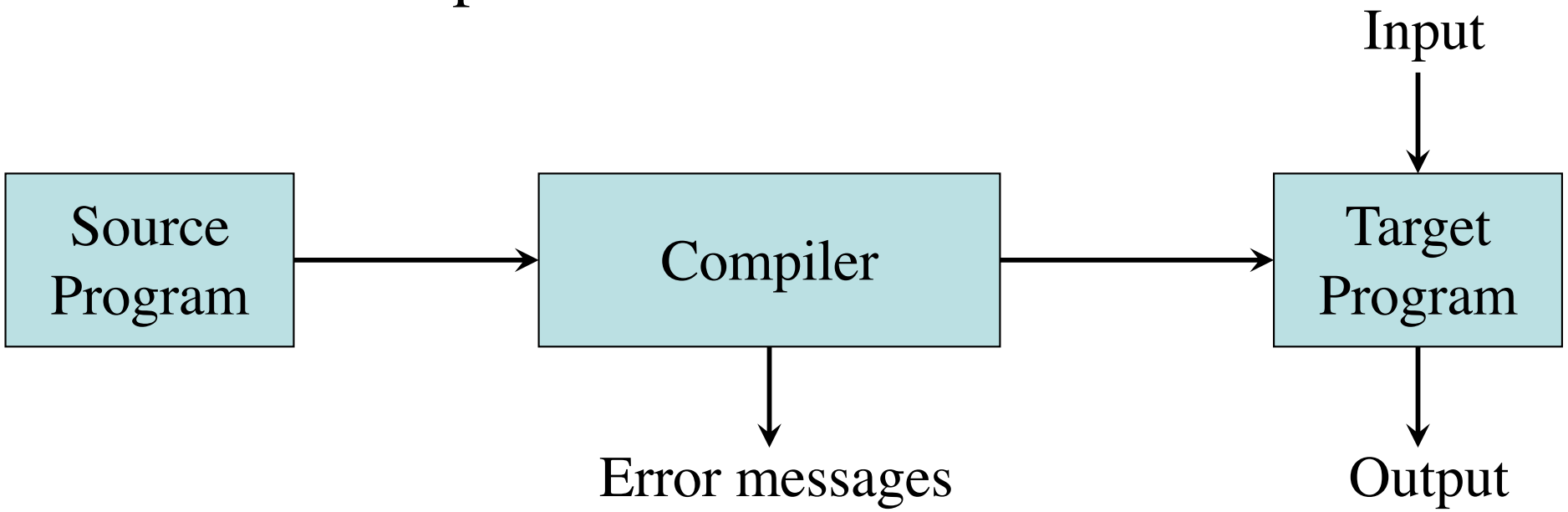
Objectives

- Be able to build a compiler for a (simplified) (programming) language
- Know how to use compiler construction tools, such as generators of scanners and parsers
- Be familiar with assembly code and virtual machines, such as the JVM, and bytecode
- Be able to define LL(1), LR(1), and LALR(1) grammars
- Be familiar with compiler analysis and optimization techniques
- … learn how to work on a larger software project!

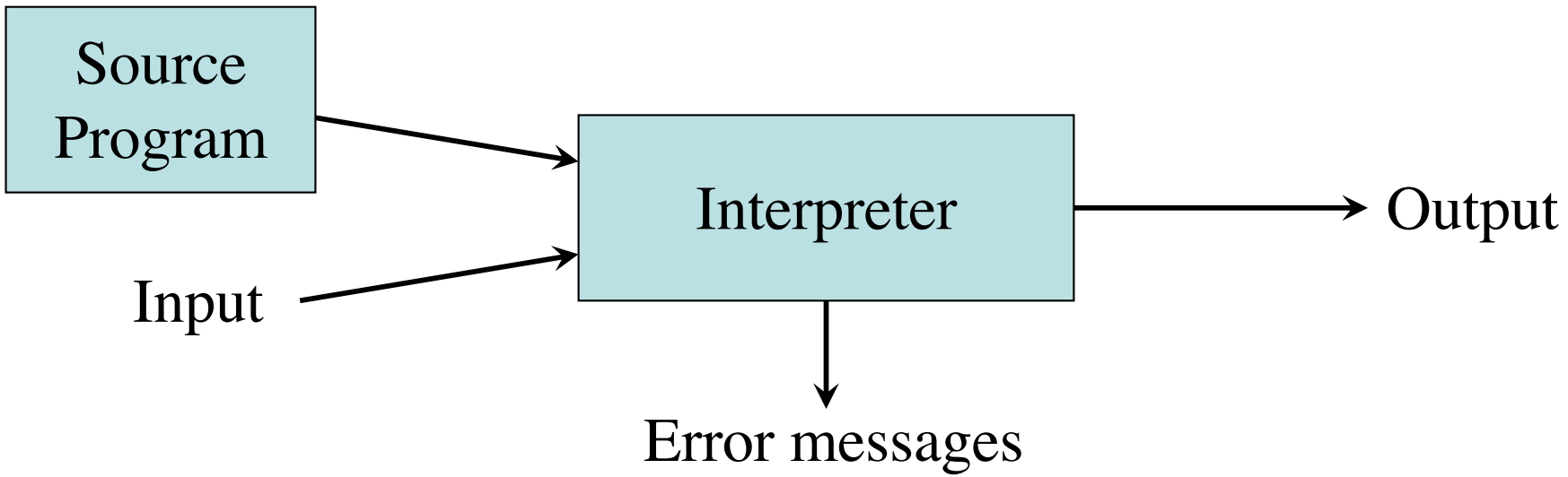
Compilers and Interpreters

- "*Compilation*"
  - Translation of a program written in a source language into a semantically equivalent program written in a target language
  - Oversimplified view:



Compilers and Interpreters (cont'd)

- "*Interpretation*"
  - Performing the operations implied by the source program
  - Oversimplified view:



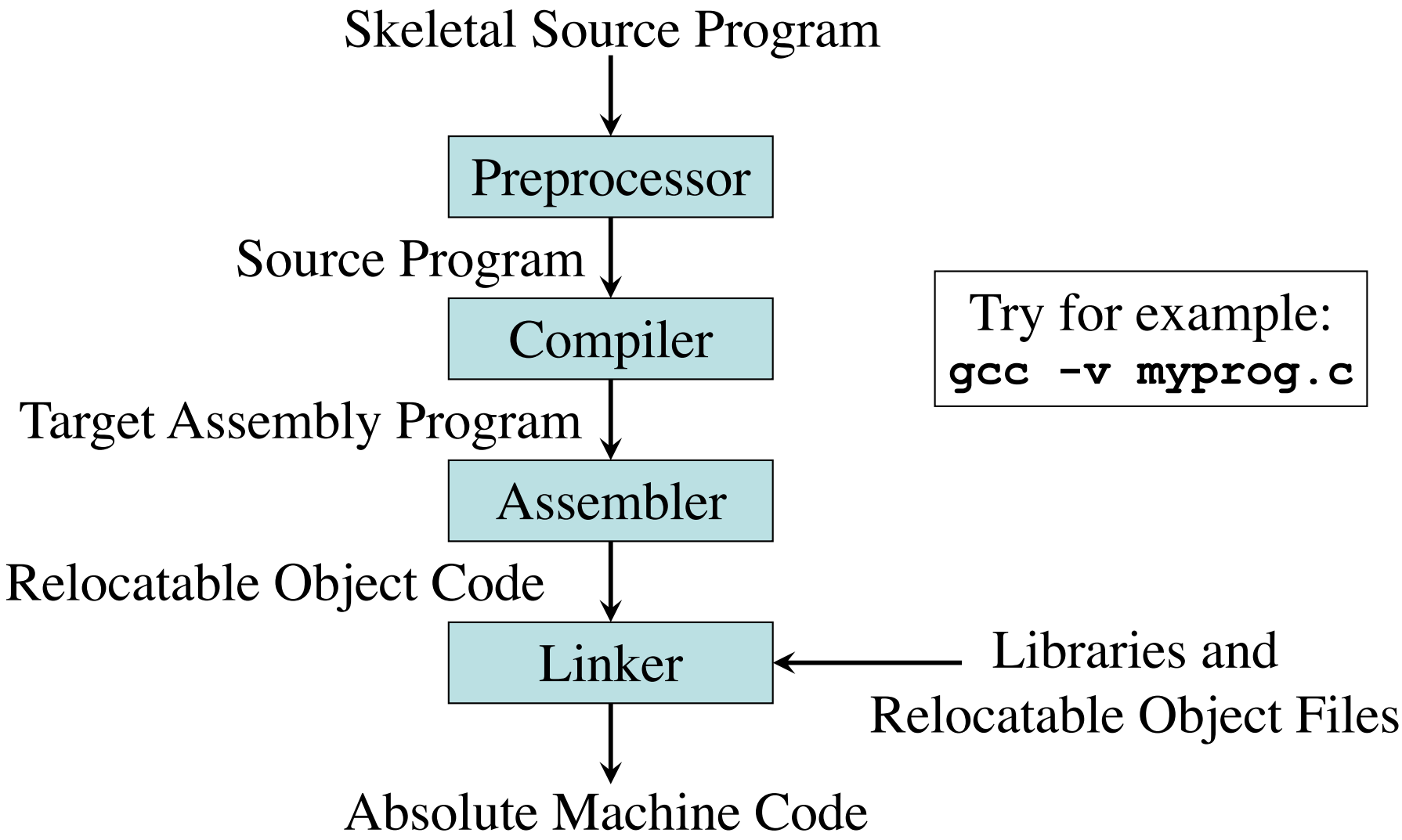
The Analysis-Synthesis Model of Compilation

- There are two parts to compilation:
  - *Analysis* determines the operations implied by the source program which are recorded in a tree structure
  - *Synthesis* takes the tree structure and translates the operations therein into the target program

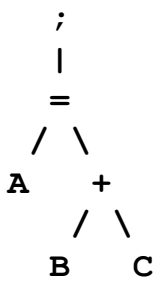
Other Tools that Use the Analysis-Synthesis Model

- *Editors* (syntax highlighting)
- *Pretty printers* (e.g. Doxygen)
- *Static checkers* (e.g. Lint and Splint)
- *Interpreters*
- *Text formatters* (e.g. TeX and LaTeX)
- *Silicon compilers* (e.g. VHDL)
- *Query interpreters/compilers* (Databases)

Preprocessors, Compilers, Assemblers, and Linkers



The Phases of a Compiler

Phase	Output	Sample
Programmer (source code producer)	Source string	`A=B+C;`
Scanner (performs *lexical analysis*)	Token string	`'A', '=', 'B', '+', 'C', ';'` And *symbol table* with names
Parser (performs *syntax analysis* based on the grammar of the programming language)	Parse tree or abstract syntax tree	
Semantic analyzer (type checking, etc)	Annotated parse tree or abstract syntax tree	

Intermediate code generator	Three-address code, quads, or RTL	`int2fp B t1`
		`+ t1 C t2`
		`:= t2 A`

Optimizer	Three-address code, quads, or RTL	`int2fp B t1` `+ t1 #2.3 A`

Code generator	Assembly code	`MOVF #2.3,r1`
		`ADDF2 r1,r2`
		`MOVF r2,A`

Peephole optimizer	Assembly code	`ADDF2 #2.3,r2` `MOVF r2,A`

The Grouping of Phases

- Compiler *front* and *back ends*:
  - Front end: *analysis* (*machine independent*)
  - Back end: *synthesis* (*machine dependent*)
- Compiler *passes:*
  - A collection of phases is done only once (*single pass*) or multiple times (*multi pass*)
    - Single pass: usually requires everything to be defined before being used in source program
    - Multi pass: compiler may have to keep entire program representation in memory

Compiler-Construction Tools

- Software development tools are available to implement one or more compiler phases
  - *Scanner generators*
  - *Parser generators*
  - *Syntax-directed translation engines*
  - *Automatic code generators*
  - *Data-flow engines*

Outline

- Introduction
- A simple One-Pass Compiler for the JVM
- Lexical Analysis and Lex/Flex
- Syntax Analysis and Yacc/Bison
- Syntax-Directed Translation
- Static Semantics and Type Checking
- Run-Time Environments
- Intermediate Code Generation
- Target Code Generation
- Code Optimization