Introduction to Compiler
2CS701 Compiler Construction

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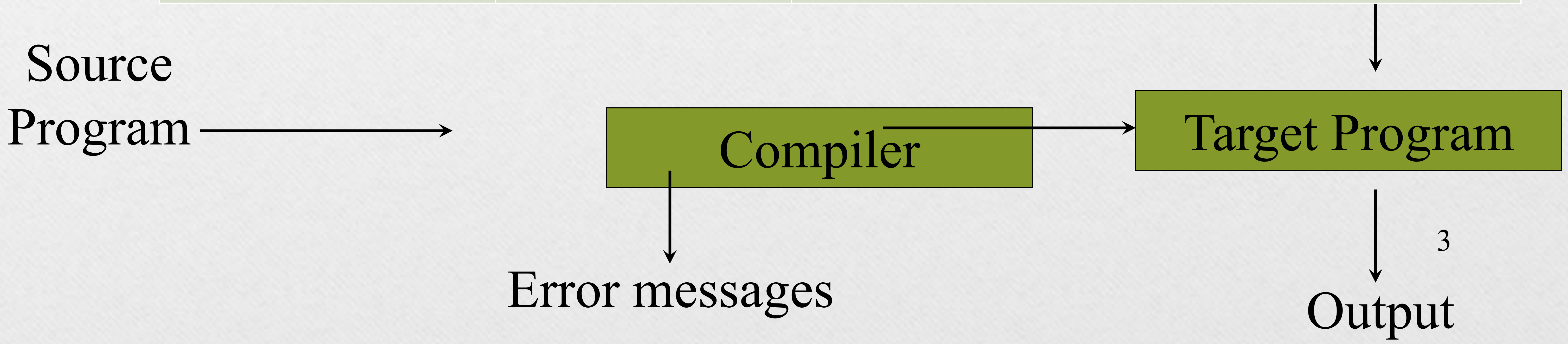
Outline

- Compiler and Interpreter
- Other types of compiler
- Analysis and Synthesis Model of compilation
- Phases of compiler
- Cousins of compiler
- Other applications of compilation techniques

Compiler

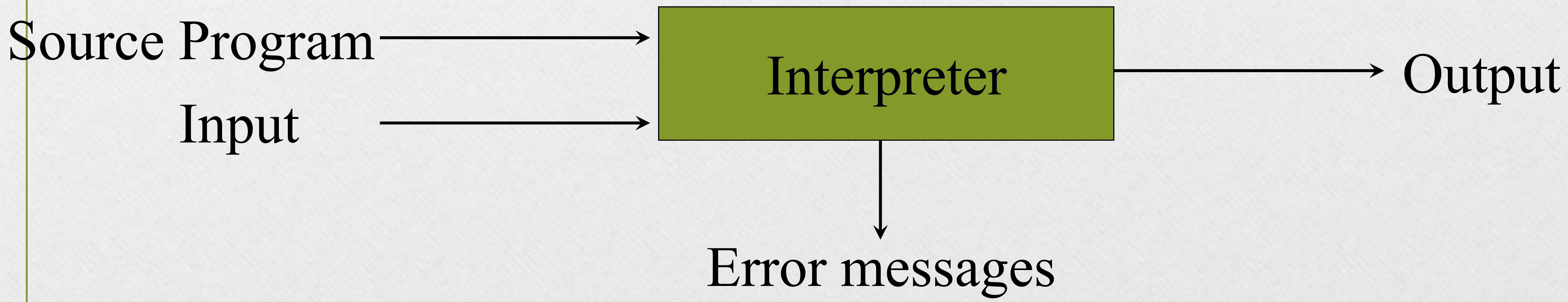
- Translation of a program written in a source language into a semantically equivalent program written in a binary/machine dependent language

Compiler	Source Language	Target Language
Gcc	C	Binary / Machine Language
G++	C++	Binary / Machine Language
Javac	Java	Byte Code



Interpreters

- Translation of an instruction of a program written in a source language into a semantically equivalent instruction written in a target (machine) language
- Execute translated line with given input
- E.g. Debugger , command line interpreter , Python Interpreter, Perl Interpreter, PHP interpreter



Types of compilers

- **Source to source compiler / Transpiler / Transcompiler :** takes the source code of a program written in a programming language as its input and produces the equivalent source code in the same or a different programming language.
- Applications :
  - An automatic parallelizing compiler will frequently take in a HLL program as an input and then transform the code and annotate it with parallel code (e.g., OpenMP)
  - translating legacy code to use the next version of the underlying programming language or an API that breaks backward compatibility

Compiler	Source Language	Target Language
Cfront	C++	C
HPHPc	PHP	C++
JSSweet	Java	Typescript

Types of compilers

- **Cross Compilers:** They produce an executable machine code for a platform but, this platform is not the one on which the compiler is running.

  For example, a compiler that runs on a PC but generates code that runs on an Android smartphone is a cross compiler.

- **Bootstrap Compilers.** These compilers are written in a programming language that they have to compile.

- **Decompiler** : translates an executable file to a high-level source file which can be recompiled successfully.

Self Evaluation

- Is Java Compiler or Interpreter?
  - **Java can be considered both a compiled and an interpreted language** because its source code is first compiled into a binary byte-code for machine, which does not exist *Java Virthual Machine).
  - This byte-code runs on the Java Virtual Machine (JVM), which is usually a software-based interpreter.
- Is compiler faster than Interpreter? How?
- What is need of Decompiler ?

The Analysis-Synthesis Model of Compilation

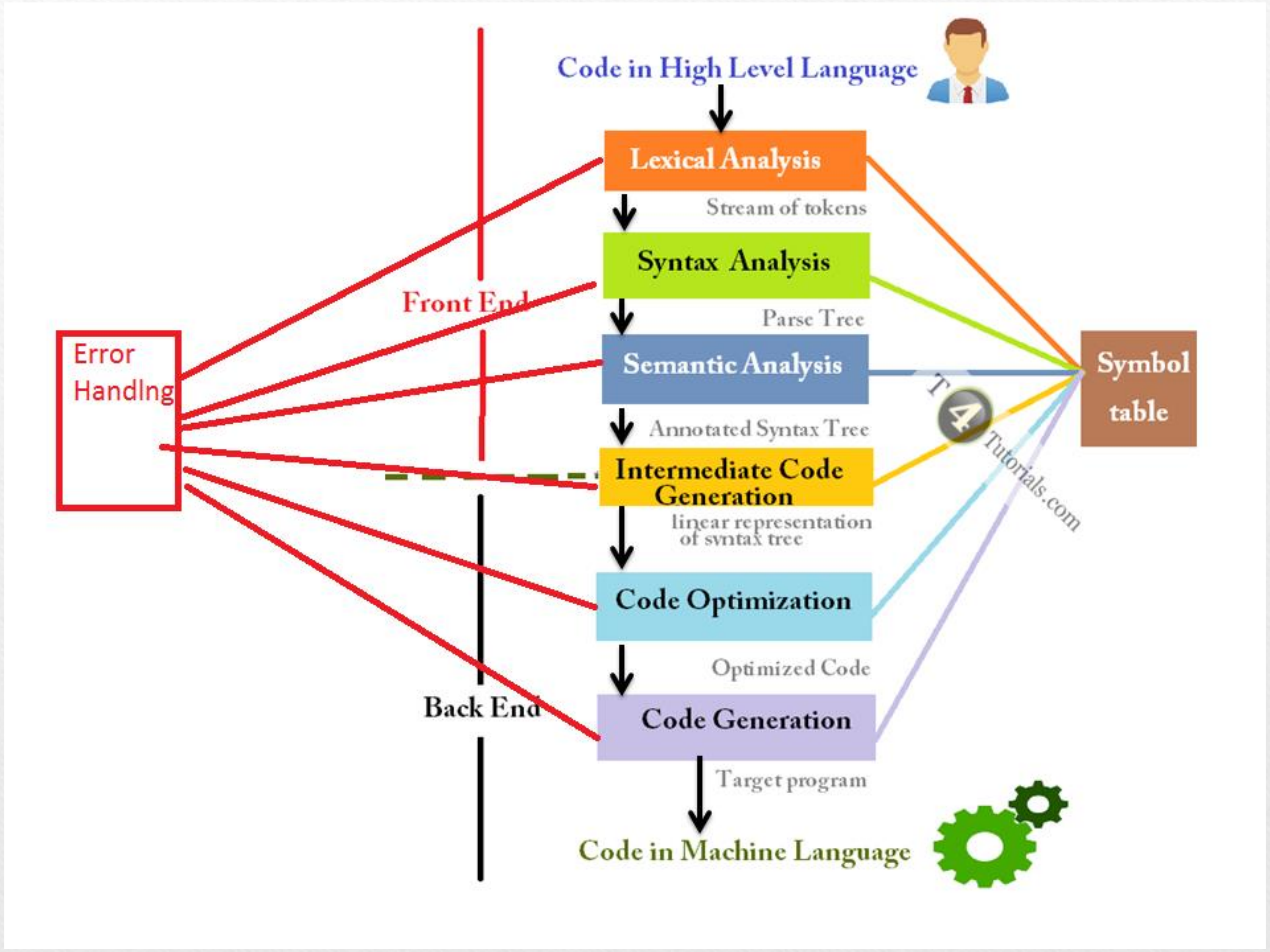
- There are two parts to compilation:
  - ***Analysis*** determines the operations implied by the source program which are recorded in a tree structure
  - ***Synthesis*** takes the tree structure and translates the operations therein into the target program

analysis : source program -> tree structure
synthesis : tree structure -> target program

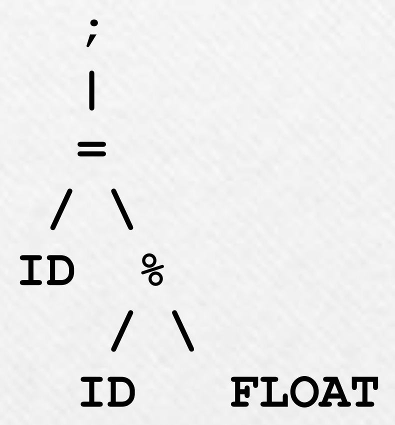
Other Tools that Use the Analysis-Synthesis Model

- *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)
- Circuit design from K-map

The Phases of a Compiler

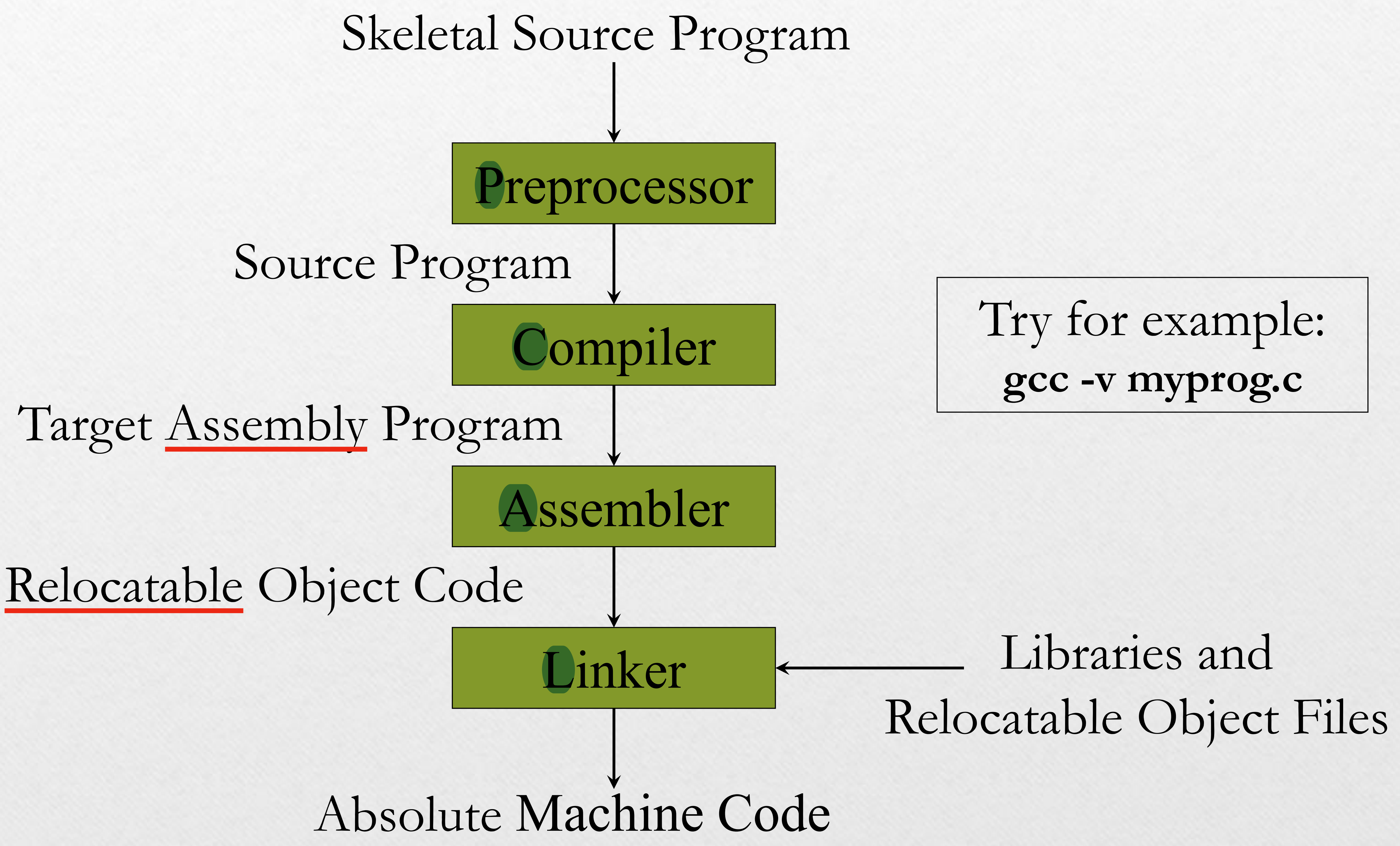


The Phases of a Compiler

Phase	Output	Sample
Programmer (source code producer)	Source string	**`A=A/5.2;`**
Scanner (performs *lexical analysis*)	Token string	**ID '=' ID '%' FLOAT ';'** And *symbol table* with names
Parser (performs *syntax analysis* based on the grammar of the programming language)	Parse tree or abstract syntax tree Or Syntax Error	
Semantic analyzer (type checking, etc)	Annotated parse tree or abstract syntax tree	**`Error:'%' operator should have both operand integer.`** **`ID '=' ID '%' fp2Int(FLOAT)`**
Intermediate code generator	Three-address code, quads, or RTL	**`fp2int 5.2 t1`** **`% A t1 t2`** **`:= t2 A`**
Optimizer	Three-address code, quads, or RTL	**`fp2int 5.2 t1`** **`% A t1 A`**
Code generator	Assembly code	**`MOVF #5.2,r1`** **`ADDF2 r1,r2`** **`MOVF r2,A`**
Peephole optimizer	Assembly code	**`ADDF2 #5.2,r2`** **`MOVF r2,A`**

Cousins of compiler

Preprocessors, Compilers, Assemblers, and Linkers



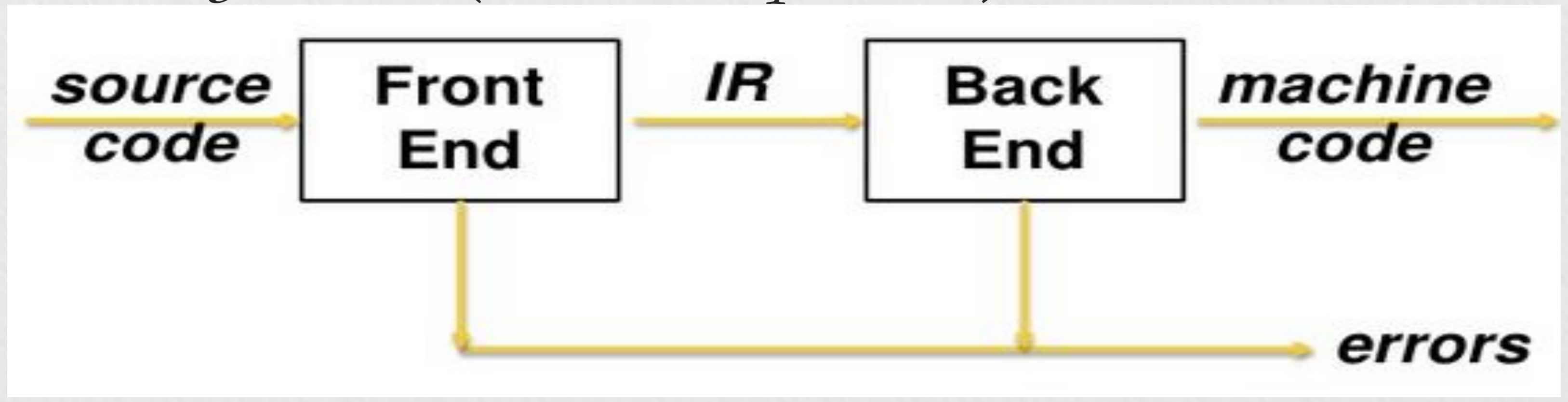
Try for example:
gcc -v myprog.c

Self Evaluation

1. Which compiler phase is optional ? Why?
2. Which compiler phase concept can be apply in text editor for spell check?
3. Which compiler phase concept can be apply in text editor for grammar check?
4. "Compiler can generate assembly code as output". State True/False. Justify
5. Does compiler recognize semantic error and reports it?
6. What is difference between code optimization phase before and after code generation?

The Grouping of Phases

- Compiler *passes:*
  - Single pass:
    - Read one part, process all phases, read next part
    - Does not look code previously processed
    - Require everything to be defined before. Else Use Backpatch
    - Require large memory
  - Multi pass: Every pass results new representation and input to next pass
    - Compiler *front* and *back ends*:
    - Front end: *analysis* (*machine independent*)
    - Back end: *synthesis* (*machine dependent*)



Other Applications of techniques used in compiler design

- Lexical Analyzer → text editors, information retrieval system, and pattern recognition programs. E.g. pretty printers apply stylist formatting to source code, markup like text using indenting styles, coloring token classes
- Syntax Analyzer → query processing system such as SQL, K-map to circuit design
- Syntax Analyzer + semantic analyzer → Equation solver

- Most of the techniques used in compiler design can be used in Natural Language Processing (NLP) systems.

Other Application of Lexical Analyzer
E.g. Pretty-printing : Formatting coding

```
int foo(int k){if(k<1||k>2)
{printf("out of range\n");
printf(“Requires a value of 1 or 2\n");}
else{printf("Switching\n");}}
```

GNU Indent Program

```
int foo(int k)
{
  if(k<1||k>2)
    {
      printf("out of range\n");
      printf(“Requires a value of 1 or 2\n");
    }
    else
    {
      printf("Switching\n");
    }
}
```

Self Evaluation

- What are advantages and disadvantages of single pass compiler and multi-pass compiler?
- Why is it preferred to keep front-end phases and back-end phases into different pass?
- Find at-least 3 applications of compiler techniques other than compiler