INTRODUCTION TO PROGRAMMING LANGUAGES

COMS W1001
Introduction to Information Science

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Today’s Topics

- Why We Need Programming Languages
  - Low-level Programming Language
  - High-level Programming Language
- How a Program Works
  - Compiler
  - Interpreters

Why We Need Programming Languages

- A computer's CPU can only understand instructions that are written in machine language.
- Assembly language was created in the early days of computing a an alternative to machine languages.
- Instead of using binary numbers for instructions, assembly language uses short words that are know as mnemonics.
- Because assembly language is so close in nature to machine language , it is referred to as a low-level language

```
LDF  R2, id3
MULF R2, R2, #60.0
LDF  R1, id2
ADDF R1, R1, R2
STF  id1, R1
```

Why We Need Programming Languages

- People still find it very difficult to write entire programs in assembly language, other programming languages have been invented.
- Programming languages are notations for describing computations to people and to machines.
- In the 1950s, a new generation of programming languages known as high-level languages began to appear
- They allow programmers to create powerful and complex programs without knowing how the CPU works, and without writing large numbers of low-level instructions.

Some High-Level Programming Languages

Languages	Description
BASIC	Beginners All-purpose Symbolic Instruction Code, 1960s
FORTRAN	FORmula TRANslator, 1950ss
COBOL	Common Business-Oriented Language, 1950s
Pascal	Originally designed for teaching programming, 1970s
C and C++	General purpose programming language, developed at Bell Lab in 1972 (C) and 1983 (C++)
C#	Around the year 2000 by Microsoft for .NET platform
Java	General purpose programming language, created by Sun Microsystem in early 1990s
JavaScript	Mainly used in web pages, created in 1990s
Pythons	General purpose programming language, created in the early 1990s
Ruby	General purpose programming language, created in the early 1990s
Visual Basic	Created in the early 1990s for Windows-based applications

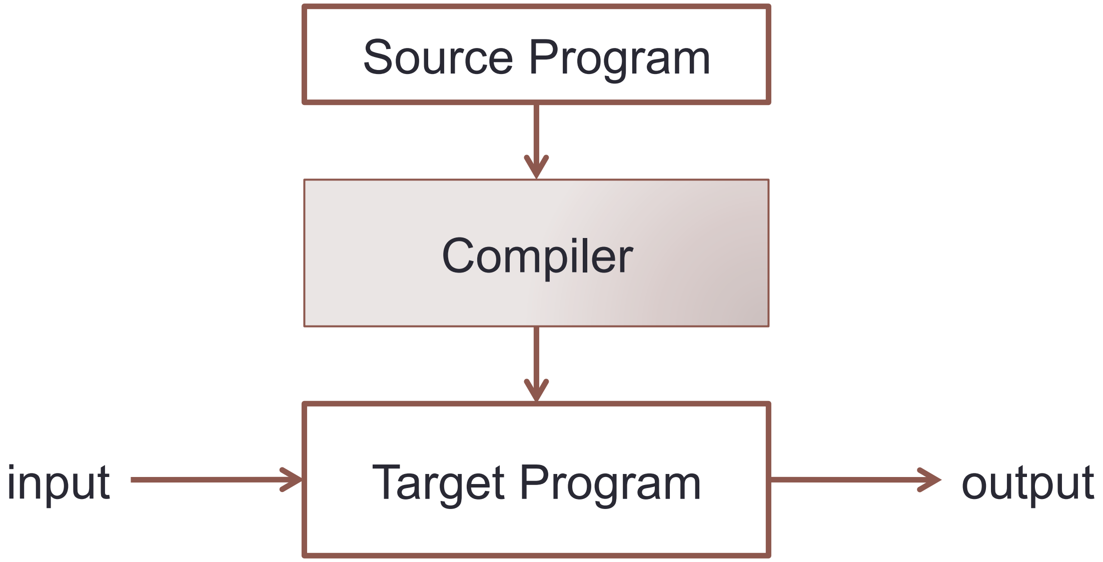
How a Program Works

- Before a program can be run, it first must be translated into a form in which it can be executed by a computer.
- The software systems that do this translation are called compilers.

- A compiler is a program that can read a program in one language – the *source* language – and translate it into an equivalent program in another language – the *target* language.

How a Program Works

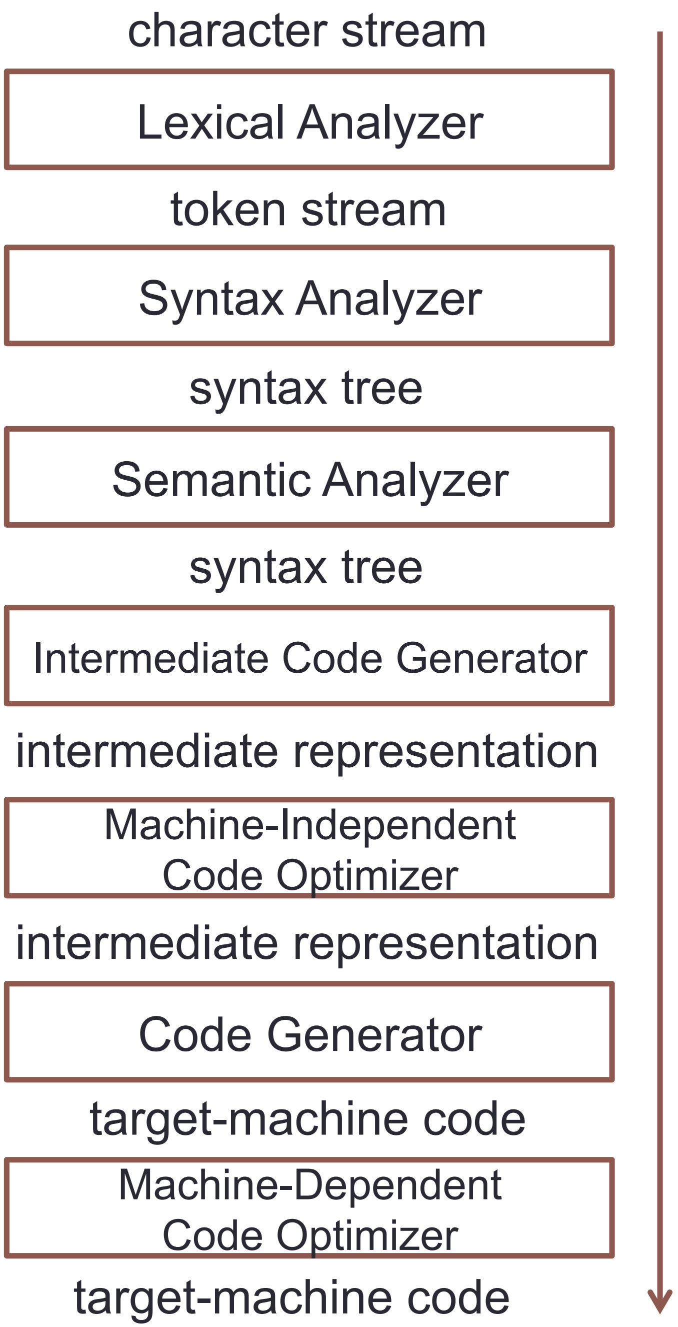
- Compiler
  - Translates a source program into a target program
  - If the target program is an executable machine-language program, it can then be called by the user to process inputs and produce outputs



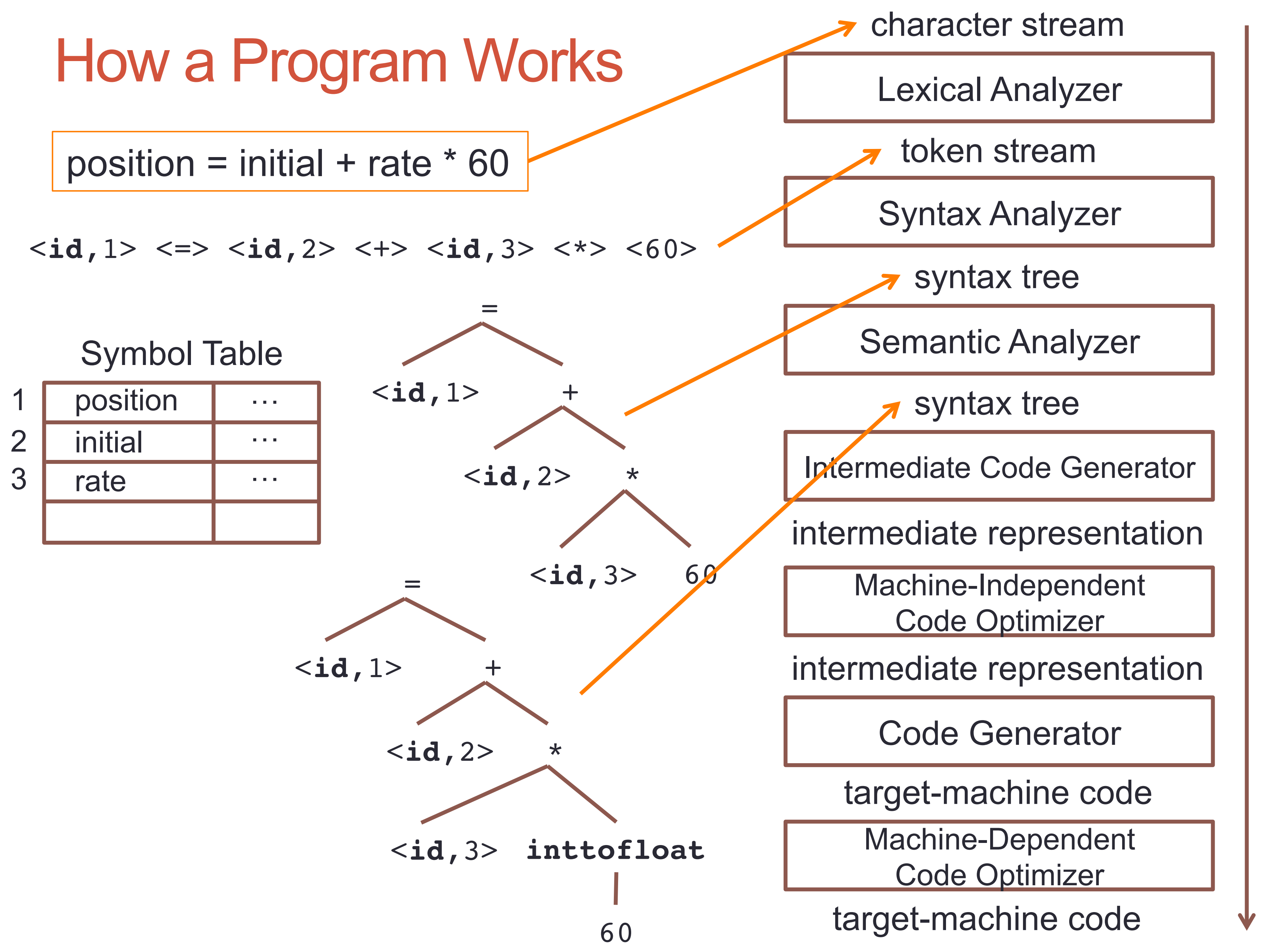
How a Program Works

- Phases of a compiler
  - Analysis part
    - breaks up the source program into constituent pieces
    - imposes a grammatical structure
    - uses this structure to create intermediate representation
  - Synthesis part
    - construct the desired target program from the intermediate representation and the information in the symbol table
  - Symbol table
    - the analysis part collects information about the source program and stores it in a data structure called a symbol table, which is passed along with the intermediate representation to the synthesis part.

Symbol Table



How a Program Works



position = initial + rate * 60

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

Symbol Table

1	position	…
2	initial	…
3	rate	…

character stream

Lexical Analyzer

token stream

Syntax Analyzer

syntax tree

Semantic Analyzer

syntax tree

Intermediate Code Generator

intermediate representation

Machine-Independent Code Optimizer

intermediate representation

Code Generator

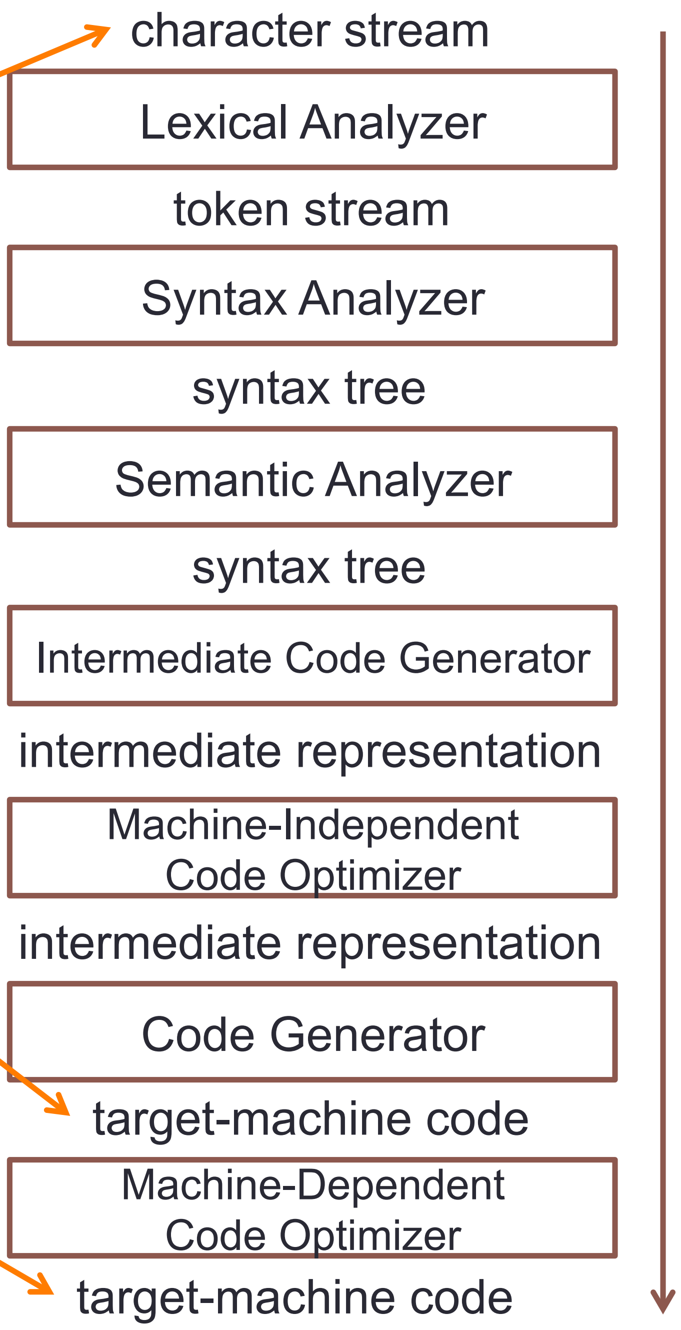
target-machine code

Machine-Dependent Code Optimizer

target-machine code

How a Program Works

position = initial + rate * 60



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Symbol Table

1	position	…
2	initial	…
3	rate	…

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

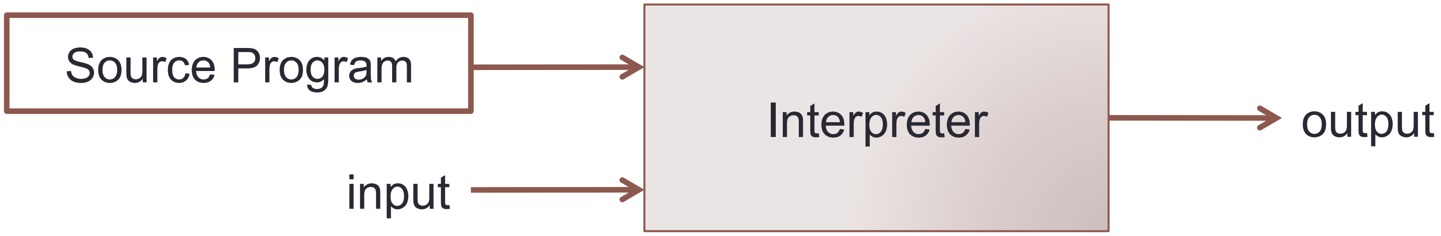
```
t1 = id3 * 60.0
id1 = id2 + t1
```

```
LDF  R2, id3
MULF R2, R2, #60.0
LDF  R1, id2
ADDF R1, R1, R2
STF  id1, R1
```

```
0001 0010 1111 0000
1110 0010 0011 1100
…
```

How a Program Works

- Interpreter
  - Translates a source program to its equivalent machine-language program and immediately executes them.



  - The Python language uses an interpreter.

References & Photo Credits

- Pearson Custom Computer Science COMS W1001 Introduction to Information Science, Columbia University. Chapter 12 Introduction to Computer and Programming by Tony Gaddis
- Compilers, Principles, Techniques, and Tools. Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman.