Compiler Design

An Introduction

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1. Pre-requisite courses
2. Introduction To Compiler Design
3. The Phases of a Compiler
4. Compiler Construction Tools

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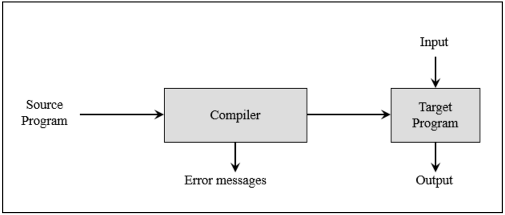
  - Before a program can be run, it first must be translated into a form (Target Program), which can be executed by a computer.
  - **Translation** of a program written in a source language into a semantically equivalent program written in a target language



Introduction To Compiler Design

- A compiler is a program translates (or compiles) a program written in a **high-level** programming language (the source language) that is suitable for human programmers into the **low-level** machine language (target language) that is required by computers.

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- During this process, the compiler will also attempt to spot and report obvious programmer mistakes that detect during the translation process.

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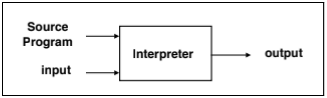
Introduction To Compiler Design

- **Interpreter:** An interpreter is another common kind of language processor. Instead of producing a target program as a translation, an interpreter appears to directly execute the operations specified in the source program on inputs supplied by the user.



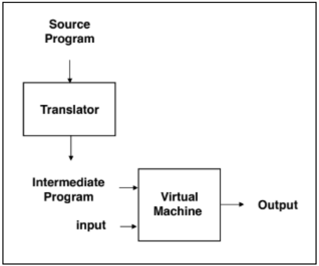
Compiler vs. Interpreter

- **Compiler vs. Interpreter**

Compiler	**Interpreter**
Takes the entire program as input	Take single instruction as input
It is Faster	It is Slower
Intermediate object code is generated.	no intermediate code is generated;
Errors are displayed after the entire program has been checked.	Errors are displayed for every instruction interpreted.
Ex: C, C++.	Ex: python, Ruby, basic.

Introduction To Compiler Design

- **Bytecode & Virtual Machine**
  A Java source program may first be compiled into an intermediate form called bytecodes. The bytecodes are then interpreted by a virtual machine. A benefit of this arrangement is that bytecodes compiled on one machine can be interpreted on another machine, perhaps across a network.



A typical Language Processing System

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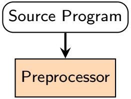
Source Program

A typical Language Processing System



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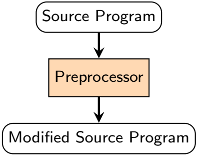

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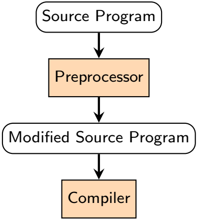

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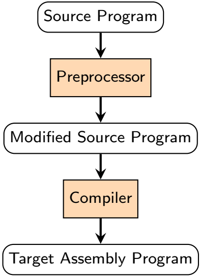

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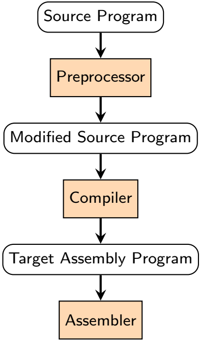

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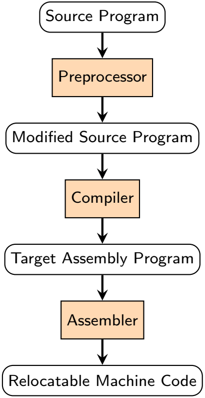

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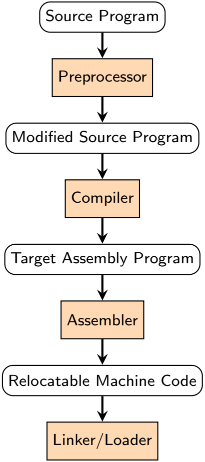

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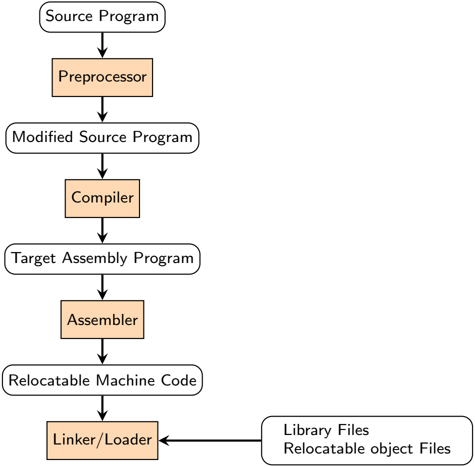

Source Program

Preprocessor

Modified Source Program

Compiler

Target Assembly Program

Assembler

Relocatable Machine Code

Linker/Loader

Library Files
Relocatable object Files

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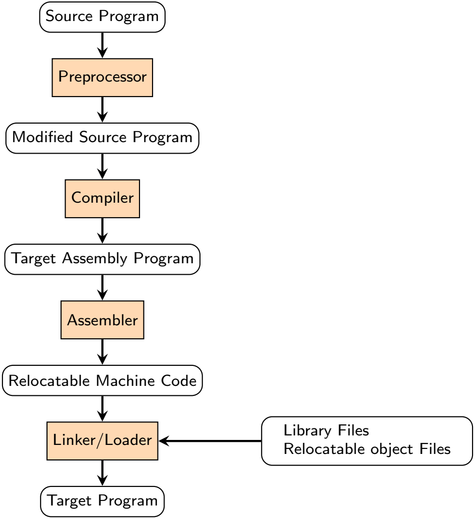

Issues related to Compiler Design

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- Correctness

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- Speed (runtime and compile time)
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- Debugging

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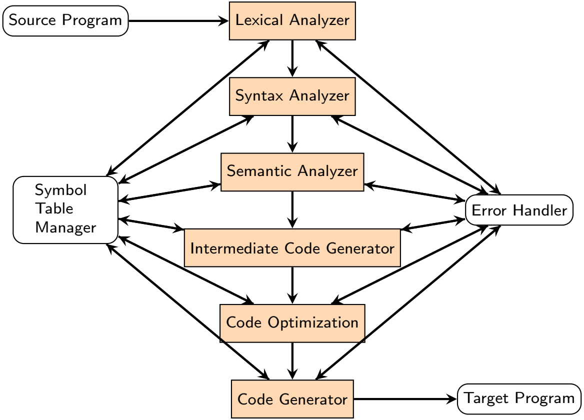
Analysis - Synthesis Model of Compilation

There are two parts of compilation:-

- **Analysis** - It breaks up the source program into constituent pieces and creates an intermediate representation of the source program. If the analysis part detects that the source program is either syntactically ill formed or semantically unsound, then it must provide informative messages, so the user can take corrective action.
- **Synthesis** - It constructs the desired target program from the intermediate representation and the information in the symbol table.

The Phases of a Compiler

- Conceptually, a compiler operates in phases, each of which translates the source program from one representation to another.



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Translation of an Assignment Statement

Translation of an Assignment Statement:

- Lexical Analyser takes the source program as input and produces a long string of tokens.
- Syntax Analyser takes an out of lexical analyser and produce a large tree.
- Semantic Analyser takes an output of Syntax analyser and produces another tree.
- Similarly Intermediate code generator takes a tree as an input produced by Semantic analyser and produces Intermediate code.

The Phases of a Compiler

$\boxed{position = initial + rate * 60}$

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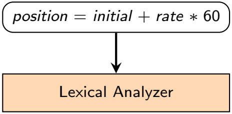

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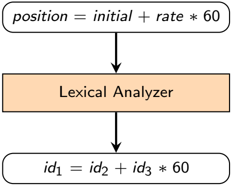

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Lexical Analyzer

$id_1 = id_2 + id_3 * 60$

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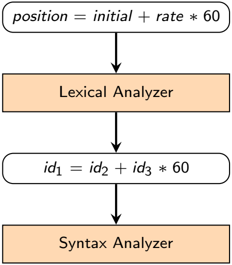

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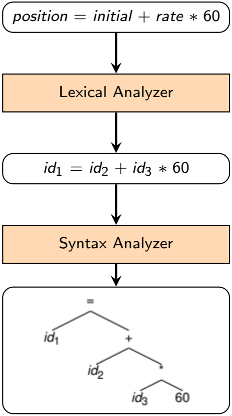

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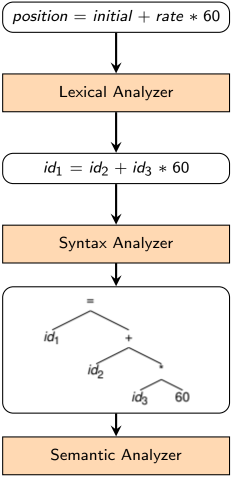

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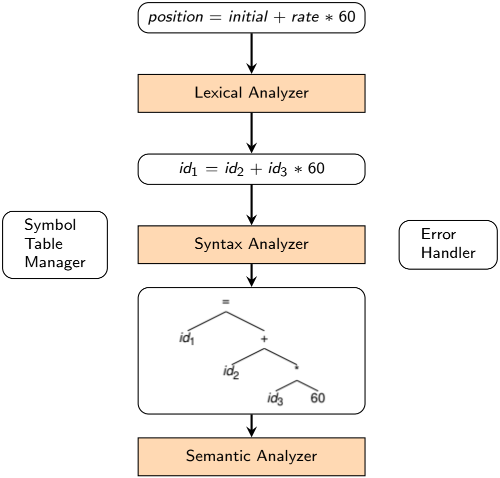

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Symbol Table Manager

Error Handler

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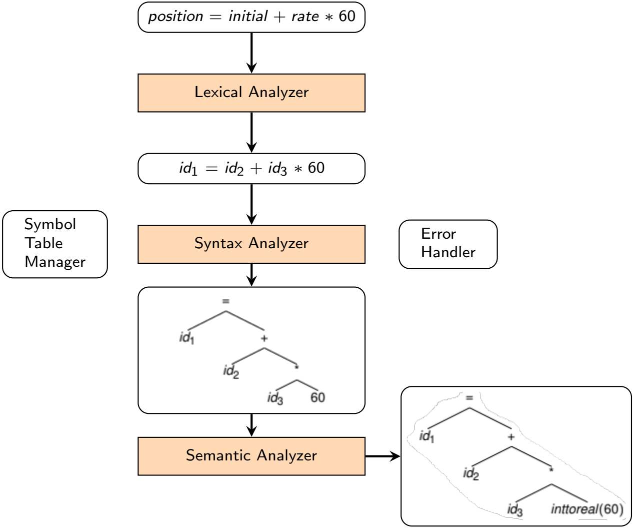

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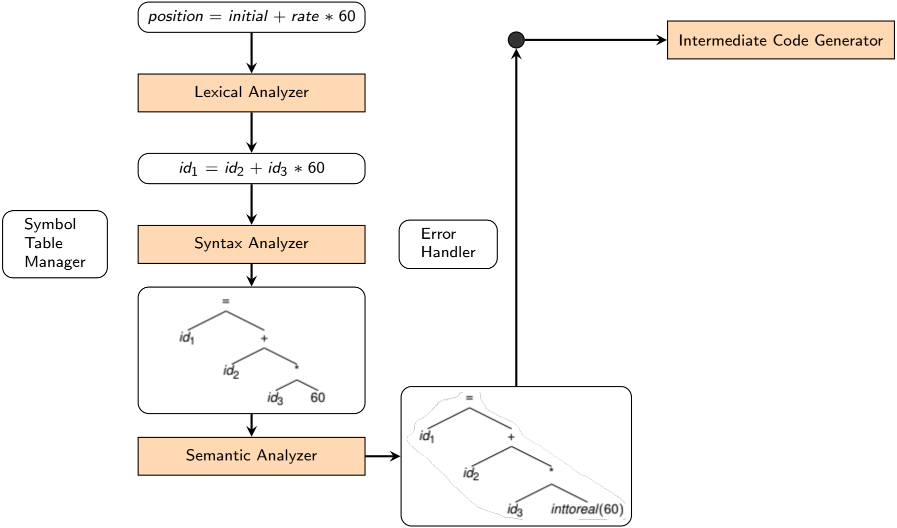

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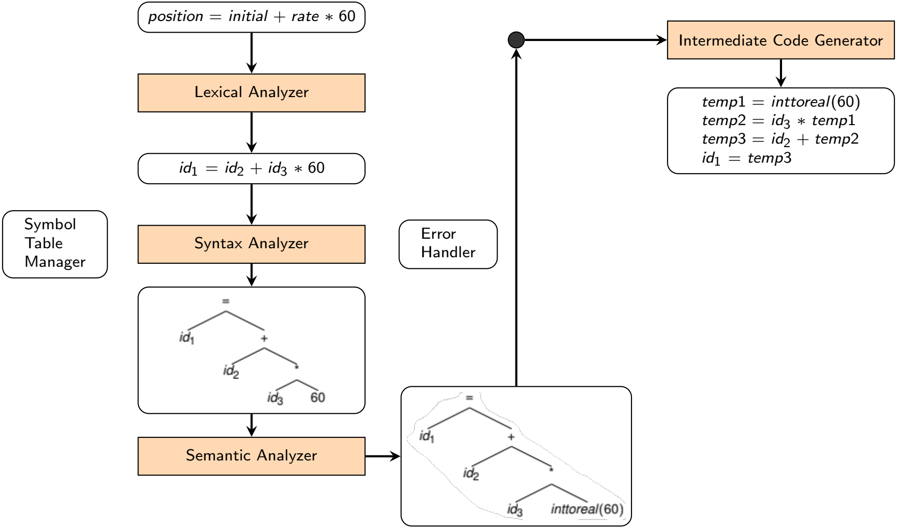

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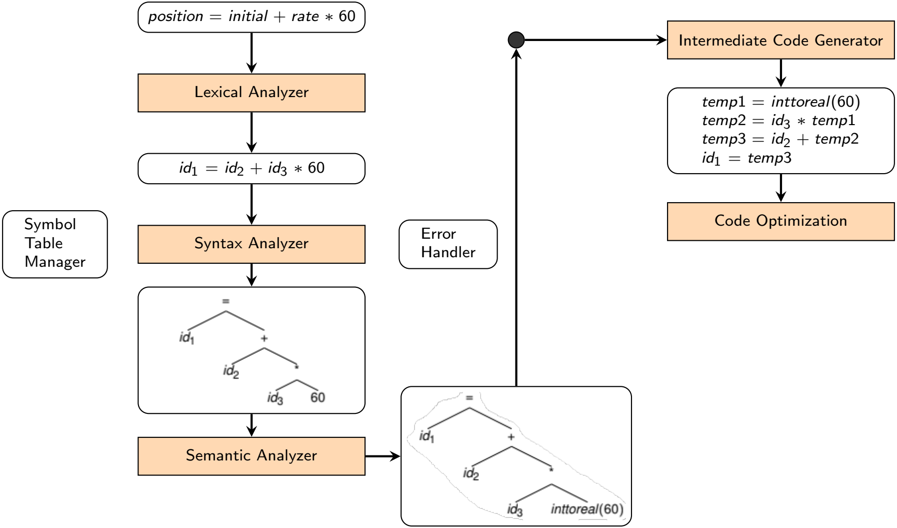

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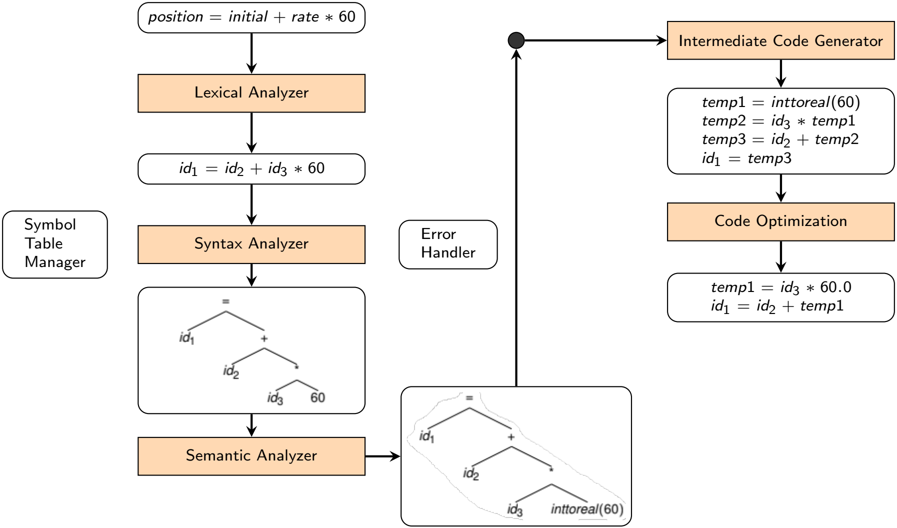

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$$\begin{aligned} temp1 &= inttoreal(60) \\ temp2 &= id_3 * temp1 \\ temp3 &= id_2 + temp2 \\ id_1 &= temp3 \end{aligned}$$

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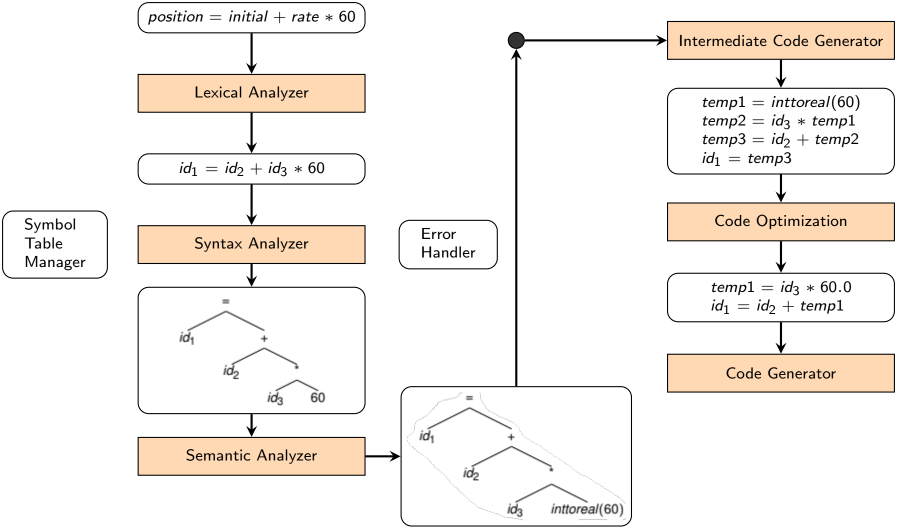

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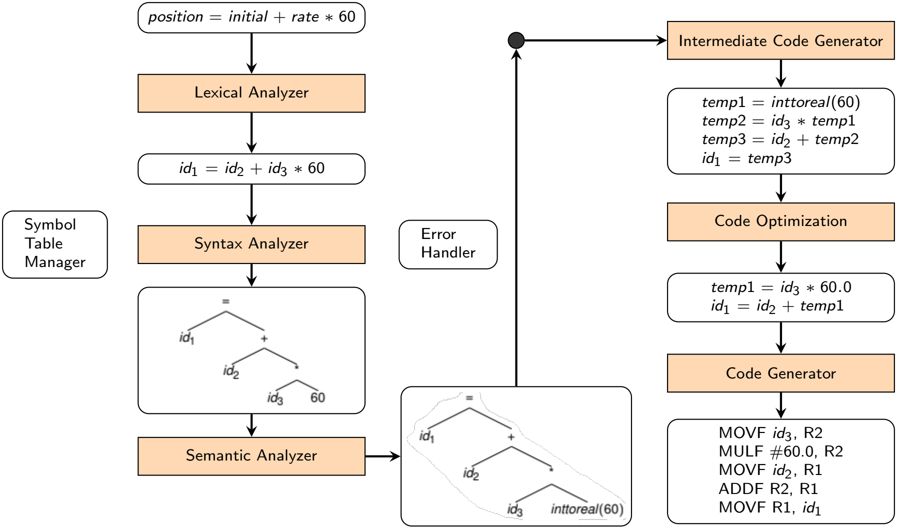

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Code Generator

MOVF id_3, R2
MULF #60.0, R2
MOVF id_2, R1
ADDF R2, R1
MOVF R1, id_1

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The Evolution of Programming Language

Classification by generation

- **First-generation languages:** machine languages.
- **Second-generation:** assembly languages
- **Third-generation:** higher-level languages like Fortran, Cobol, Lisp, C, C++, C#, and Java.
- **Fourth-generation languages:** languages designed for specific applications like NOMAD for report generation, SQL for database queries, and Postscript for text formatting.
- **Fifth-generation language** has been applied to logic- and constraint-based languages like Prolog and OPS5.

Impacts on Compilers

- The advances in programming languages placed new demands on compiler writers.
- Compiler writers would take maximal advantage of the new hardware capabilities.
- Good software-engineering techniques are essential for creating and evolving modern language processors.

Other Applications

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- Many software having a complex front-end may need techniques used in compiler design. (A symbolic equation solver which takes an equation as input. That program should parse the given input equation)
- Most of the techniques used in compiler design can be used in **Natural Language Processing (NLP)** systems

References

- Alfred V. Aho, Ravi Sethi, Jeffrey D Ullman, “Compilers Principles Techniques and Tools”, Pearson Education.