CS301 W'99 Lecture Notes
Lecture 1

CS301/302
Programming Languages and Compiler Design

Compiler Design & Implementation	Language Design & Implementation

Course Goals

- Improve understanding of **languages** and **machines**.
- Learn practicalities of **translation**.
- Learn **"anatomy"** of programming languages.
- Apply computer science **theory** to practical problems (using **tools**).
- Do large programming **project**.

Compilers

A **compiler** is a **translator** from "high-level" language to assembly code/object language.

Language L $\longrightarrow$ $\boxed{\textbf{TRANSLATOR}}$ $\longrightarrow$ Language L'

Examples of translators:

Pascal,C, etc.	$\longrightarrow$	**Compiler**	$\longrightarrow$	Machine Code
Java	$\longrightarrow$	**Compiler**	$\longrightarrow$	Byte Code
Ratfor	$\longrightarrow$	**Preprocessor**	$\longrightarrow$	Fortran
Tex	$\longrightarrow$	**Text Formatter**	$\longrightarrow$	Postscript
SQL	$\longrightarrow$	**DB Optimizer**	$\longrightarrow$	Query plan

We study common features of translators, by building one.

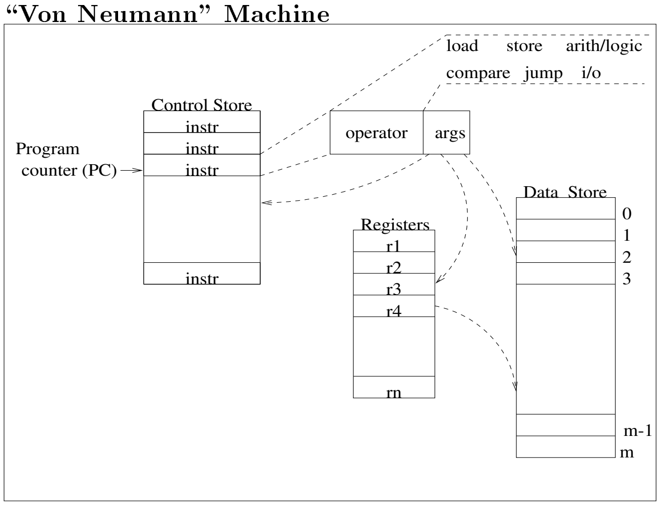
Language Design

We study languages from an **implementor's** viewpoint.

- How do **compilation feasibility** and **runtime efficiency** affect language design?

(There are more "theoretical" approaches to studying programming languages, and there are interesting languages that don't compile easily...)

"Von Neumann" Machine



Key Characteristics

- Sequential control flow + labels + jumps
- Small set of built-in data types and operators (e.g., byte, integer, floating point)
- Flat linear address space.
- Memory hierarchy (registers faster than memory faster than disk).

"High-Level" Languages

E.g., Fortran, Pascal, C, Cobol, Java, ...

Example

```
PROCEDURE rev (a:real array, n:int)
  LOCAL VAR i,j: int; x: real;
  BEGIN
    i := 0; j := n - 1;
    WHILE i < j DO
      x := a[i]; a[i] := a[j]; a[j] := x;
      i := i + 1; j := j - 1;
    END
END
```

Features

- Expressions (arithmetic, logical)
- Control structures (loops, conditionals, etc.)
- Type declarations and type checking
- Composite types (arrays, records, etc.)
- Procedures/Functions, with private scope
- **Abstraction** facilities!

How can we make high-level language and Von Neumann machine meet?

Answer:

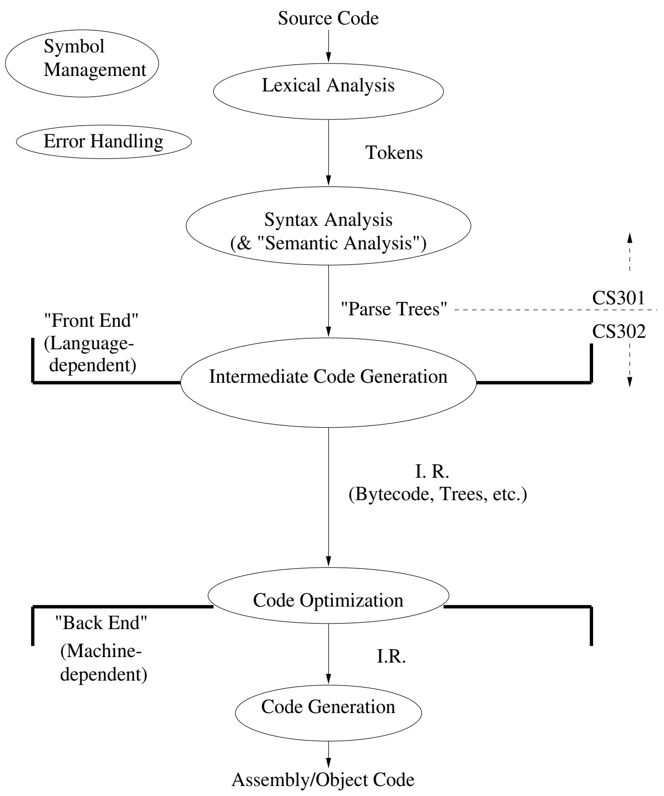
- Translate HLL into lower-level code (in traditional compiler, to machine code.)

and/or

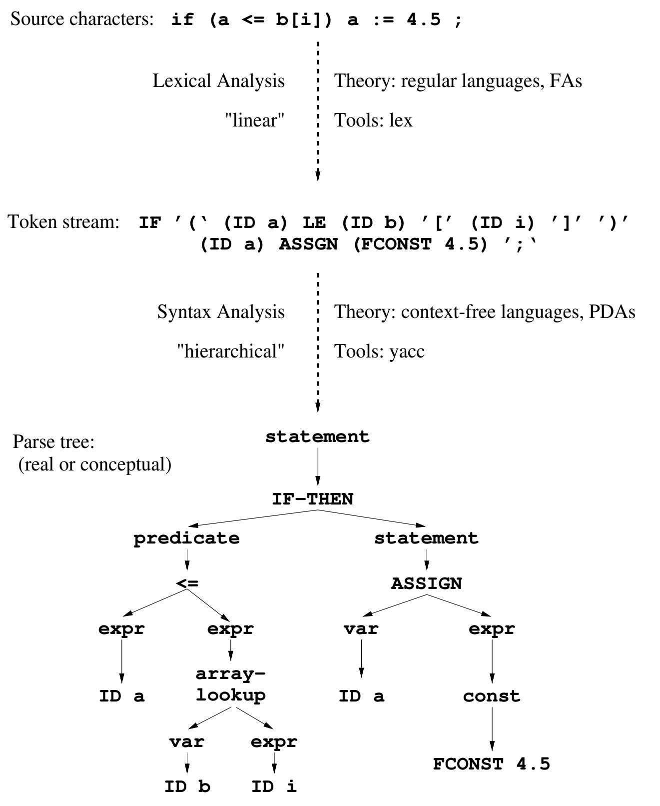
- Build a "higher level" virtual machine (in traditional interpreter, perhaps a stack machine.)

In practice, we do some of both, even in a compiler, since generated machine code makes use of a runtime library and operating system.

Compiler Structure: Want Simplicity and Flexibility



Example



Language Definition

Syntax is easy.

• Well-understood.

• Good theory: regular and context-free languages and automata.

• Good tools, even for complex cases.

Semantics are hard.

• Inherently complex.

• Variety of choices:

Informal	—	Reference Manual
Operational	—	Definitional interpreter
		(↑ we will focus here)
Axiomatic	—	Logic
Denotational	—	Mathematical functions
		etc.

• Few tools.