Programming Languages

Lecture 3
Section 1.3

Robb T. Koether

Hampden-Sydney College

Mon, Sep 2, 2013

Outline

High-Level Languages

C++ Code

```
cin >> cost;
if (cost > 100.0)
{
    discount = 0.10 * cost;
    price = cost - discount;
}
else
    price = cost;
cout << price;
```

- Instructions use some English words (if, else, while, etc.)
- Expressions are written in something resembling standard algebraic notation.

High-Level Languages

C++ Code

```
int c = 3*(10 + 20);
```

- C code to add 10 and 20 and multiply by 3.

Assembly Language

Assembly Code

```
li   $s0,10
addi $s1,$s0,20
li   $s0,3
mult $s1,$s0
mflo $s1
```

- Each instruction represents a single basic operation at the machine level (add, multiply, compare, etc.)
- Mnemonics are used instead of words.

Machine Language

Machine Code

Hex	Binary	Assembly
2410000A	00100100000100000000000000001010	li $s0,10
22110014	00100010000100010000000000010100	addi $s1,$s0,20
24100003	00100100000100000000000000000011	li $s0,3
02300018	00000010001100000000000000011000	mult $s1,$s0
00008812	00000000000000001000100000010010	mflo $s1

- Each instruction represents a single basic operation.
- Each instruction is written entirely numerically.

Outline

Program Translation

- A computer is capable of interpreting and executing only machine language (numerical) instructions.
- Humans (almost always) write programs in high-level languages such as C++.
- Therefore, a C++ program must be *translated* into machine language in order to be run.

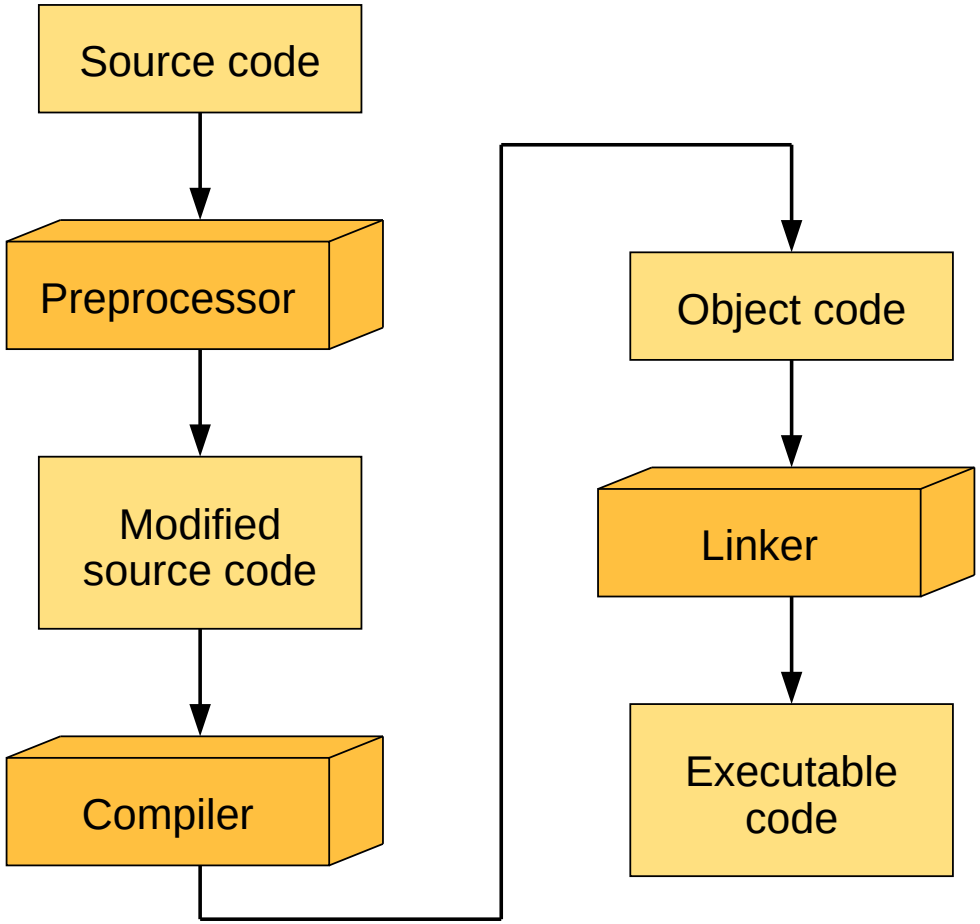
Compilers

- A compiler is a program that translates a high-level language such as C++ into machine language.
- The compiler must first check the syntax of the source code.
- A syntax error is a violation of the grammar rules of the language.
- If there are syntax errors, then error messages are displayed and the process stops.
- If there are no syntax errors, then the compiler produces the object code.

Linkers

- A linker combines the object code produced by the compiler with library functions (e.g., the square root function) needed by the program.
- If the linker is unable to locate a function, it reports a link error and the process stops.
- If there are no link errors, the linker produces a fully functioning program.

Program Translation



Loaders

- The loader copies the program into a suitable location in main memory and begins execution.
- A run-time (or logical) error is an error that occurs during execution.
- Typically, run-time errors cannot be detected by the compiler or the linker before execution.
- Division by zero would be a run-time error.

Assemblers

- Many compilers produce assembly code as an intermediate step, and then invoke an assembler to finish the translation.
- An assembler translates an assembly language program into machine language.
- Assembly code is more readable than machine code.

Outline

The C++ Program Hierarchy

- A statement typically performs a single task.
  - For example, evaluate a formula.
- A function is a group of statements that accomplishes a task requiring several steps.
  - For example, insert a new name into a list of names.
- A file contains a group of related functions.
  - For example, all functions that manage lists of names.
- A program consists of a collection of related files.

Statements

- A statement is a one-line instruction.
- A statement typically performs a single action.
- Examples
  - Evaluate a formula.
  - Print a line of output.
  - Make a yes/no decision.

Functions

- A function consists of several statements which together perform a single task as a component of a larger problem.
- Each function is given a name.
- Program execution begins with the function `main()`.
- Examples
  - `average()`: Find the average of a set of numbers.
  - `insert()`: Insert a new name into a list of names.

Files

- A file consists of a set of functions having something in common.
- Each file is stored separately under its own name.
  - For example, `list.cpp`.
- Files are compiled separately from each other, to be linked later.

Projects

- A project consists of several files containing all the functions which, when linked together, will form a complete program.
- The project is given a name.
- For example, `ListManager.vcxproj`.

The C++ Program Hierarchy

MyProg.vcxproj

```
// MyProg.cpp

int main()
{
    :
}
    :
```

```
// stats.cpp

float avg(float a, float b)
{
    return (a + b)/2.0;
}

float max(float a, float b)
{
    if (a > b)
        return a;
    else
        return b;
}
    :
```

```
// list.cpp

void insert(...)
{
    :
}

void delete(...)
{
    :
}

int search(...)
{
    :
}
    :
```

Outline

Example of a C++ Program

- Example
  - `GradeReport.cpp`
  - `GradeStats.cpp`

Outline

Assignment

Assignment

- Read Section 1.3.