Structure of Programs

Computer programs are among the most complex artifacts engineered by humankind. Consider the following:

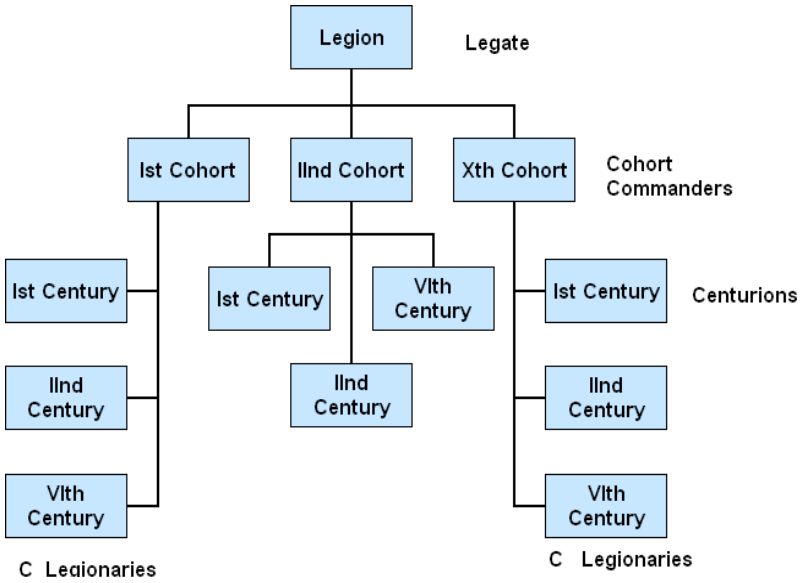
1. A 700 page novel occupies 2.6 MB of disk space.
2. Windows XP takes about 1 GB.
3. A switch built by Nortel in the mid 90's took about 6 million lines of code

How do we manage such complexity? We use a strategy known as *Divide and Conquer*, one of the oldest strategies used by humankind.

1. Complex systems are *modularized*—broken into smaller more manageable pieces
2. The modules themselves are often broken into smaller modules, and those into smaller modules again.
3. The set of modules is organized *hierarchically* to constitute the system

This schema is widely used

Structure of the Roman Army—a rigid hierarchy



With 6000 men under his command a Roman Legate couldn't know every legionary. His job was to worry about the *big picture*. He would give commands like, *"Move the Ist cohort forward"* or, *"Hold the IIIrd cohort in reserve."*

At the bottom level, the centurion would know each of his legionaries. He would decide who best should be on the critical left edge of the shield wall, who in the centre. It was his job to sweat the *details*.

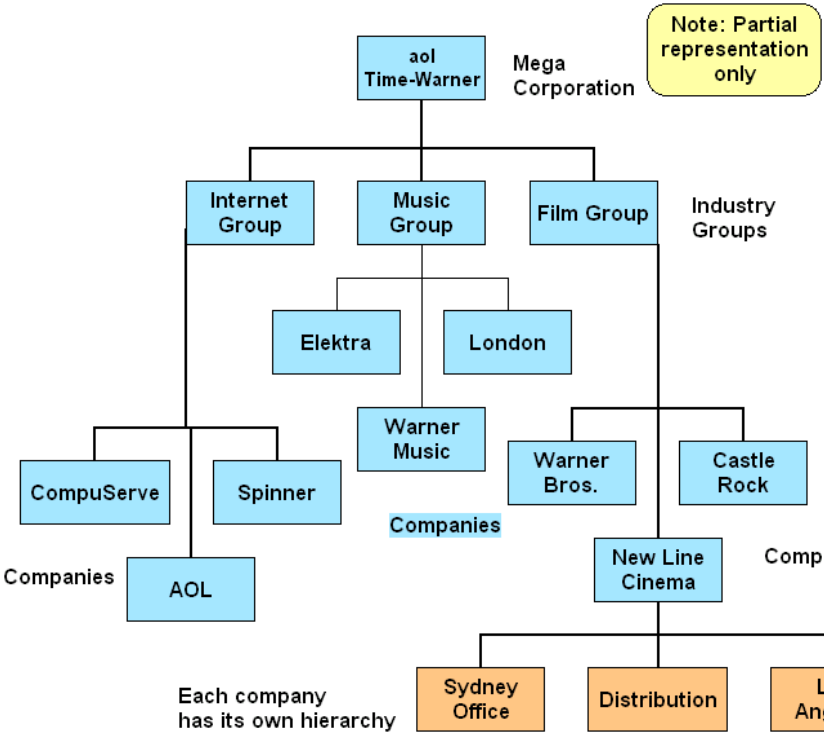
Modern Corporations—A Flexible Hierarchy

·Hanna-Barbera

Cable Systems
Time Warner Cable

(Parenting, Baby Talk, Baby on the Way)
This Old House
The Health Publishing Group
Real Simple
Golf Magazine
Popular Science
Ski
Yachting Magazine
American Express Publishing Corporation (partial ownership; includes Travel & Leisure, Food & Wine, Departures, SkyGuide)
DC Comics
·MAD Magazine

Straightening out the Hierarchy



1. Each corporation creates its own hierarchy, according to its own needs
2. Hierarchies tend to grow organically
3. Nevertheless, chart typical of modern mega-corporation

4. Each company inside mega-corporation would have its own org chart (hierarchy)
5. High degree of complexity

Common Features of Hierarchies

1. Drawing shows modules for a modern army—used by many countries

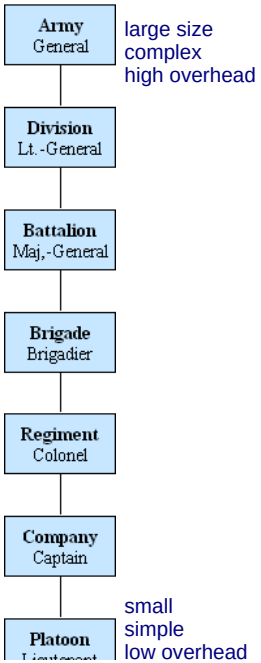
2. Really a tree since an army has a number of divisions, a division a number of battalions and so on

3. Different *kinds* of modules at different levels.

4. Modules towards top are bigger, more complex

5. Modules towards bottom are smaller, simpler

6. Modules towards top have high overhead—generals



large size
complex
high overhead

small
simple
low overhead

require large staffs to run an army

7. Modules towards bottom have low overhead—one lieutenant and one sergeant to run a platoon

Early in 20th century, Americans introduced the *squad*

Smallest unit of all

Handfull of people under a single corporal (very low overhead)

Very focussed—one job at a time

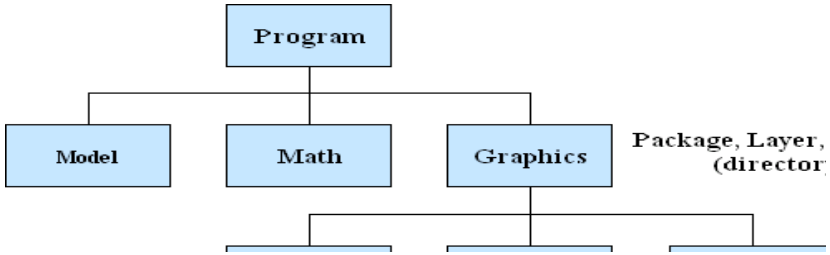
- Hold south end of the bridge
- Scout that village
- Take that machine gun

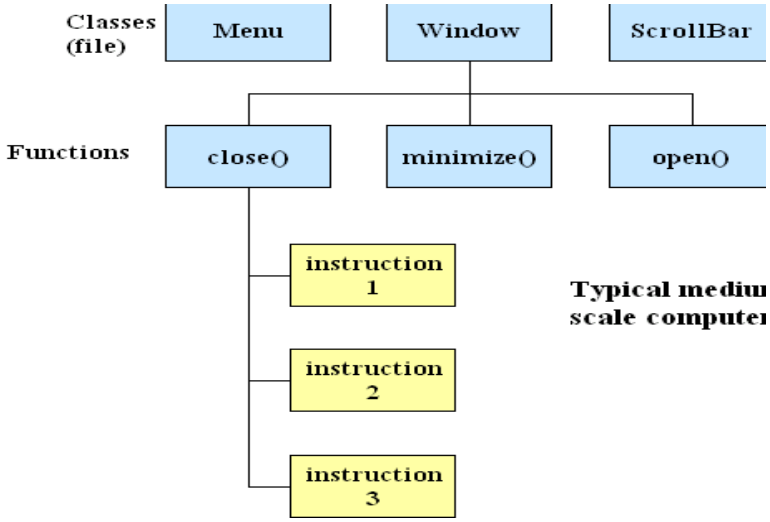
In this course we will focus on the squads of computer programming.

1. small amounts of code
2. single well specified task
3. minimal overhead

Programming Modules

Computer programs modularized





Teaching Machine

Typical medium scale program

1. 7000 programming hours
2. 14 packages
3. 14 sub-packages
4. over 700 classes
5. around 5000 functions

Mini-Programs

Full model too complex to teach initially

Concentrate on a mini-

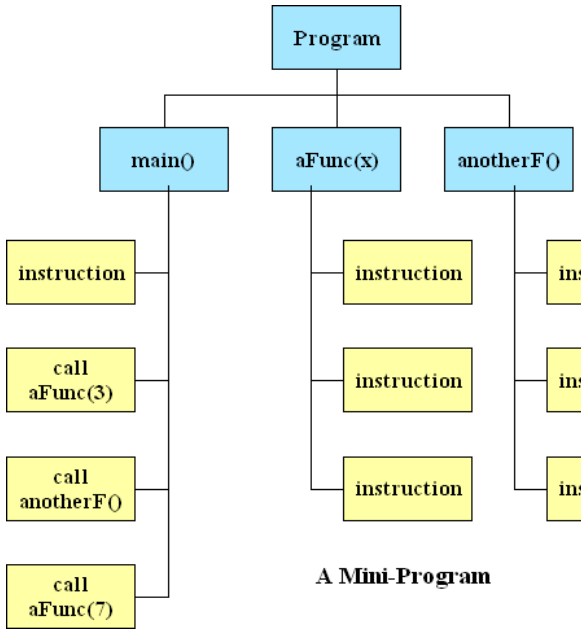
model

Only kind of modules are functions—the *squads* of the progamming world

1. small
2. single task
3. low overhead

Every C/C++ program includes one (and one only) function called `main()`

`main()` is the starting point of the program



An Even Smaller Model

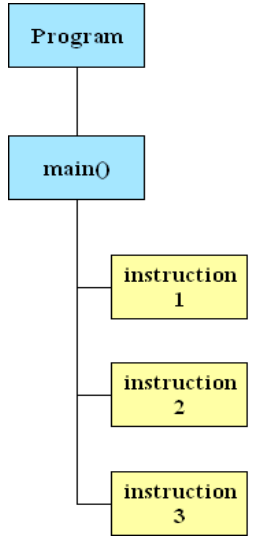
We can reduce the model above even farther by only having the main function

This is what we will start with.

It is important to remember that what we are actually learning how to do is to write a single function

Writing a program with more than one function is not much different

1. each function will be wriiten pretty much the same
2. Later you will have to learn how to connect the functions together.



Structure of the smallest possible C/C++ program

Notice that the instructions above are numbered.

This is to indicate that instructions in a program are executed in sequence.

1. The first instruction is executed
2. Then the second instruction is executed
3. Then the third instruction is executed

and so on.

The Build Process

Computer programs have to be *built*. We use a number of processes (computer programs) to build a program

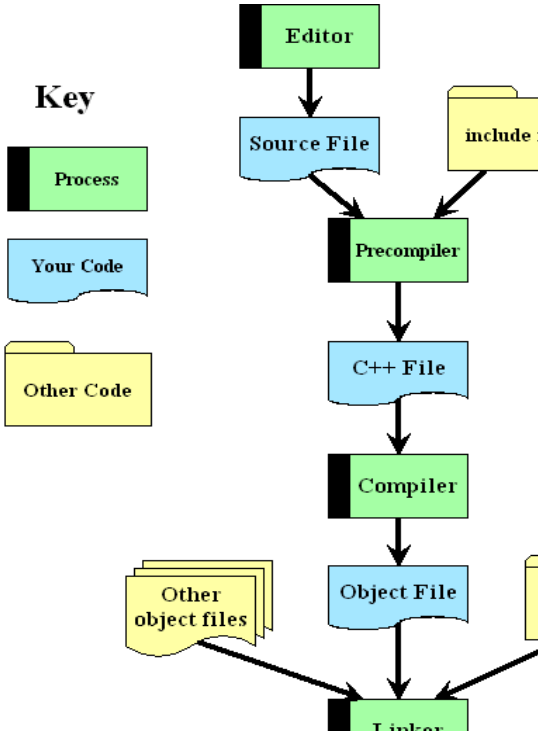
An **editor** is a specialised word processor used to prepare source modules in the language of choice (e.g. C++, Java, Fortran, Basic)

The **precompiler** adds in standard pre-written code (boilerplate) from include files you specify to produce a complete source module.

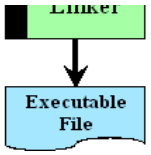
The precompiler is like a secretary that helps you pull together a full source document.

The **compiler** produces object code for the target computer/operating system.

The compiler is like a translater that converts your module from the language of your choice (C++) to language the computer (PC, MAC, Sun) understands.



The **linker** ties multiple modules together into a complete program



1. Your module
2. Other modules from the same project
3. Modules from the library

An *executable* is a program that will run on the computer. The editor, precompiler, compiler and linker are all *executables*.

So is your program!

A Traditional First Program

Here is a traditional first program you will see in almost every textbook in C++.

hello.cpp

```
#include <iostream>
using namespace std;

int main(){
    cout << "Hello world!";
    return 0;
}
```

The first line is an instruction to our precompiler "secretary" saying we want to use the standard input/output system (the `iostream`). The secretary (the precompiler program) will go and fetch all the boilerplate code from the `iostream` file and insert it right where we wrote the line.

The second line makes reference to where the names we're going to use may be found. It's a little bit like the statement you might find in the beginning of some engineering textbooks saying *in this book we're going to use the ISO names*

The third line is blank, a seperator to help our eye group logical entities together.

The fourth line is the beginning of our one and only function, `main`. Every program has one (and one only) `main` function. So if your program has only one module, it's got to be `main`.

The fifth line is our first line of active computer code. It is an instruction to the computer saying, *please output the words, "hello world!"*

We'll explain the sixth line later.

This page last updated on Thursday, January 8, 2004