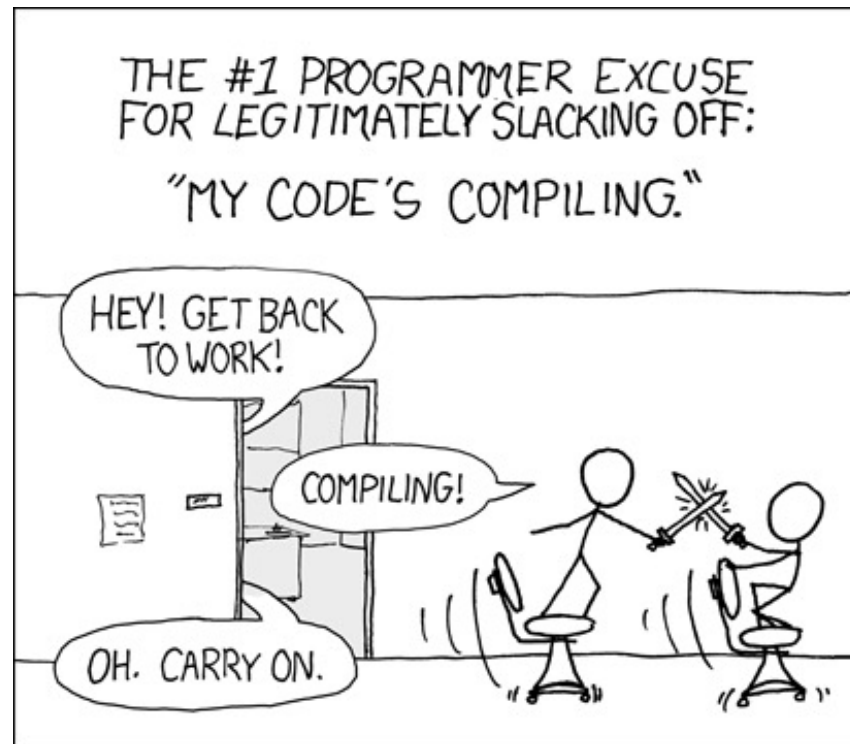


VE280 Programming and Elementary Data Structures

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Developing and Compiling Programs on Linux



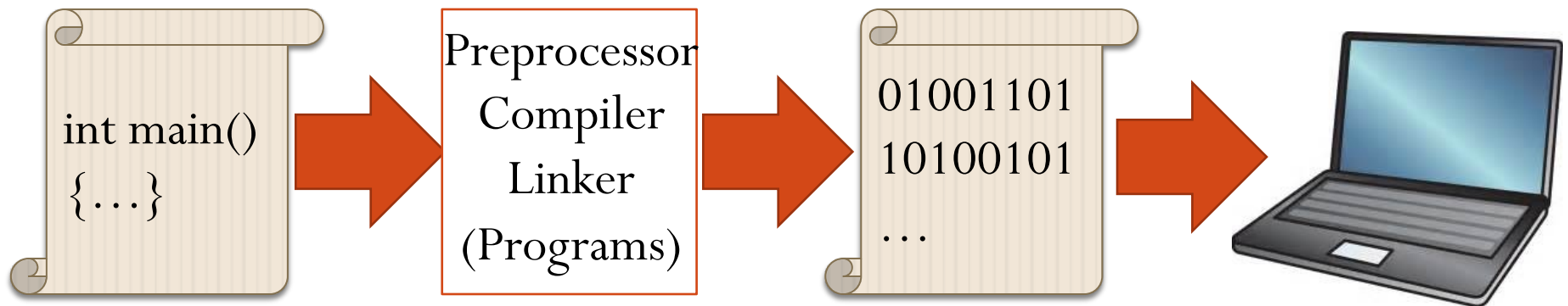
Announcements

- Git server at JI
 - <https://focs.ji.sjtu.edu.cn/git/VE280-23su>
- Lab 1 to be released today!
 - Due date: D+1week
- Project P1 to be released next Tuesday!
 - Due date: D+2week
- OH Times updated (see Canvas)
 - Mon., Wed., Thu. 8pm-10pm; Mon. → Tue. 8pm-9pm

Learning Objectives

- Understand the compilation process
- Know how to compile a single source file
- Know how to compile multiple source files

Basic Working Mechanism of Computer



Developing a Program on Linux

Single Source File

- Write the source code, for example, using **gedit**
- Compile the program
 - Compiler: `g++`
 - Command: `g++ -o program source.cpp`
 - `-o` option tells what the name of the output file is.
- Run the program: `./program`
- Useful options of `g++`
 - `-g`: Put debugging information in the executable file
 - `-Wall`: Turn on all warnings!

Compile a Program

`g++ -o program source.cpp`

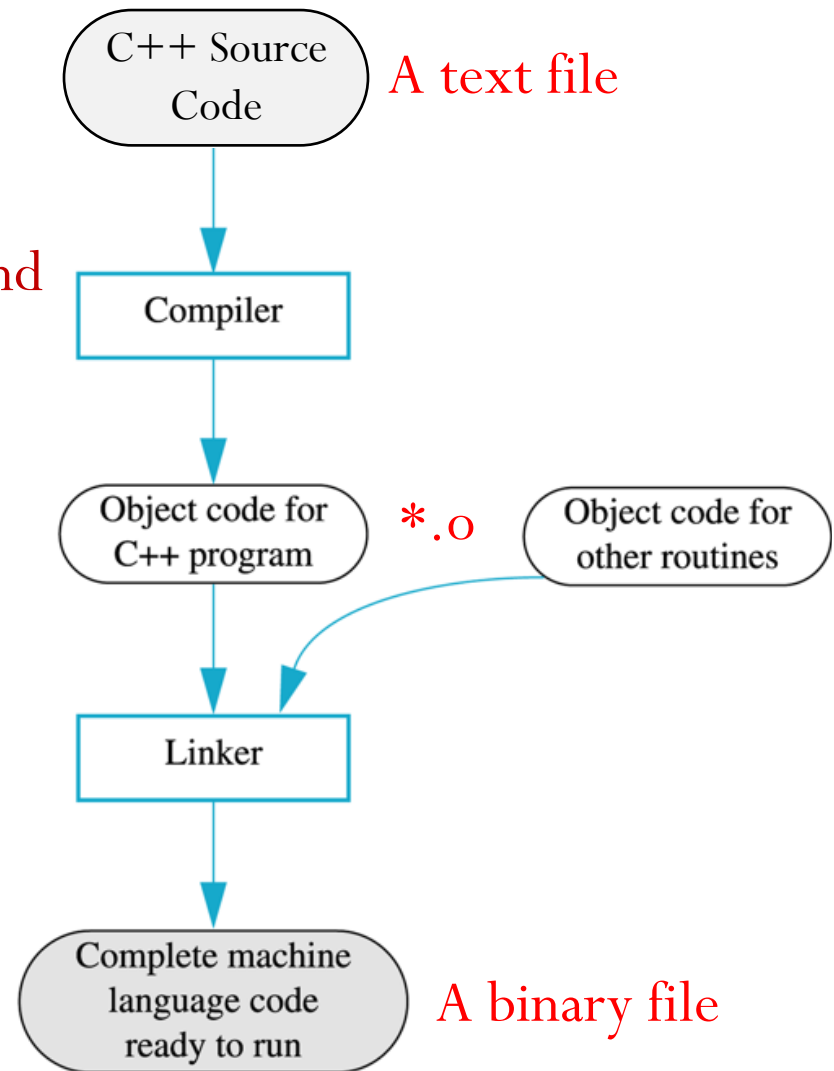
= `g++ -c source.cpp`
`g++ -o program source.o`

Link command

Object code: portion of machine code that has NOT yet been linked into a complete program

- Just machine code for one particular library or module
- Can be generated by command

`g++ -c source.cpp`





A large project is usually split into several source files in order to be manageable. Why?

Select all the correct answers.

- **A.** To speed up compilation – changing a single line only requires recompiling a single small source file. Much faster!
- **B.** To increase organization – make it easier for you to find functions, variables, etc.
- **C.** To facilitate code reuse.
- **D.** To split coding responsibilities among programmers.



Developing Program on Linux

Multiple Source Files

- Multiple source files include two types of files
 - header files – “.h” files: normally contain class definitions and function declarations.
 - C++ source files – “.cpp” files: normally contain function definitions and member functions of classes.
- Example

```
// add.h
#ifndef ADD_H
#define ADD_H
int add(int a, int b);
#endif
```

```
// add.cpp
int add(int a, int b)
{
    return a+b;
}
```


Developing Program on Linux

Multiple Source Files

- If a function in another file calls function `add()`, we should put `#include "add.h"` in that file.

- Example

```
// run_add.cpp
#include "add.h"
int main()
{
    add(2, 3);
    return 0;
}
```

In C++, the **preprocessor** replaces each **#include** by the contents of the specified file.

Headers Often Need Other Headers

line.h

```
#include "point.h"  
...
```

drawing.h

```
#include "point.h"  
#include "line.h"  
...
```

- Consequence: A header file may be included more than once in a single source file
 - E.g., in `drawing.h`, we include `point.h` twice

Problem of Multiple Inclusions

- The including of a header file more than once may cause **multiple** definitions of the classes and functions defined in the header file.
 - Compiler complains!
- Solution: **header guard**.
 - It avoids **reprocessing** the contents of a header file if the header has already been seen.

Header Guard

```
// add.h  
#ifndef ADD_H  
#define ADD_H  
int add(int a, int b);  
#endif
```

Header guard to prevent multiple definitions!

- `#ifndef VAR`: a conditional directive --- tests whether the **preprocessor variable** VAR has **not** been defined.
 - If not defined, `#ifndef` **succeeds** and all lines up to `#endif` are processed.
 - Specially, `#define` defines VAR.
 - If defined, `#ifndef` **fails** and all lines between `#ifndef` and `#endif` are **ignored**.

Header Guard

```
// add.h
#ifndef ADD_H
#define ADD_H
int add(int a, int b);
#endif
```

- What happens if the header is included the **first** time?
 - `#ifndef` succeeds. `ADD_H` is defined and the content is included
- What happens if the header is included the **second** time?
 - Since `ADD_H` has been defined the first time we include the header, `#ifndef` fails. The lines between `#ifndef` and `#endif` are ignored
 - Good! No multiple declarations of the function `add`
- With a header guard, we guarantee that the definition in the header is just seen **once**!

Compiling Multiple Source Files

- To compile multiple source files, use command
 - `g++ -Wall -o program src1.cpp src2.cpp src3.cpp`

Program name

All .cpp files

- E.g., `g++ -Wall -o run_add run_add.cpp add.cpp`
- Note: you don't put ".h" in the compiling command
 - I.e., you don't need
`g++ -Wall -o program src1.cpp src1.h src2.cpp src3.cpp`
 - Why? ".h" files are already included.
E.g., `run_add.cpp` includes `add.h`

Another Way

- Generate the object codes (.o files) **first**
- Example: `g++ -Wall -o run_add run_add.cpp add.cpp`
 - **Equivalent** way:
`g++ -Wall -c run_add.cpp # will produce run_add.o`
`g++ -Wall -c add.cpp # will produce add.o`
`g++ -Wall -o run_add run_add.o add.o`



What are the advantages/disadvantages of compiling the cpp files separately?

Select all the correct answers.

- **A.** Advantage: Only changed files need to be recompiled.
- **B.** Advantage: It is required for code reuse.
- **C.** Disadvantage: It requires a lot of typing!
- **D.** Disadvantage: It requires us to remember which files have been changed.



A Better Way: Makefile

```
all: run_add
```

- The file name is “**Makefile**”
- Type “**make**” on command-line

```
run_add: run_add.o add.o
```

```
    g++ -o run_add run_add.o add.o
```

```
run_add.o: run_add.cpp
```

```
    g++ -c run_add.cpp
```

```
add.o: add.cpp
```

```
    g++ -c add.cpp
```

```
clean:
```

```
    rm -f run_add *.o
```

A Rule

Target: Dependency
<Tab> Command



Don't forget the Tab!

Dependency: A list of files
that the target depends on

A Better Way: Makefile

```
all: run_add
```

```
run_add: run_add.o add.o  
    g++ -o run_add run_add.o
```

```
run_add.o: run_add.cpp  
    g++ -c run_add.cpp
```

```
add.o: add.cpp  
    g++ -c add.cpp
```

```
clean:  
    rm -f run_add *.o
```

There is a target called “all”

- It is the **default** target
- Its dependency is program name
- It has no command

A Rule

Target: Dependency
<Tab> Command

Usually, there is a target called “clean”

- A **dummy target**. Type “make clean”
- It has no dependency!
- Question: what does “clean” do?

A Better Way: Makefile

`all: run_add`

`run_add: run_add.o add.o`

`g++ -o run_add run_add.o add.o`

`run_add.o: run_add.cpp`

`g++ -c run_add.cpp`

`add.o: add.cpp`

`g++ -c add.cpp`

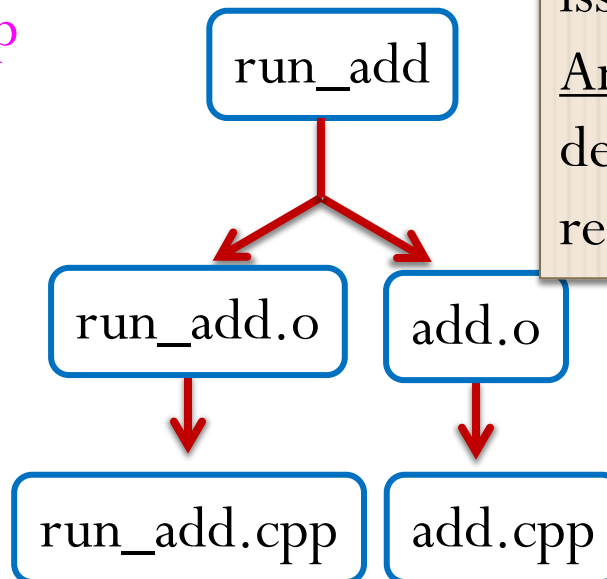
`clean:`

`rm -f run_add *.o`

A Rule

Target: Dependency
<Tab> Command

Dependency Graph



When is a command issued?

Answer: When dependency is more recent than target

References

- Makefile
 - <http://www.cs.colby.edu/maxwell/courses/tutorials/maketutor/>
- Developing Programs on Linux
 - C++ Primer, 4th Edition, Chapter 2.9