C++: A simple program

- Intro - <u>I will gloss over a lot of details</u>

Outline

- Source Code
- IDE and compiler interaction
- Compiling and Running (no IDE)
- Debugging (no IDE)
- Compiling, Running and Debugging with IDE

Source Code – hello.cpp

```cpp
// a small C++ program
#include <iostream>     ⟵

int main()     ⟵
{
    std::cout << "Hello, world!" << std::endl;
    return 0;     ⟵
}
```

Main special function, you cant call it, may or may not return value (only time compiler will not force return)

all C++ programs start with main(),

libraries Don't have a main

Can also have int main(int argc, char* argv[]) {

Java like stuff ;

          Comments

          case sensitivity

          ;

          {}

          function format

          return

#include – gives declaration of cout, Needed to define what couts params and return type are   compiler needs this info in order to set aside memory in .o file for function calls to another file

or library

open \<iostream\> in eclipse

The purpose of a header file is to hold declarations for other files to use.

Std::endl the end of line char

Non Java like

#include

Something Different– header files

- Java
  - classes are all in 1 file
  - import statements used to include references to classes from libraries
- C++
  - classes are in 2 files (.cpp and .h)
  - Include files reference a library (or object file)- linker includes it in executable
- C++ is more difficult to use in this respect

```
import java.lang.String;
```

```
#include <string>
```

- C++ is a pain this way, have to manually locate the header files and the .o or library files the headers are associated with
- Takes longer to compile, the preprocessor loads the header, the compiler compiles it and the linker creates an executable

- Libraries
- Libraries are groups of functions that have been "packaged up" for reuse in many different programs. The core C++ language is actually very small and minimalistic — however, C++ comes with a bunch of libraries, known as the C++ standard libraries, that provide programmers with lots of extra functionality. For example, the iostream library contains functions for doing input and output. During the link stage of the compilation process, the libraries from the C++ standard library are the runtime support libraries that are linked into the program
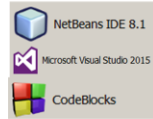
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IDE and compiler interaction
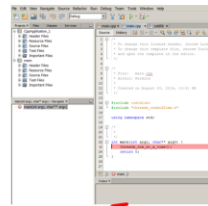
Integrated Development environment (IDE)
Such as…

NetBeans IDE 8.1

Microsoft Visual Studio 2015

CodeBlocks

But an IDE makes it easier
Especially on large projects

IDE uses compiler

IDE uses debugger

Compiler
(like gcc)

Debugger
(like gdb)

You only need these

Compiler generates executable

debugs

Executable application

To generate this

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Compilers

- see https://en.wikipedia.org/wiki/List_of_compilers#C.2B.2B_compilers

Compiler	Author	Windows	Unix-like	Other OSs	License type	IDE?	Standard conformance		
							C++11	C++14	C++17
C++Builder	Embarcadero (CodeGear)	Yes	OS X, iOS[2]	No	Proprietary	Yes	Yes/No	Yes/No	Yes/No
							(Supported via Clang.[3])		
Turbo C++ Explorer	Embarcadero (CodeGear)	Yes	No	No	Freeware	Yes	?	?	?
C++ Compiler	Embarcadero (CodeGear)	Yes	No	No	Freeware	No	?	?	?
CINT	CERN	Yes	Yes	BeBox, DOS, Convex, etc.	X11/MIT	Yes	?	?	?
Borland C++	Borland (CodeGear)	Yes	No	DOS	Proprietary	Yes	No	No	No
Turbo C++ for DOS	Borland (CodeGear)	No	No	DOS	Proprietary	Yes	No	No	No
Clang	LLVM Project	Yes	Yes	Yes	BSD-like	Xcode, QtCreator (optional)	Yes	Yes	Partial
CodeWarrior	Metrowerks	Yes	Yes	Yes	Freeware	Yes	?	?	?
Comeau C/C++	Comeau Computing	Yes	Yes	Yes	Proprietary	No	No	No	No
CoSy compiler development system	ACE Associated Compiler Experts	Yes	Yes	No	Proprietary	No	?	?	?
Digital Mars	Digital Mars	Yes	No	DOS	Proprietary	No	?	?	?
EDGE ARM C/C++	Mentor Graphics	Yes	Yes	Yes	Proprietary	Yes	?	?	?
Edison Design Group	Edison Design Group	Yes	Yes	Yes	Proprietary	Yes	Yes	Yes	Partial
GCC	GNU Project	MinGW, Cygwin	Yes	Yes	GPLv3	QtCreator, Kdevelop, Eclipse, NetBeans, Code::Blocks, Geany	Yes[4]	Yes	Partial
Visual C++	Microsoft	Yes	can target Linux, OS X, Android and iOS (since VS 2015)	No	Proprietary	Yes	Yes[5]	Incomplete	Incomplete

- **Clang was the big dog, no GCC has caught up (most popular on linux) note the IDEs,**
- **Note the state of Visual C++, again its not OS, platform dependant… but it out of the box works**

Getting a compiler

- Visual C++ - comes with MS compiler, see Readings

- GCC – depends on OS
  - Linux install build essentials to get GCC

```
$ sudo apt-get update
$ sudo apt-get upgrade
$ sudo apt-get install build-essential
$ gcc -v
$ make -v
```

  - Windows – minGW or Cygwin for GCC
    - http://www.mingw.org/wiki/HOWTO_Install_the_MinGW_GCC_Compiler_Suite
    - https://www.cygwin.com/

- **sudo apt-get update $ sudo apt-get upgrade $ sudo apt-get install build-essential**
- **Probably need to add path**
- Edit /etc/bash.bashrc to add the installation path to the PATH environment variable
- **export PATH=/path/bin:${PATH}**
- **Then source bashrc file**
- **Apple- just works**

Compiling/Linking - overview
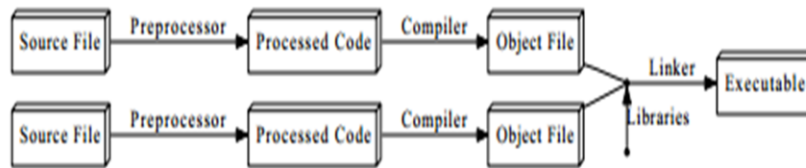
Source File – .cpp .hpp .h files files

Preprocessor – program that performs text substitution

Compiler- converts preprocessed source code to object code for a particular processor

Linker – Links object files and external libraries to form exe (or library)

Will always link the Cruntime and StandardLibrary

See http://www.ntu.edu.sg/home/ehchua/programming/cpp/gcc_make.html for more information

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Preprocessor – It works on one C++ source file at a time by replacing #include directives with the content of the respective files (which is usually just declarations), doing replacement of macros (#define), and selecting different portions of text depending of #if, #ifdef and #ifndef directives.

Output is pure C++ no preprocessor directives

Anything with # infront is preprocessor stuff

Compiler – generates compiler errors,

Linker- generates linker errors, takes your object files, and any external libraries that you are using, and combines them into an executable (or a library)

Once again IDE's do this under the covers for you

Exe or lib that is suitable to run on 1 platform (like windows, sometimes specific versions of windows) or Mac or Linux,
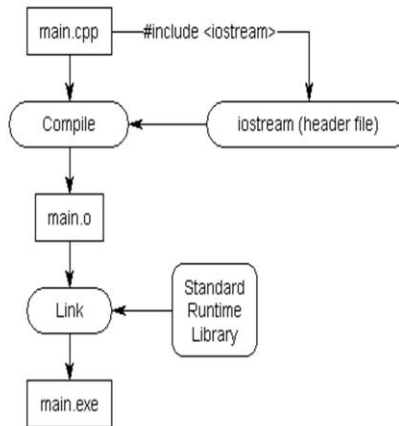
Compiling/Linking

```
// a small C++ program
#include <iostream>

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

See http://www.ntu.edu.sg/home/ehchua/programming/cpp/gcc_make.html for more information
Diagram from http://www.learncpp.com/cpp-tutorial/19-header-files/

Preprocessor reads the #include and inserts that header file into main.cpp (file becomes much larger)

Compile it

Then link it to the standard library (iostream is a description of and how to use all the functions and objects in the standard runtime library) defined in libstdc++-6.dll

Any program that uses <iostream> and compiled with minGW will link to this library

show example using depends

Libstdc++-6.dll standard library for minGW

MSVCRT.dll c runtime and Microsoft

MSVCPRT.LIB standard library Microsoft

Compiling/Linking – Example 1

- As simple as g++ -o hello.exe hello.cpp
- Can become very complex
- Commands reside in make file


```
Administrator: C:\Windows\system32\cmd.exe

C:\Users\lynn\Dropbox\Classes\CPSC427\Week 1\Demo>g++ -o hello.exe hello.cpp

C:\Users\lynn\Dropbox\Classes\CPSC427\Week 1\Demo>dir
 Volume in drive C has no label.
 Volume Serial Number is CC85-3F4B

 Directory of C:\Users\lynn\Dropbox\Classes\CPSC427\Week 1\Demo

08/10/2013  11:50 PM    <DIR>          .
08/10/2013  11:50 PM    <DIR>          ..
08/10/2013  11:15 PM               124 hello.cpp
08/10/2013  11:50 PM            74,957 hello.exe
               2 File(s)         75,081 bytes
               2 Dir(s)  68,860,616,704 bytes free

C:\Users\lynn\Dropbox\Classes\CPSC427\Week 1\Demo>hello
Hello, world!
```

console apps, no ui, launched from command line,

Build from command line

-o output executable file

-c compile and assemble but no link

-g requests that the compiler and linker generate and retain symbol information in the executable itself.

-I show include files and where they are from

 g++ --help

Demo this

Compiling/Linking – Example 2

- 2 source files; hello.cpp, myfunc.cpp
- 1 user defined header file myfunc.h
- See Project -> 2_files_simple

```cpp
//hello.cpp
#include <iostream>
#include <string.h>
#include "myfunc.h"

int main()
{
    std::string a = myfunc();
    std::cout << a << std::endl;
    return 0;
```

```cpp
//myfunc.h
#include <iostream>
std::string myfunc();
```

```cpp
//myfunc.cpp
#include "myfunc.h"

std::string myfunc()
{
    return "hello world";
}
```

Show proj

Hello.cpp

Diff?

#include <filename>

#include "filename"

difference between is the location the preprocessor searches for the file to be included.

"" the preprocessor searches in the same directory as the file being compiled (and also user specified dirs). This method is normally used to include underline programmer defined headers.

<> used for standard library headers - the search is performed in an implementation dependent manner, normally through predesignated directories.

WHERE ARE THESE INCLUDE FILES?
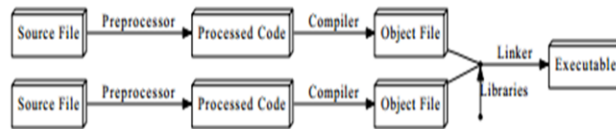**DEMO**
Use 'include browser'view

Drop hello.cpp on this view

For both <iostream> and "myfunc.h"
Right click->show in->Properties->location

Compiling/Linking – Example 2

Slight edit of dir output

-c compile and assemble but no link (generate .o object file)

-o generate executable from object files

 g++ --help

    – Here I am compiling 2 files and linking them to form an executable
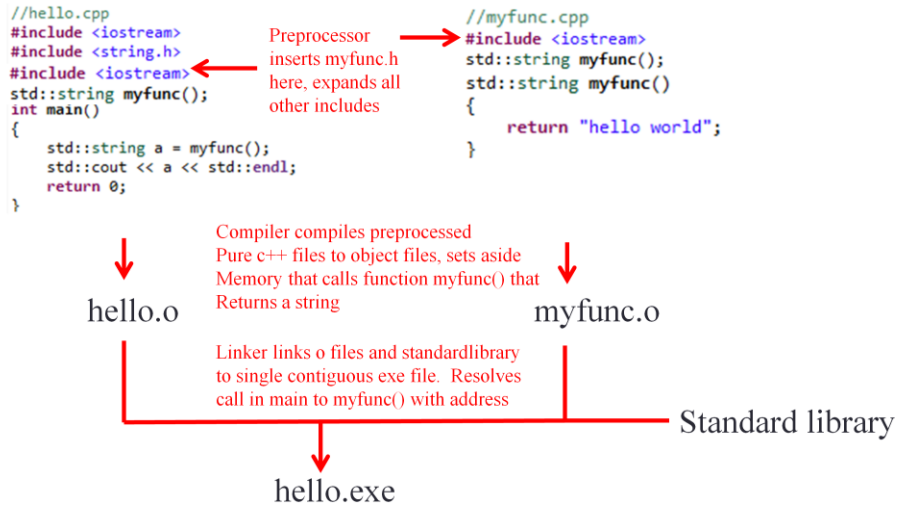
        Preprocessor – subs in contents of <iostream> and myfunc.h into hello.cpp, myfunc.cpp

        Compiler- converts preprocessed hello.cpp, myfunc.cpp to object code for a *particular processor*

        Linker – Links hello.o, myfunc.o and any external libraries to form exe

        means 1 continuous block of code or address spaces

Demo

Compiling/Linking – Example 2

```
//hello.cpp
#include <iostream>
#include <string.h>
#include <iostream>
std::string myfunc();
int main()
{
    std::string a = myfunc();
    std::cout << a << std::endl;
    return 0;
}
```

Preprocessor inserts myfunc.h here, expands all other includes

```
//myfunc.cpp
#include <iostream>
std::string myfunc();
std::string myfunc()
{
        return "hello world";
}
```

Compiler compiles preprocessed Pure c++ files to object files, sets aside Memory that calls function myfunc() that Returns a string

hello.o

myfunc.o

Linker links o files and standardlibrary to single contiguous exe file. Resolves call in main to myfunc() with address

Standard library

hello.exe

Hello uses myfunc(), how does it know definition/declaration?

CLICK

Doesn't, until preprocessor replaces #include myfunc.h with declaration

CLICK

Now it knows declaration

Compiler sets aside memory needed to call myfunc w/no arguments that returns string (does not know address of call yet)

CLICK

Linker wires the 2 object files and the standard library into a single exe

Resolves call to myfunc with an absolute address

How does it do this? Demo on board

Compiling/Linking – Example 2

Diagram from http://www.learncpp.com/cpp-tutorial/19-header-files/
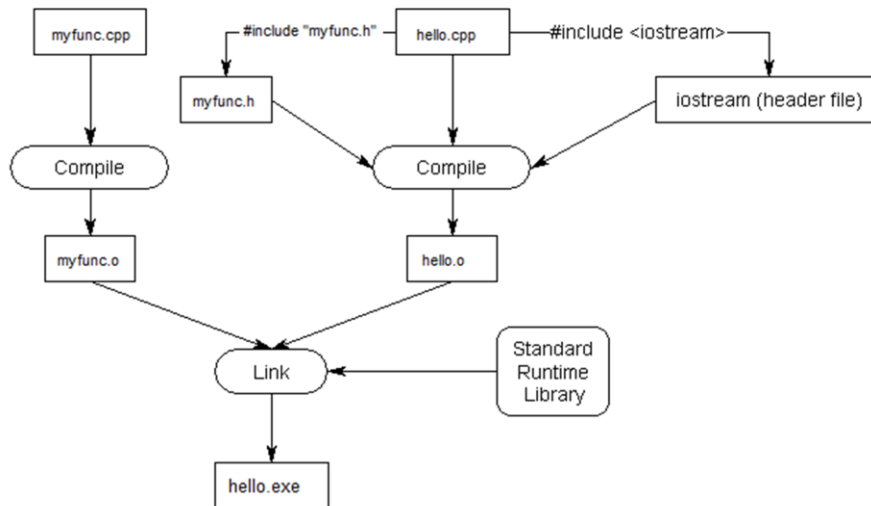
Diagram – if cant do prev slide animation

Point

Most projects have many files, compilation of each file takes time

If just change 1 file why recompile all? If cpp file **just recompile that file and relink all** the other object files

Saves a lot of time, Eclipse does not do this, it will rebuild the whole thing

Visual studio does do this, its better than eclipse in this respect for large projects

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Debugging

```
Perkins@R343-M1 C:\test
$ g++ -g main.cpp                                          -g compile with debug info

Perkins@R343-M1 C:\test
$ gdb a.exe                                                start debugger
(gdb) break main                                           break at beginning
Breakpoint 1 at 0x1004010ed: file main.cpp, line 5.
(gdb) run                                                  run
Starting program: /cygdrive/c/test/a.exe
[New Thread 7128.0x1ac8]
[New Thread 7128.0x670]
[New Thread 7128.0x1640]
[New Thread 7128.0x1e8c]

Breakpoint 1, main () at main.cpp:5
5               std::cout<<"hello world"<<std::endl;
(gdb) list                                                 Show lines around breakpoint
1       #include <iostream>
2
3       int main()
4       {
5               std::cout<<"hello world"<<std::endl;
6               int a=1;
7               int b=a+1;
8               return 0;
9       }(gdb) n                                            Next line
hello world
6               int a=1;
(gdb) n
7               int b=a+1;
(gdb) a
Ambiguous command "a": actions, add-auto-load-safe-p
(gdb) print a                                              Print value of a
$1 = 1
(gdb)
```
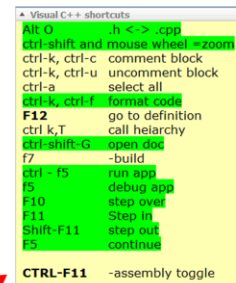
- **https://www.cs.swarthmore.edu/~newhall/unixhelp/howto_gdb.html#badprog**

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Compiling/Linking – Using an IDE

- **Let Integrated Development Environment (IDE) handle all details**
- **(build settings still there just using default project settings)**

- Create C++ project
- Copy 3 files from example 2 to it
- Build it
- Here are some key shortcuts

```
▲ Visual C++ shortcuts                          ⊗
Alt O              .h <-> .cpp
ctrl-shift and mouse wheel  =zoom
ctrl-k, ctrl-c   comment block
ctrl-k, ctrl-u   uncomment block
ctrl-a           select all
ctrl-k, ctrl-f   format code
F12              go to definition
ctrl k,T         call heiarchy
ctrl-shift-G     open doc
f7               -build
ctrl – f5        run app
f5               debug app
F10              step over
F11              Step in
Shift-F11        step out
F5               continue

CTRL-F11   -assembly toggle
```

Key bindings I use

Know about make process (Compile/Link,Load on cmd) but don't have to be expert

Can set various compiler and linker switches and options in Eclipse, do this as your projects become more sophisticated

Demo

Go over what is in directory

       Include folders, declarations of stuff we will need

       <IOStream> put mouse on it and F3 to see its contents

Where is it, (save as does not work correctly in eclipse)

       Add the 'include browser' (window->show view->C++ …)

       drop file on it, list all the includes

       right click on <iostream>, Show in->properties

       See where its coming from (helps to prevent insidious bug where you are including stuff from different versions

minGW4.6 verses 4.8 etc)

Running

- **Its an Executable! (no virtual machine)**
- **Can run from command line or IDE**
- **Fast Demo Various bits of IDE**


```
Administrator: C:\Windows\system32\cmd.exe
C:\Users\lynn\Dropbox\Classes\CPSC427\Week 1\Demo>g++ -o hello.exe hello.cpp

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C:\Users\lynn\Dropbox\Classes\CPSC427\Week 1\Demo>hello
Hello, world!
```

Run it,

from eclipse will be in the console window

from file system it will be in a command window

When only Cout from program then exit, doubleclick on .exe will cause cmd window to open cout then close, very quickly

Instead open command window, go to debug dir, and run, output will stay visible

show example using depends

Show dlls attached to it as part of process explorer, or dependency walker

useful for seeing if wrong version of dll is attached (dll hell, can't tell which version of dll is attached)

Libstdc++-6.dll standard library for minGW

MSVCRT.dll c runtime and Microsoft

MSVCPRT.LIB standard library Microsoft

We will go over all these techniques as we go along

What have we learned

- C++ has lots of similarities to Java (more as we go)
- How to write a simple C++ program
- How to compile using command line
- How to use an IDE to create a program
- **For this class and most likely professionally, let the IDE manage your builds.**
- Basic IDE usage (Debug/release build, variables, breakpoints etc)
- How to run a program
- PRACTICE PLEASE

However, open source people often really know the build process, the language and have efficient development techniques.

Finished 3-4:15 class

Must have a main

Faster than java

Alluded to standard library