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C++ London

uni

Initial C++ — session 3

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Register now for C++ on Sea!

https://cpponsea.uk/

About these sessions

- An introduction to C++
- A mixture of talks, class exercises and homework
- We can’t turn you into an expert (sorry!)
- …but we’ll try to give you enough information to get started

Feedback

- We’d love to hear from you!
- The easiest way is via the *cpplang* channel on Slack — we have our own chatroom, *#cpplondonuni*
- Go to https://cpplang.now.sh/ for an “invitation”

Last week...

- Further intro to C++
- Commonly used types (integer types, `std::string`, `std::vector`)
- Declaring variables
- The `const` keyword
- Type deduction with the auto keyword

This week...

- Getting set up with a compiler and CLion
- The C++ compilation model
  - What compilers do
  - Using the compiler from the command line
  - The C++ compilation process
  - Separate compilation
  - Using libraries
  - Header files and `#include`

Getting set up for C++

- So far we have only used an online compiler to write examples
- Today we’re going to make sure everyone is set up with a working compiler and IDE (integrated development environment)
- In this course we’ll use the CLion IDE and either the GCC or Clang compiler

Installing a compiler

- Windows:
    - Go to https://nuwen.net/mingw.html and select either of the mingw.exe download links
    - Run the executable and select the install directory (e.g. C:\MinGW)
- Mac:
    - Open a Terminal window and enter
        - `xcode-select --install`
    - This will download and install the command-line development tools
- Linux:
    - Try running `CC --version` in a terminal window. If this works, you already have a C++ compiler installed
    - Otherwise, please install g++ using your system package manager

Installing CLion

- Please go to https://www.jetbrains.com/clion/ and download CLion via the “start a 30 day trial” link

- Run the installer and then launch CLion

- The wizard should guide you through the process of creating a “toolchain”

    - Windows: when prompted, tell it that you want to use MinGW, and enter the directory you selected earlier (e.g. C:\MinGW)

    - Mac and Linux: CLion should automatically detect your compiler

Running CLion

- Live demo

Exercise

- In CLion, follow the steps you've just seen to create a new C++ executable project
- Ensure that you can compile and run this program successfully
- If you have any problems, please let one of us know

Any questions before we move on?

Compilers for C++

- There are many C++ compilers out there, but the “big three” are:
  - The GNU Compiler Collection (GCC), called MinGW on Windows
  - Clang, part of the LLVM project
  - Microsoft Visual C++ (MSVC), part of Visual Studio
- In this course we will be using GCC/MinGW or Clang

What is a compiler?

- A *compiler* is a program which takes source code (text) and processes it into some other (lower-level) form

- For example, a Java compiler will accept Java source code, and process it into Java bytecode

- In C++, the compiler will usually generate *machine code*, that is, instructions to be executed directly on the CPU

- Typically, this machine code is specific to a particular CPU architecture and operating system combination

What does a compiler do?

- It’s the compiler’s job to translate your source code into machine code

- It does this by first checking the *syntax* of your source code: whether you have used symbols and keywords in a way it can understand.

- It then checks the *semantics* of your program: whether it “makes sense”

What does a compiler do?

- If the compiler cannot understand your program, it will terminate with an error, usually called a *compiler error* or *compile-time error*

- In C++ we generally **strongly** prefer compile-time errors to run-time errors (those that occur when the program executes)

- Once it has checked that it understands your program, the compiler will proceed to translate it into machine code, typically applying *optimisations* to make it execute faster

Invoking the compiler

- On Unix systems, we can run the C++ compiler on the command line, passing it the name of the file(s) we want to compile, and the output name, e.g.

  ```
  CC my_file.cpp -o my_exe
  ```

- This can be very useful for small test programs

- (This is also possible on Windows with MinGW: use `g++.exe` rather than CC)

Exercise

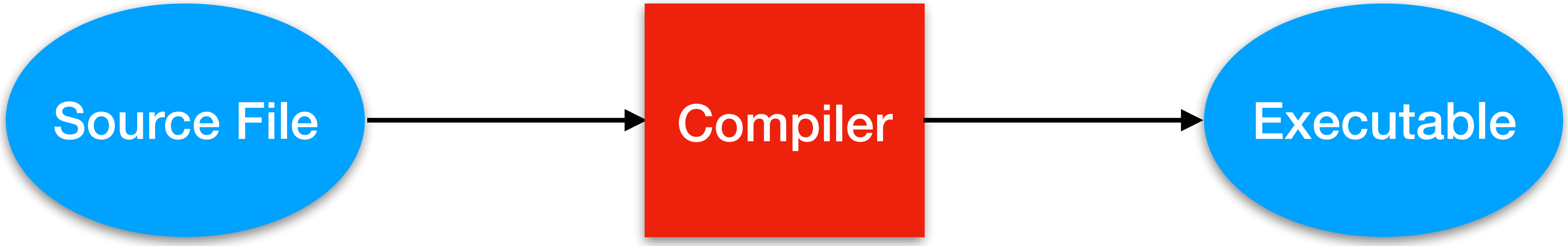
- Open a text editor and enter the “Hello World” program on the right
- Save this file as “hello_world.cpp”
- Compile this file using the command line

```cpp
#include <iostream>

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

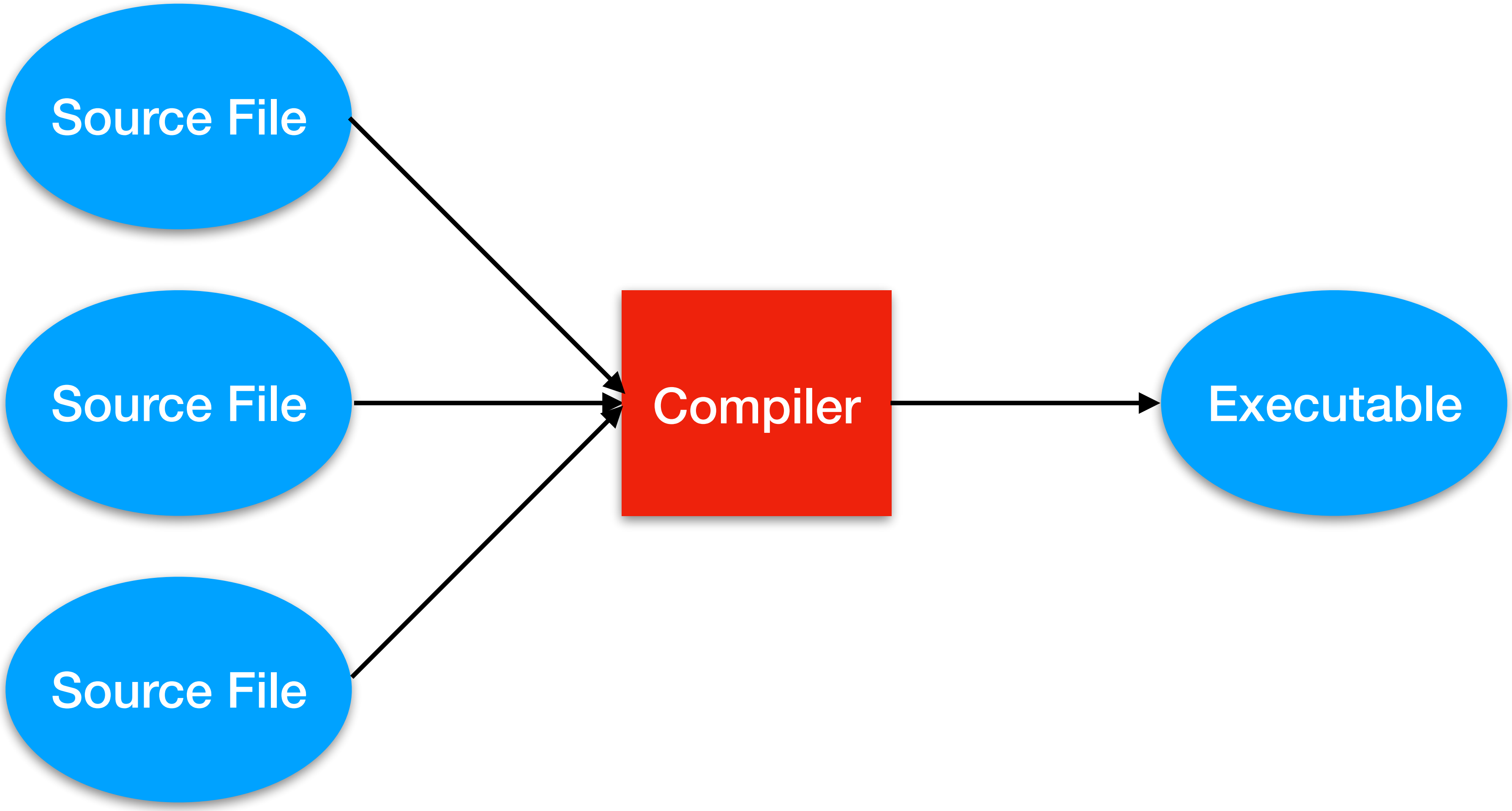
The compilation process

- Schematically, the process we have just used looks like this:



The compilation process

- We can also pass multiple files to the compiler at once



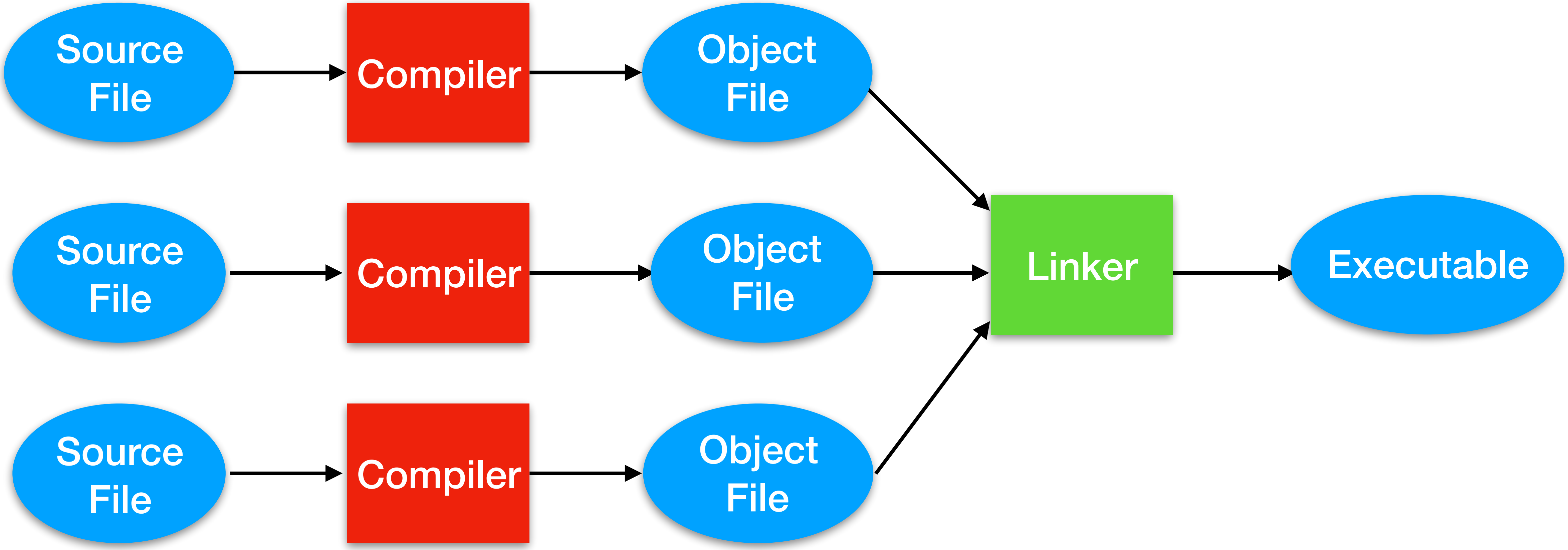
Separate compilation

- In real-world programs however, we usually don’t want to compile all our files at once

- Instead, we send each file individually to the compiler, which produces *object files* (typically with a `.o` or `.obj` extension)

- Another program called the *linker* collects these object files and links them together into an executable

Separate compilation



Using libraries

- Real-world programs are usually built using software from difference sources, called *libraries*

- Libraries compiled into object files, which are provided to the *linker*

- We’ve already used one! The *C++ standard library* is bundled with your compiler, and is automatically linked to C++ programs

Separate compilation

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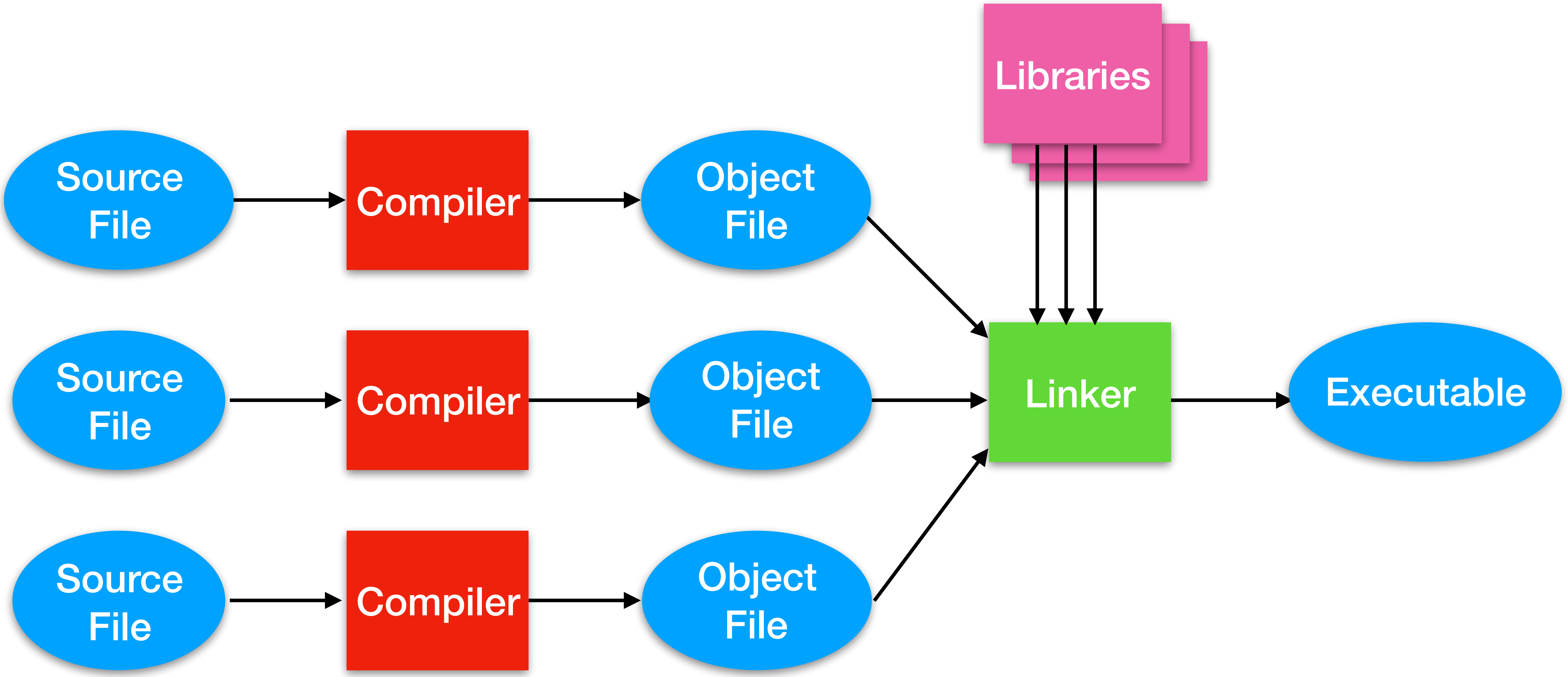

Build systems

- Managing the compilation process with multiple source files and libraries is usually automated by build tools or build systems

- These take care of noticing which files have been edited, and recompiling only what is necessary

- There are many, many different build systems out there (MSBuild, Automake, waf, Scons, Meson, etc etc)

Build systems

- The most common build system for C++ projects is CMake, which is supported directly by CLion and most other C++ IDEs

- In general, we'll be relying on CLion to manage our CMake configuration…

- …but if you're curious, you can take a look at CMakeLists.txt in a CMake project

Headers and implementation files

- As we’ve seen, each source file is processed individually by the compiler

- But we generally want to re-use types and functions between different source files!

- In C++ this is accomplished using *header files*, or simply *headers*

- Because headers also contain source code, we will sometimes use the term *implementation file* to refer to files that are passed directly to the compiler

- Typically, implementation files have a `.cpp` extension. Header files usually use `.hpp` or `.h`

Headers

- Generally, we place function *delarations* into header files, and the function *implementations* into implementation files

- If the compiler has seen the declaration of a function, it knows how to call it

- Later, the linker matches up function *calls* in one object file to function *implementations* in another

- Lots of other things also go in header files (type definitions, templates, inline functions etc) which we'll cover later

Using header files

- We can include a header file in an implementation file using the `#include` command

- For headers in our own project we need to say

```
#include "header.hpp"
```

- For headers from other libraries we need to say

```
#include <header.hpp>
```

Using header files

- `#include` performs a literal copy and paste of header file text wherever it's called

- Header files can (and usually do) `#include` other headers that they rely on

- We need to be careful to ensure that a header is `#include`-d only once in each implementation file

- We normally use include guards to prevent this, or compiler-specific mechanisms like `#pragma once`

- CLion will generate include guards for you

Creating headers and source files in CLion

- Live demo

Exercise

- In CLion, create a new C++ executable project if you have not already done so
- Add a source file `example.cpp`, with a matching header
- In example.cpp, write a function `add(int a, int b)` which returns `a + b`.
- Add a *declaration* of this function to the `example` header
- In `main.cpp`, use this function print the result of 3 + 4.

Homework

- Write a function `fib(int n)` which returns a `vector<int>` containing the first n Fibonacci numbers

- Place the *declaration* of your function in a header `fibonacci.hpp`, and the *definition* in `fibonacci.cpp`. Test this function from your `main()` routine.

- Add two new optional parameters to your `fib()` function, allowing the user to specify the initial “seed” values. These should default to 0 and 1 if the user does not supply them.

- Extension: in CLion, create a new `libfibonnaci` *library* containing your `fib()` function, along with a test program that ensures the results are correct.

Next time

- Value semantics and object lifetime fundamentals
- Basic control flow
    - If statements
    - Loops

Online resources

- https://isocpp.org/get-started
- cppreference.com — The bible, but aimed at experts
- cplusplus.com — Another reference site, also has a tutorial section
- learncpp.com — Free online tutorial, very up-to-date
- https://www.pluralsight.com/authors/kate-gregory - Comprehensive set of courses from an experienced C++ trainer (free trial)
- reddit.com/r/cpp_questions
- Cpplang Slack channel — https://cpplang.now.sh/ for an “invite”
- StackOverflow (but…)