# Makefiles

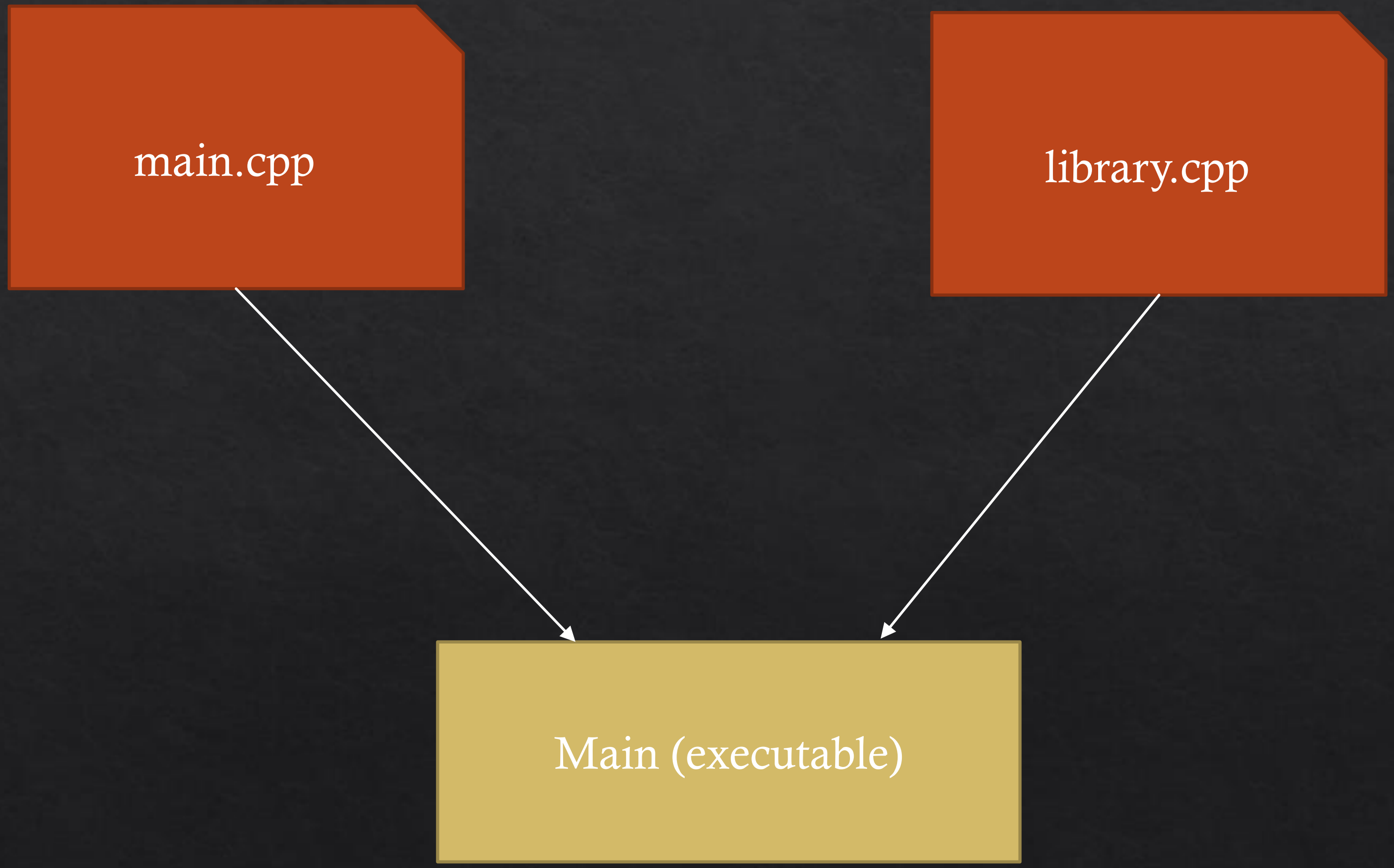
## What are they for?

- From https://www.gnu.org/software/make/ :
  - GNU Make is a tool which controls the generation of executables and other non-source files of a program from the program's source files.
- In other words, it’s a way to specify and automate your build process.

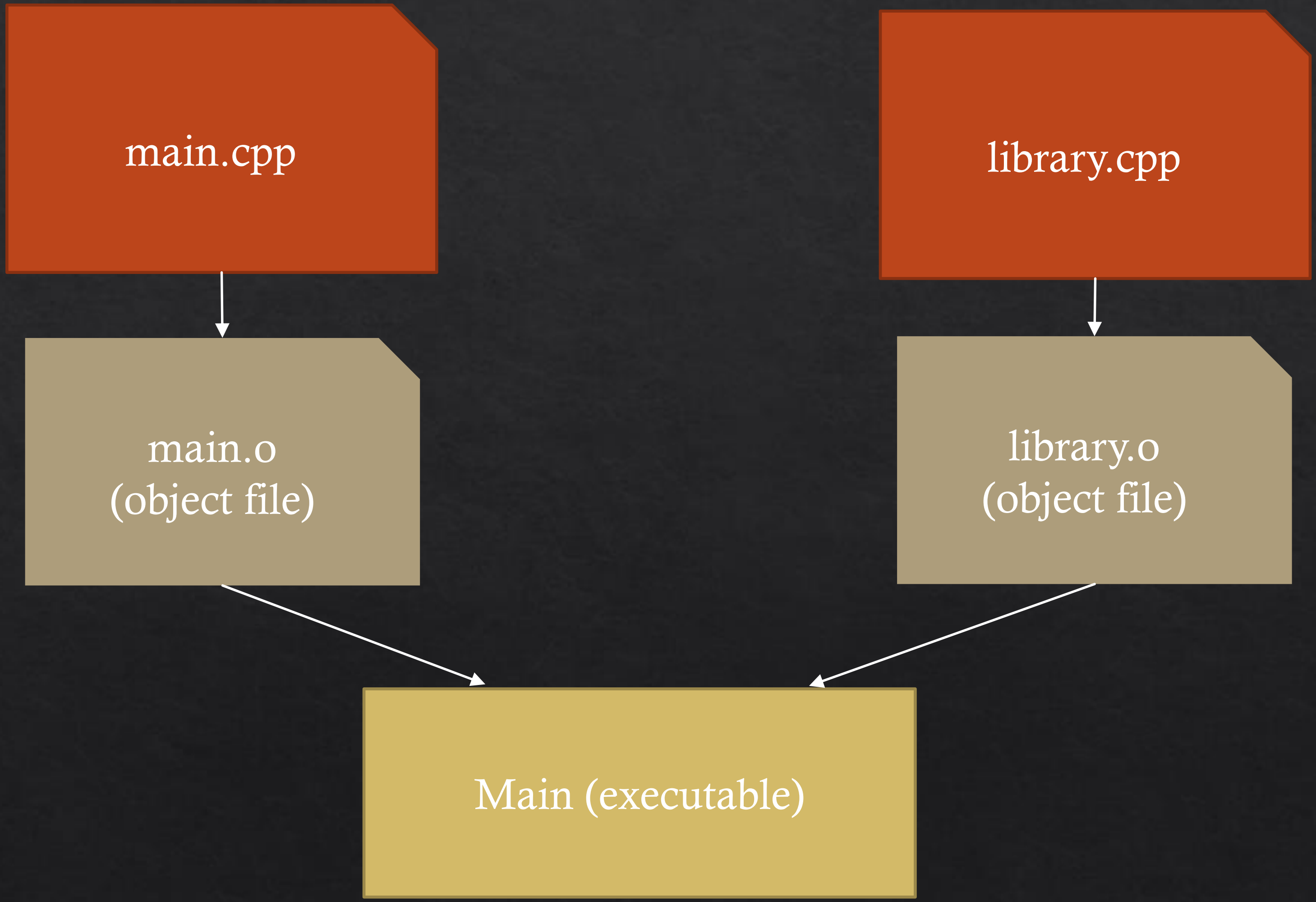
## How is a C++ program compiled?

- When you type:
  - g++ library.cpp main.cpp –o main
- … what exactly is the compiler doing?

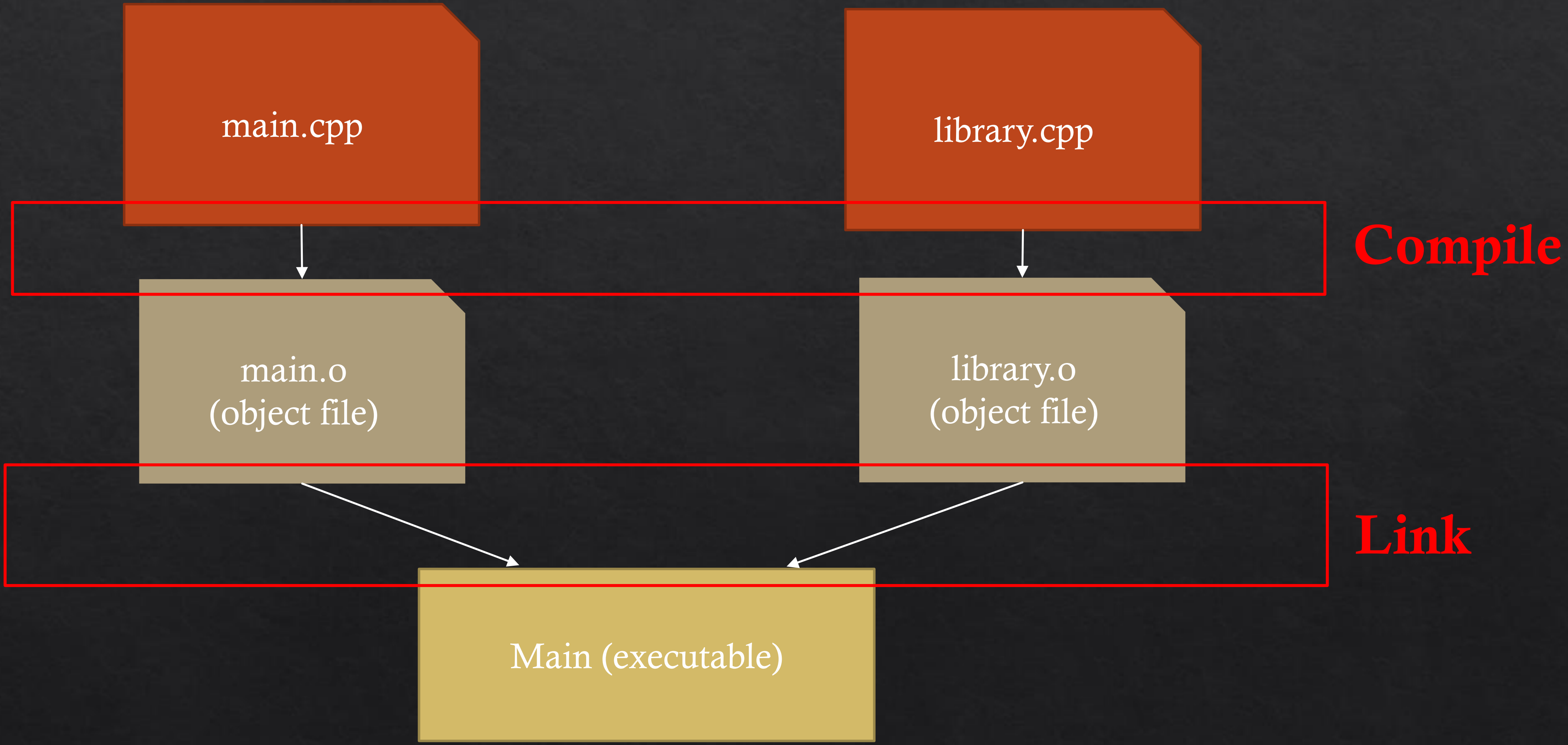
# Appearance



# Reality


main.cpp
library.cpp
main.o
(object file)
library.o
(object file)
Main (executable)

# Reality


main.cpp
library.cpp
Compile
main.o
(object file)
library.o
(object file)
Link
Main (executable)

## The “-c” flag

- Turns out we can ask the compiler to only do the “compile” step:
  - g++ main.cpp –c –o main.o
  - g++ library.cpp –c –o library.o
- “-c” stands for ***compile only***.
- The above commands creates “main.o” and “library.o”.
- It **does not** link them together.

## Linking them together

- Pass the object files to g++, as if they were cpp files:
  - ~~g++ library.cpp main.cpp -o main~~
  - g++ **library.o main.o** -o main

## Why would you do that?

- Simple: if you changed “library.cpp”, you do not have to recompile “main.cpp”!

## Now we can explain Makefiles!

- Think of makefiles as recipes:
  - The ingredients for “main.o” is “main.cpp”.
  - The ingredients for “library.o” is “library.cpp”.
  - The ingredients for “main” is “main.o” and “library.o”.

  - To make “main.o”, do “g++ main.cpp –c –o main.o”
  - To make “library.o”, do “g++ library.cpp –c –o library.o”
  - To make “main”, do “g++ main.o library.o –o main”

## In Makefile language:

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

library.o: library.cpp
    g++ library.cpp -c -o library.o

main: main.o library.o
    g++ main.o library.o -o main
```

## More compiler flags

- **-Wall**: Tells the compiler to warn you of possible errors in your code.
- **-O1, -O2, …**: Tells the compiler to magically optimize your code.
  - Don’t do this if you are debugging your code!
- **-g**: (You’ve seen this last time) Tells the compiler to generate useful information for the debugger.

## Now with make with more flags

```
main.o: main.cpp
    g++ -Wall -O2 main.cpp -c -o main.o

library.o: library.cpp
    g++ -Wall -O2 library.cpp -c -o library.o

main: main.o library.o
    g++ -Wall -O2 main.o library.o -o main
```

## Now with make with more flags

```
main.o: main.cpp
    g++ -Wall -O2 main.cpp -c -o main.o

library.o: library.cpp
    g++ -Wall -O2 library.cpp -c -o library.o

main: main.o library.o
    g++ -Wall -O2 main.o library.o -o main
```

# Automatic variables

```
cxx = g++ -Wall -O2

main.o: main.cpp
	$(cxx) $< -c -o main.o

library.o: library.cpp
	$(cxx) $< -c -o library.o

main: main.o library.o
	$(cxx) main.o library.o -o main
```

- "$<" stands for "first item in the dependency list"

## Automatic variables

```
cxx = g++ -Wall -O2

main.o: main.cpp
    $(cxx) $< -c -o $@

library.o: library.cpp
    $(cxx) $< -c -o $@


main: main.o library.o
    $(cxx) main.o library.o -o $@
```

- “$<” stands for “first item in the dependency list”
- “$@” stands for “the name of the target”