Programming in GNU/Linux

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Before we begin

- Go to `Software & Updates` and make sure that under `Downloadable from the Internet` the `main` and `universe` checkboxes are checked
- Now run the update

```
$ sudo apt update
```

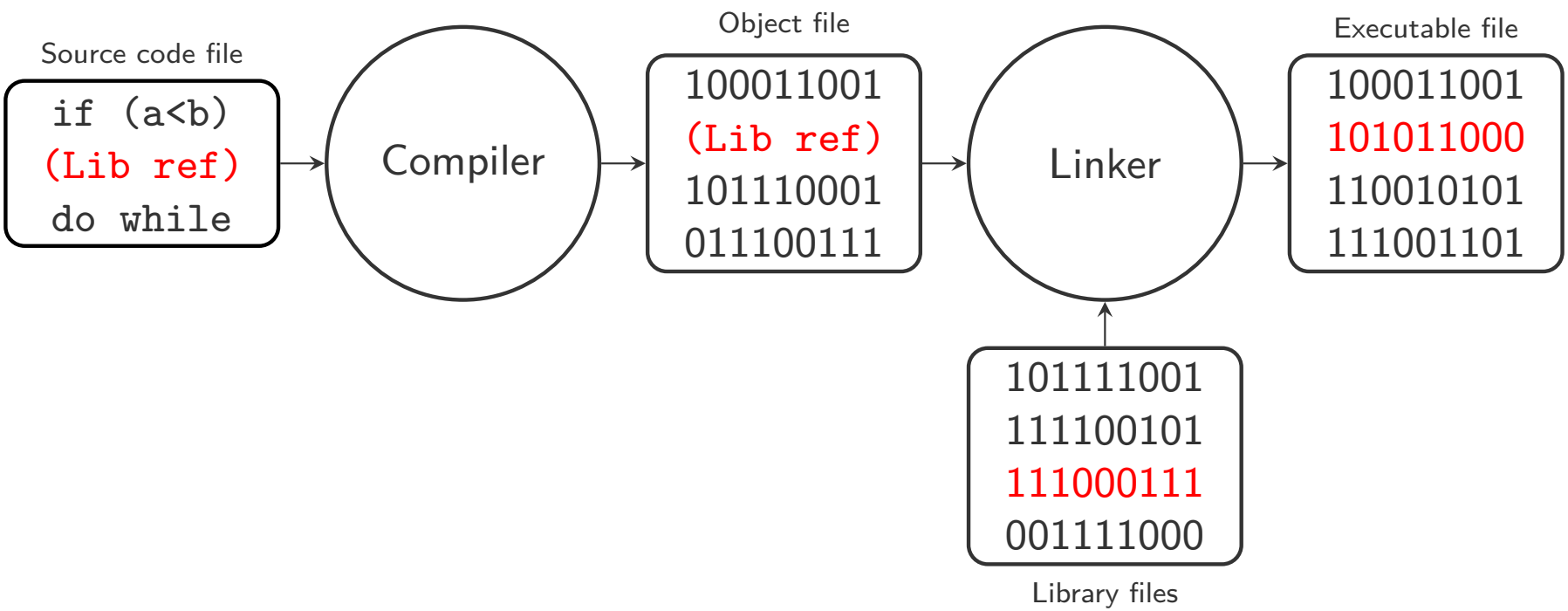
- Be sure to install the following for the class

```
$ sudo apt install cmake g++
```

- For laboratory exercize you will also need OpenCV (probably already installed!)

```
$ sudo apt install ros-$ROS_DISTRO-vision-opencv
```

Developing a program



Writing a program in Linux

- Let's write a program called `hello.c` in C

```c
#include <stdio.h>
int main()
{
  printf("Hello!\n");

  return 0;
}
```

- Use your favorite text editor to make the source code

```
$ nano hello.c
$ gedit hello.c
```

Compiling proper

- People often under ‘compilation’ mean the entire build process (compiling and linking), so to emphasize the literal step we say ‘compiling proper’
- To compile the source code we call the C compiler (gcc)

```
$ gcc -c hello.c
```

- The result is an object file `hello.o`, which is nothing but a machine-readable source code version with references to library functions

Linking

- To link the object file with certain libraries which contain 'built-in' functions (like `printf`) we execute

```
$ gcc -o hello hello.o
```

- This step replaces the references in the object file with functions from library files (for static libraries)
- The result is a binary file `hello` that we can run (since usually not in `PATH` we must specify the location with `./`)

```
$ ./hello
Hello!
```

- Possibly the binary will not be executable — check with `ls -la` and change if needed with `chmod`

Splitting the code

- Let's write a function in a separate file `print_time.c` that will print the date and time, and which will be called from `hello.c`

```c
#include <stdio.h>
#include <time.h>

void print_time(void)
{
        time_t now;
        time(&now);

        printf("Today is %s\n", ctime(&now));
}
```

Splitting the code

- To be able to use it in `hello.c` we need to write also the header file `print_time.h` with the function prototype

```
void print_time(void);
```

- Now we modify the `hello.c`

```
#include <stdio.h>
#include "print_time.h"

int main()
{
  printf("Hello!\n");
  print_time();

  return 0;
}
```

Splitting the code

- Building and execution goes as follows

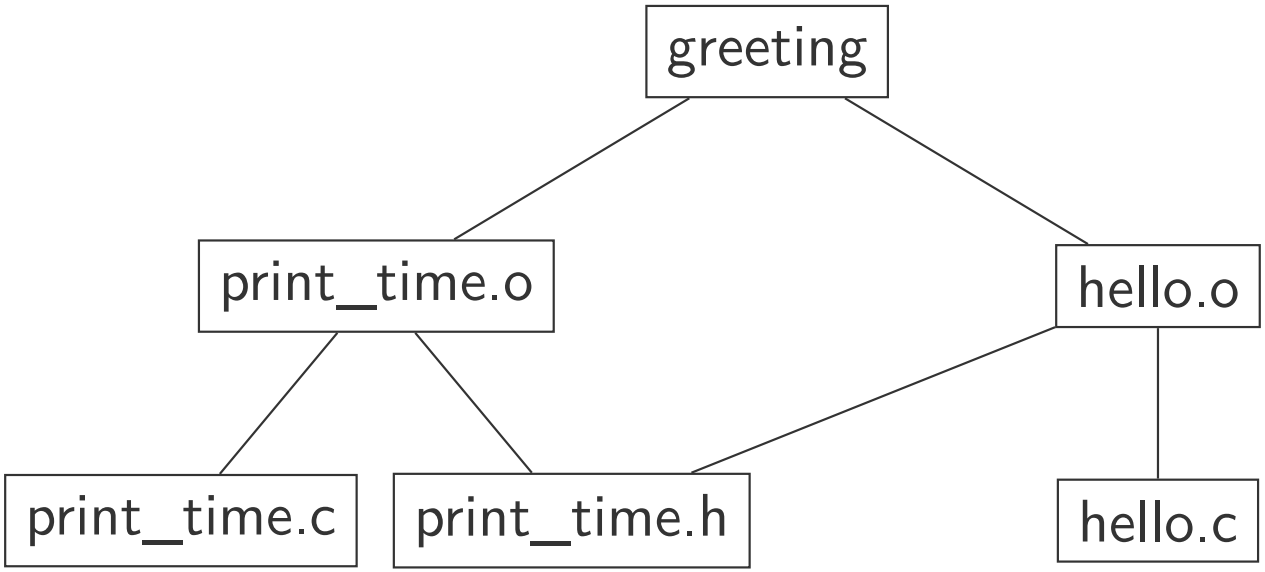
```
$ gcc -c hello.c print_time.c
$ gcc -o greeting hello.o print_time.o
$ ./greeting
Hello!
Today is Thu Nov 26 10:17:01 2020
```

- If only `print_time.c` changes we do not need to compile the whole project again
- How to build and take care of dependencies automatically?

Makefiles

- When project consists of multiple files (`*.c`, `*.h`) manual compiling and linking quickly becomes tedious
- Makefiles with the `make` utility can automatically build and manage the project
- Let's look at the dependency tree of the `greeting` project

Makefiles


greeting
print_time.o
hello.o
print_time.c
print_time.h
hello.c

Makefiles

- Makefile has the following format

```
target: source file(s)
        command (must be preceded by a tab)
```

- The greeting project makefile (connect it with the dependency tree)

```
greeting: hello.o print_time.o
        gcc -o greeting hello.o print_time.o
hello.o: hello.c
        gcc -c hello.c
print_time.o: print_time.c
        gcc -c print_time.c
```

Makefiles

- When we call `make` the utility will read the `makefile`

```
$ make
gcc -c hello.c
gcc -c print_time.c
gcc -o greeting hello.o print_time.o
```

- Often practical to include is `clean` target to get rid of built files (no dependencies are stated)

```
clean:
        @rm -rf *o greeting
```

- When executed as `make clean` it will delete all `*.o` files and the `greeting` binary
- If `@` is placed then there will be no output on the terminal

Libraries

- Libraries can be static (`*.a`) or shared (*.so)
- At linking stage the static library gets placed in the final program, while in the case of shared library only a reference is placed inside
- Program having references to shared libraries must be able to see them during execution
- Libraries are usually located in `/lib`, `/usr/lib` and `/usr/local/lib`

CMake

- A cross-platform, open-source build system
- In other words, a tool for making makefiles (in case of Linux) which wraps around native build system (e.g. if on another computer we don't have `gcc` but `gcc-xyz` we would have to replace it in the `makefile`)
- Instead of explicitly writing dependencies and commands as in the case of a `makefile`, with CMake we will describe how to make a `makefile`
- Of course, the final result will be an automatically generated `Makefile`

CMake

- Let's build our previous project `greeting` (without the `print_time.c` for now) with CMake
- Make a text file called `CMakeLists.txt` (this is what CMake will read to do its magic)
- In our project directory with the source `hello.c` make a folder called `build` where all our build files will be stored

CMake

- Edit the `CMakeLists.txt` as follows

```
# We name our project
project(greeting)
# This tells CMake to compile hello.c and name it hello
add_executable(greeting hello.c)
```

- Navigate to the `build` folder and run

```
$ cmake ..
$ make
```

- We tell CMake where the sources are and then we make the project

CMake

- Let's now build the `greeting` project, but with the `print_time.c`
- Copy files `print_time.c` and `print_time.h` in your folder along with `hello.c`
- In a way, what we did before was to include the `print_time.c` function as a static library directly in the `hello` binary
- Now, we will do it explicitly and create a static library

CMake

- Add the following lines to your `CMakeLists.txt`

```
# We add the file as a static library called TimeLibrary
add_library(TimeLibrary STATIC print_time.c)
# This tells CMake to link greeting with the TimeLibrary
target_link_libraries(greeting TimeLibrary)
```

- after running `cmake` and `make` you should see `libTimeLibrary.a` in your `build` folder

Exercize

Try moving your `greeting` binary to another folder and running it. Does it need to see `libTimeLibrary.a`? Add `TimeLibrary` as a shared library in your `CMakeLists.txt` and `cmake` and `make` your project again. Move your `greeting` binary to another folder and run it. Now cut/copy `libTimeLibrary.so` to the same folder as `greeting` binary. What happens? Can `greeting` see the library now? (see here for help)