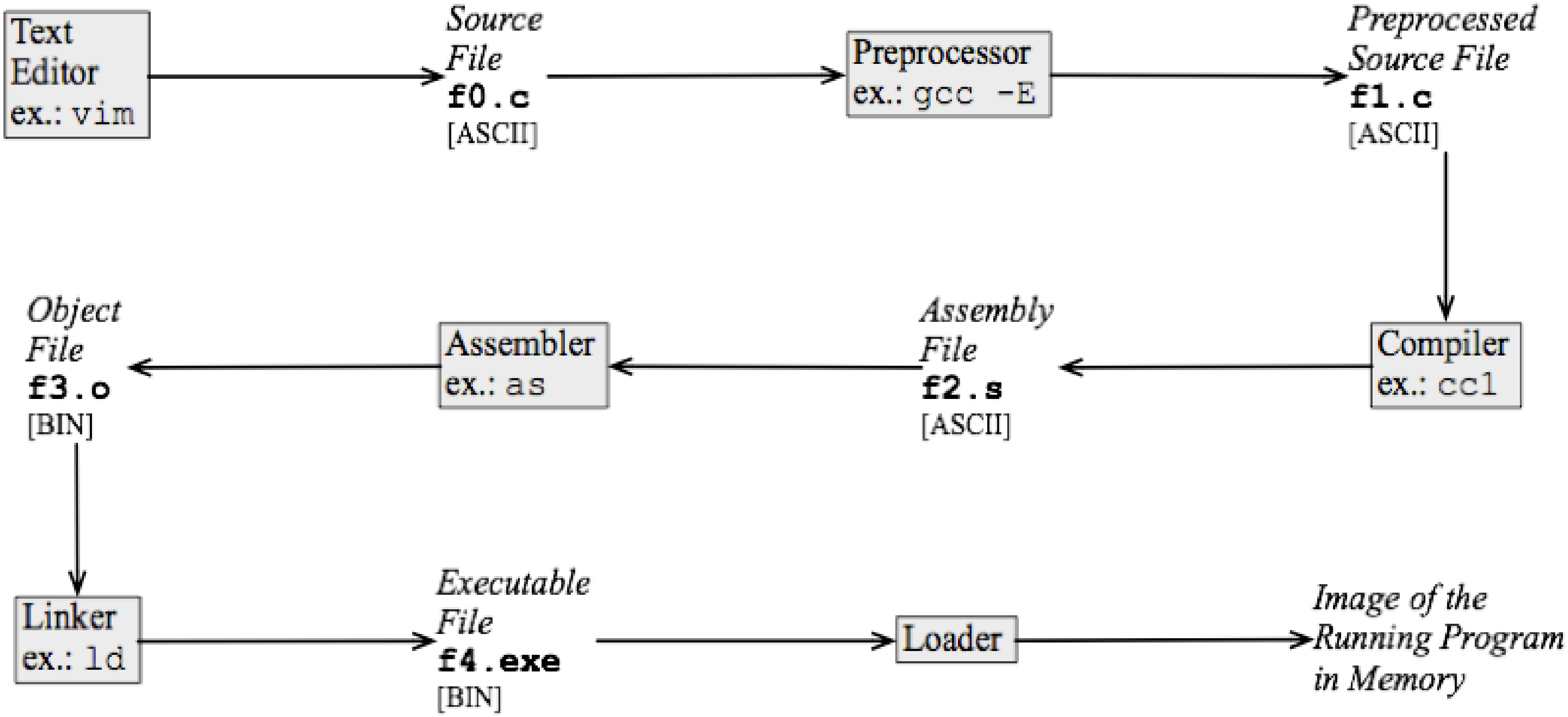
CS35L – *Winter19*

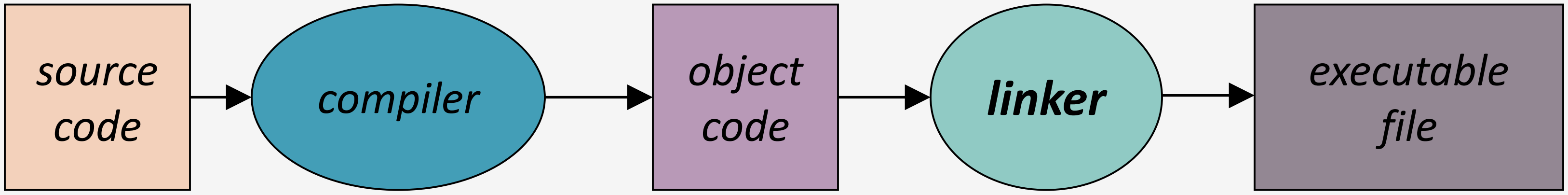
Slide set:	7.1
Slide topics:	Dynamic linking
Assignment:	7



Lifecycle of a program

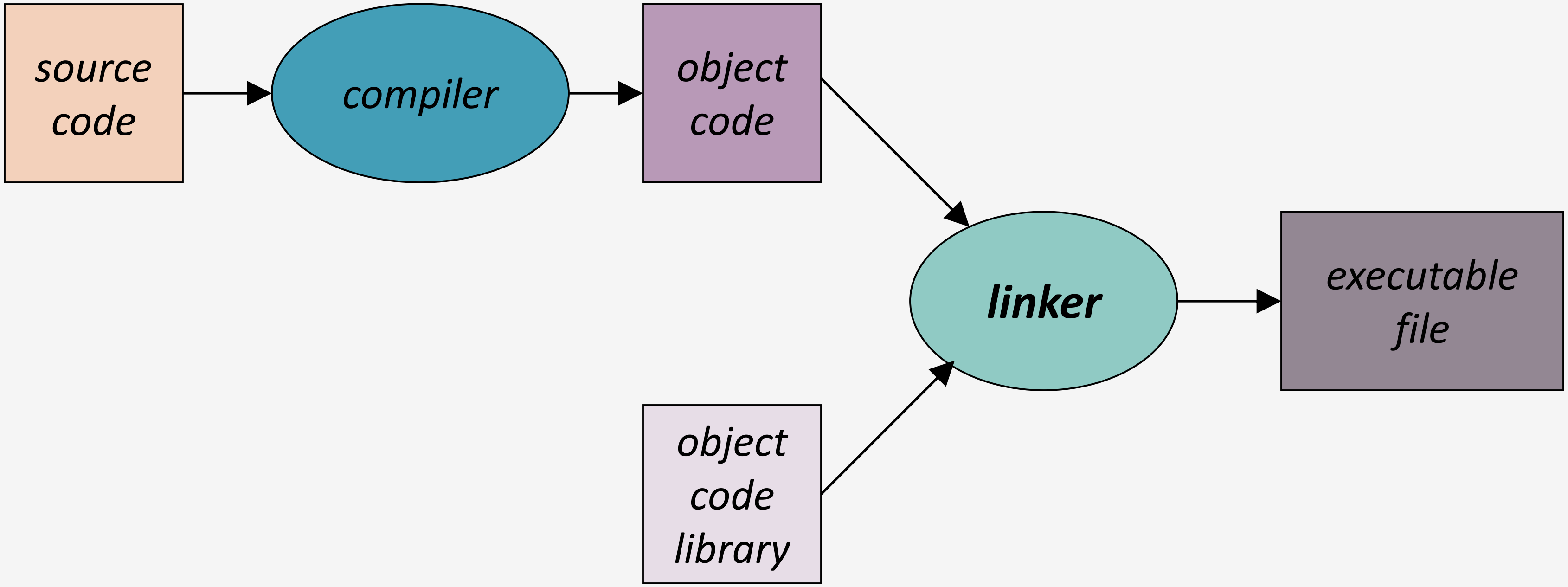
Building an executable file

Translates programming language statements into CPU's machine-language instructions



Takes one or more object files generated by a compiler and combines them into a single executable file

Building an executable file - dynamically

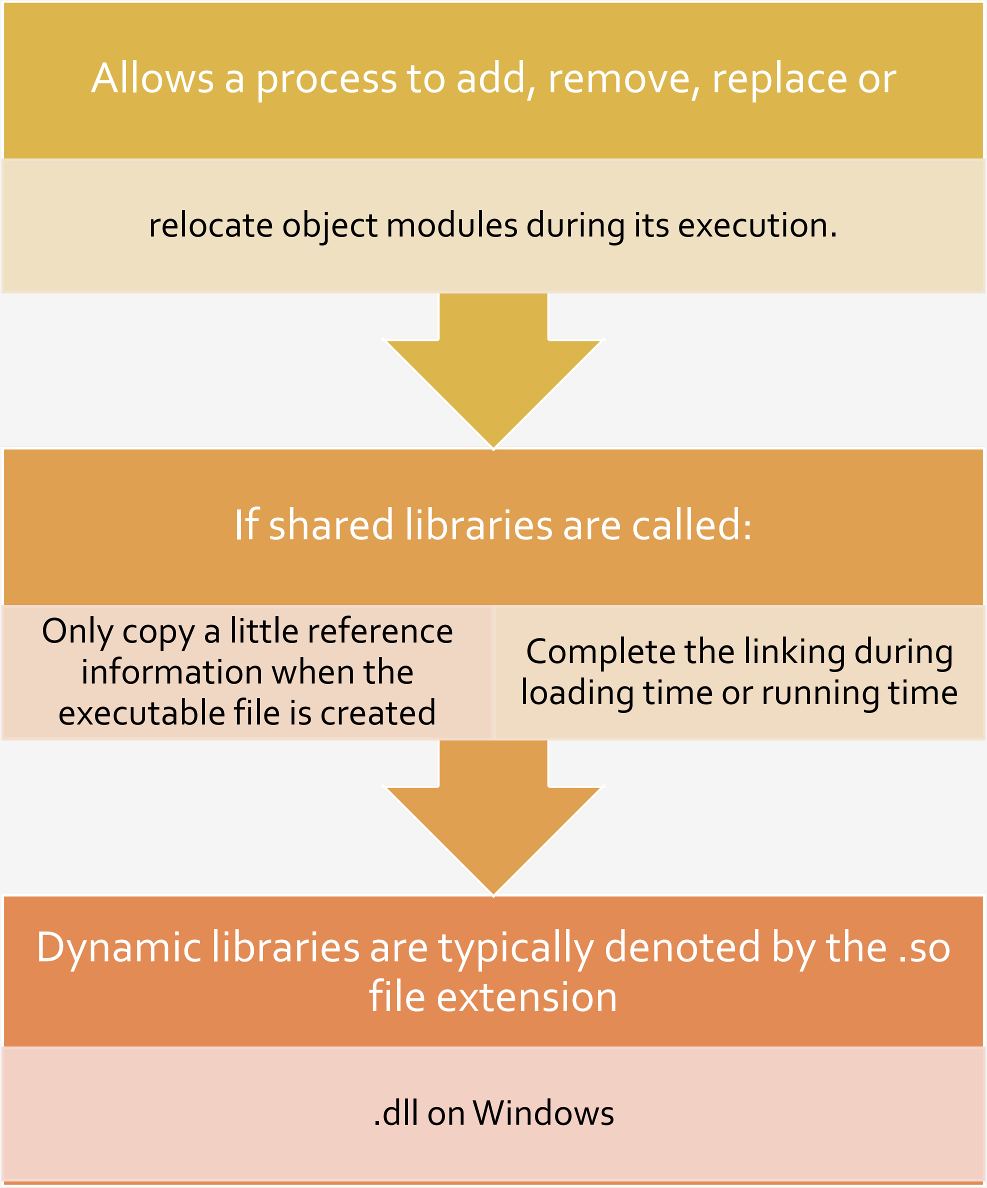


A previously compiled collection of standard program functions

Static Linking

- Carried out only once to produce an executable file
- If static libraries are called, the linker will copy all the modules referenced by the program to the executable
- Static libraries are typically denoted by the .a file extension

Dynamic Linking



Allows a process to add, remove, replace or

relocate object modules during its execution.

If shared libraries are called:

Only copy a little reference information when the executable file is created

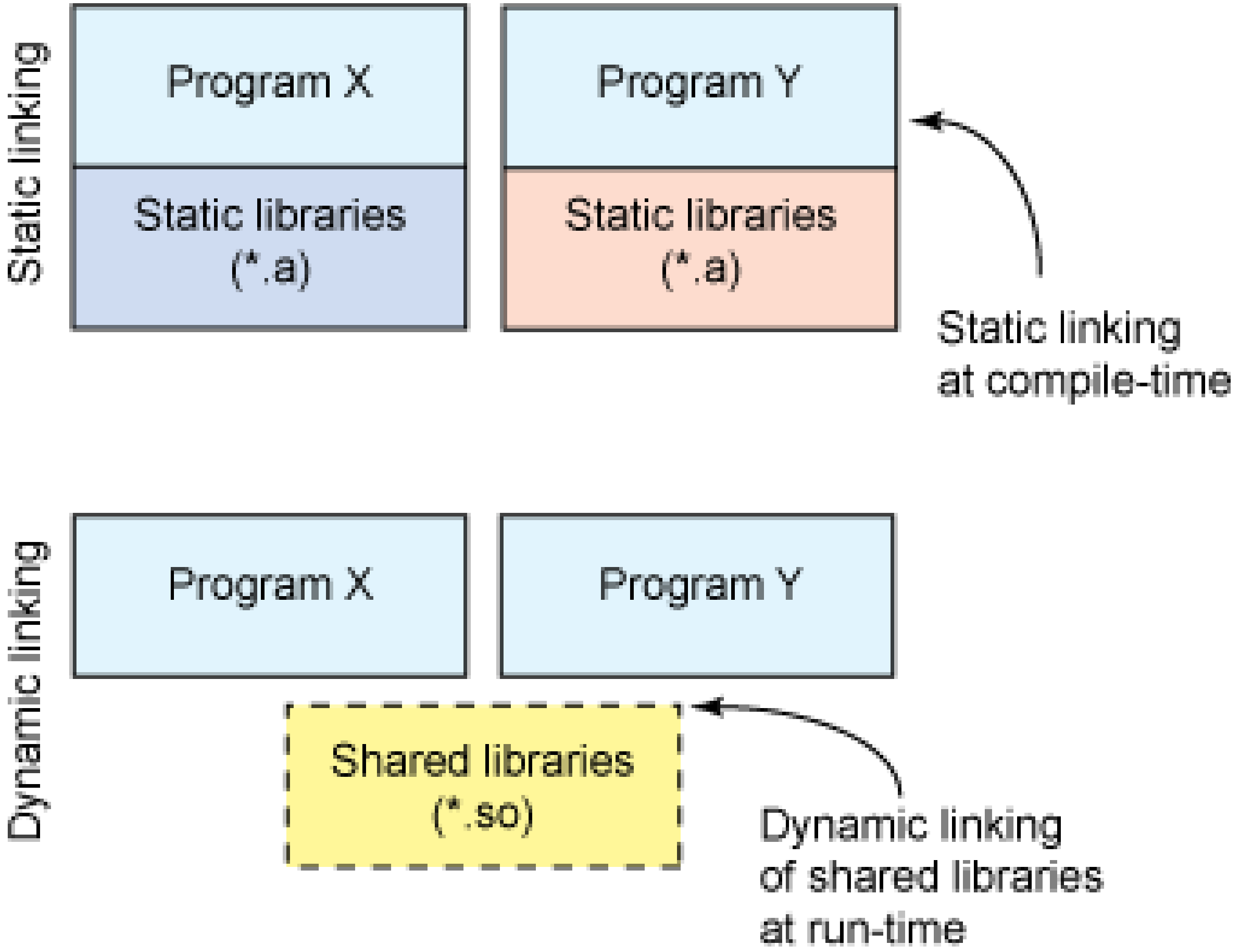
Complete the linking during loading time or running time

Dynamic libraries are typically denoted by the .so file extension

.dll on Windows

Linking and Loading

- Linker collects procedures and links together the object modules into one executable program
- Why isn't everything written as just one **big** program, saving the necessity of linking?
  - Efficiency: if just one function is changed in a 100K line program, why recompile the whole program? Just recompile the one function and relink.
  - Multiple-language programs
  - Other reasons?


Static linking
Program X
Static libraries
(*.a)
Program Y
Static libraries
(*.a)
Static linking
at compile-time
Dynamic linking
Program X
Program Y
Shared libraries
(*.so)
Dynamic linking
of shared libraries
at run-time

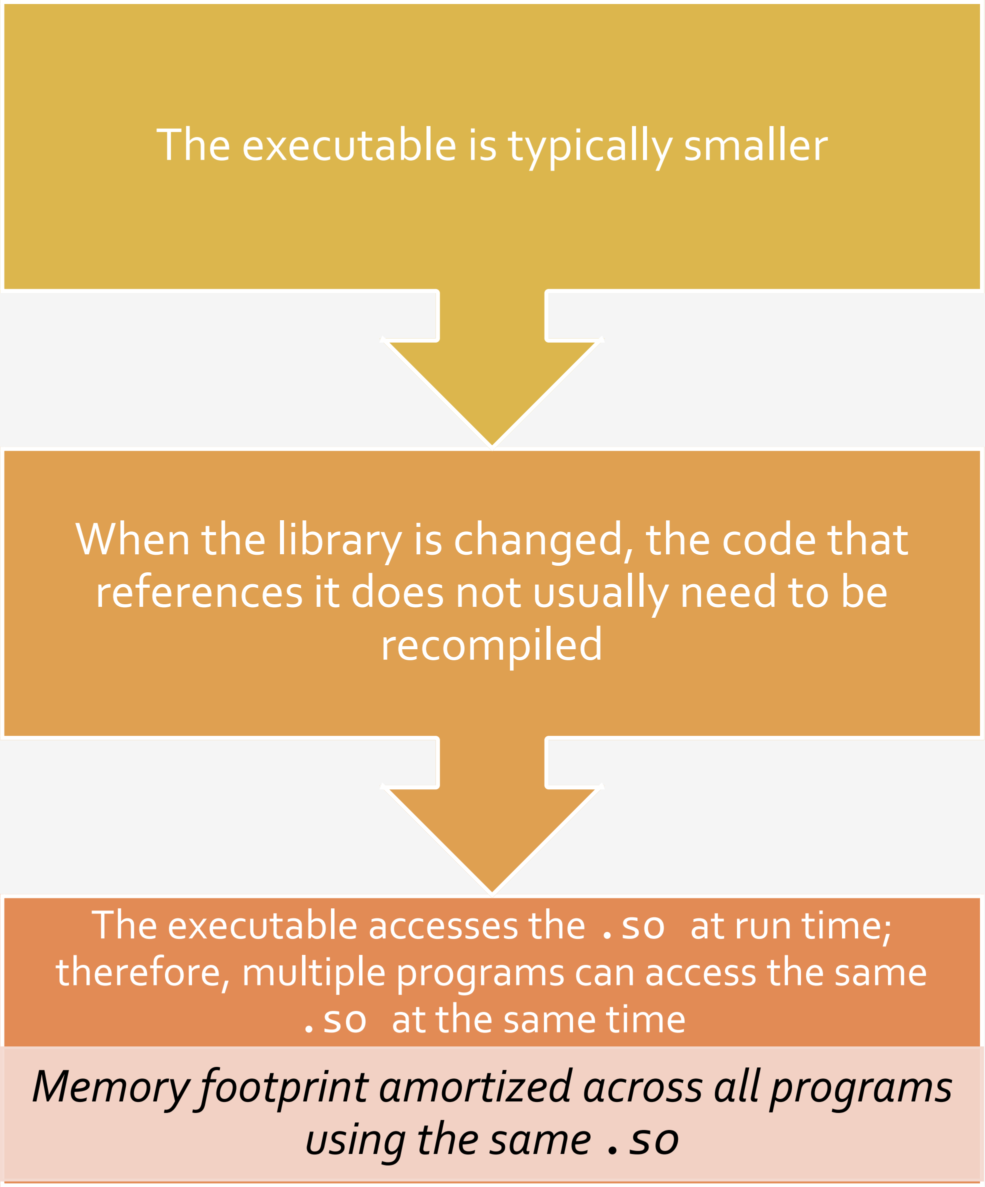
Dynamic linking

- Unix systems: Code is typically compiled as a *dynamic shared object* (DSO)
- Dynamic vs. static linking resulting size

```
$ gcc -static hello.c -o
hello-static
$ gcc hello.c -o hello-
dynamic
$ ls -l hello
     80 hello.c
  13724 hello-dynamic
1688756 hello-static
```

- If you are the sysadmin, which do you prefer?

Advantages of dynamic linking



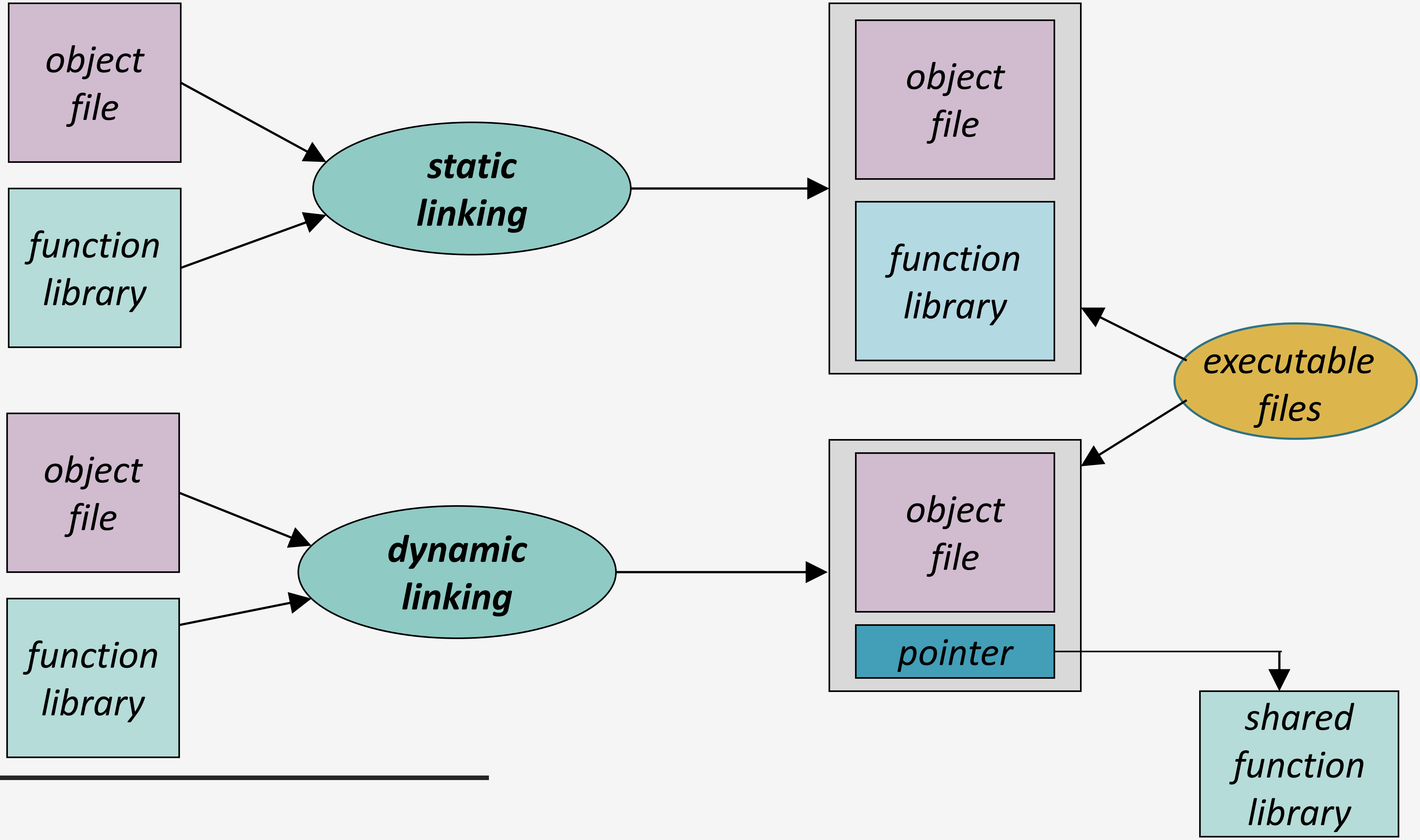
The executable is typically smaller

When the library is changed, the code that references it does not usually need to be recompiled

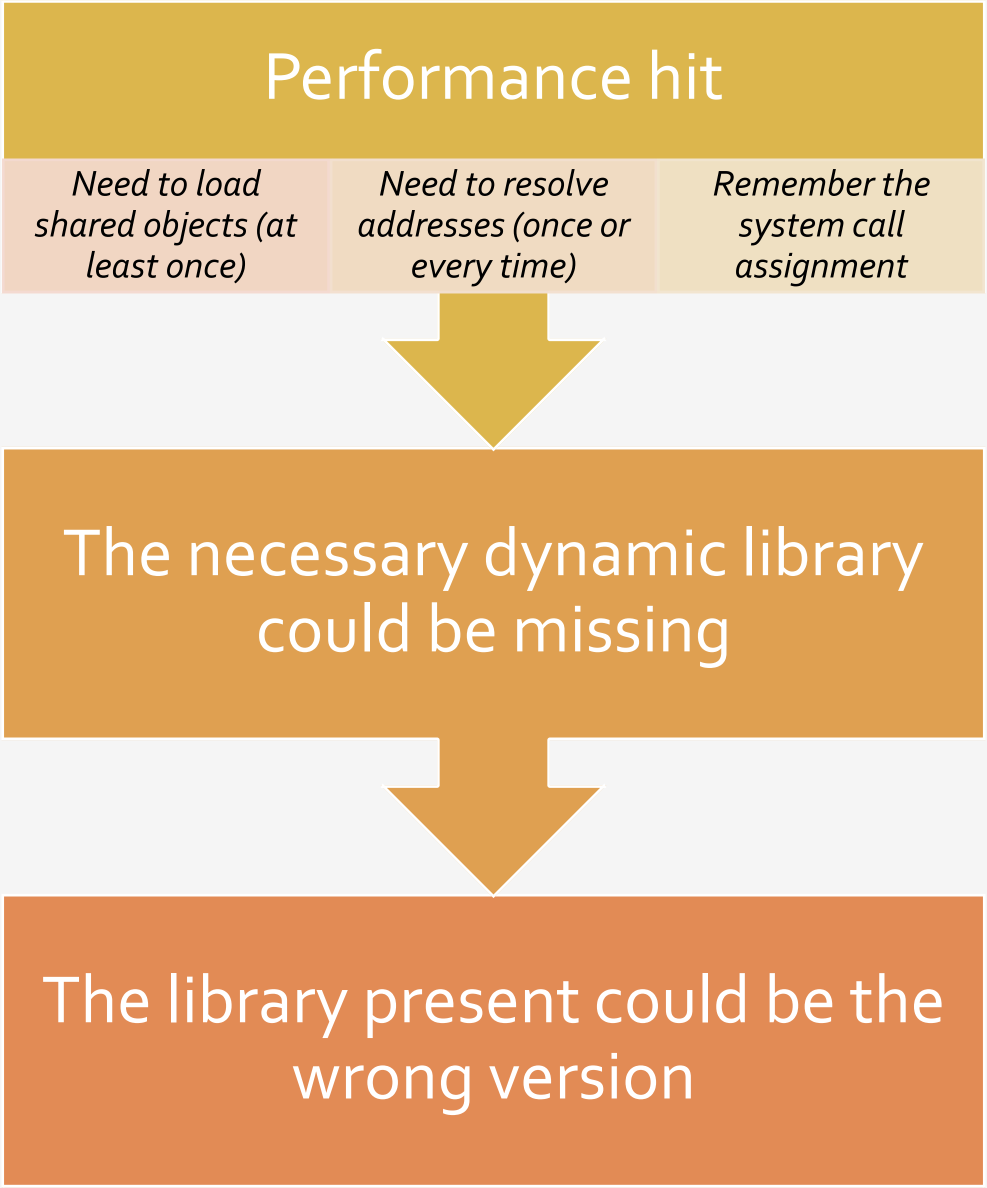
The executable accesses the `.so` at run time; therefore, multiple programs can access the same `.so` at the same time

Memory footprint amortized across all programs using the same `.so`

Smaller is more efficient



Disadvantages of dynamic linking



Performance hit

Need to load shared objects (at least once)

Need to resolve addresses (once or every time)

Remember the system call assignment

The necessary dynamic library could be missing

The library present could be the wrong version

GCC Flags

- `-fPIC`: Compiler directive to output position independent code, a characteristic required by shared libraries.
- `-l`***`library`***: Link with "`lib`***`library`***`.a`"
  - Without `-L` to directly specify the path, `/usr/lib` is used.
- `-L`***`path`***: At **compile** time, find the library from this path.
- `-Wl,rpath=.`: `-Wl` passes options to linker.
  - `-rpath` at **runtime** finds `.so` from this path.
- `-c`: Generate object code from c code but do not link
- `-shared`: Produce a shared object which can then be linked with other objects to form an executable.
- https://gcc.gnu.org/onlinedocs/gcc/Link-Options.html#Link-Options

Creating static and shared libs in GCC

- mymath.h

```
#ifndef _MY_MATH_H

#define _MY_MATH_H

void mul5(int *i);

void add1(int *i);

#endif
```

- mul5.c

```
#include "mymath.h"

void mul5(int *i)

{

  *i *= 5;

}
```

- add1.c

```
#include "mymath.h"

void add1(int *i)

{

  *i += 1;

}
```

Shared

*set the environment variable **LD_LIBRARY_PATH** to include the path that contains libmymath.so*

```
gcc -Wall -fPIC -c mul5.c add1.c

gcc -shared -Wl,-soname,libctest.so.1 -o libctest.so.1.0

mul5.o add1.o

(OR gcc -shared -fpic -o libctest.so mul5.o add1.o)
```

Static

```
gcc –c mul5.c -o mul5.o

gcc –c add1.c -o add1.o

ar -cvq libmymath.a mul5.o add1.o
```

http://www.yolinux.com/TUTORIALS/LibraryArchives-StaticAndDynamic.html

Lab 8

- Write and build simple `cos(sqrt(3.0))` program in C
  - Use `ldd` to investigate which dynamic libraries your `cos` program loads
  - Use `strace` to investigate which system calls your `cos` program makes
- Use “`ls /usr/bin | awk 'NR%101==nnnnnnnnn%101'`” to find ~25 linux commands to use `ldd` on
  - Record output for each one in your log and investigate any errors you might see
  - From all dynamic libraries you find, create a sorted list
    - Remember to omit the duplicates!