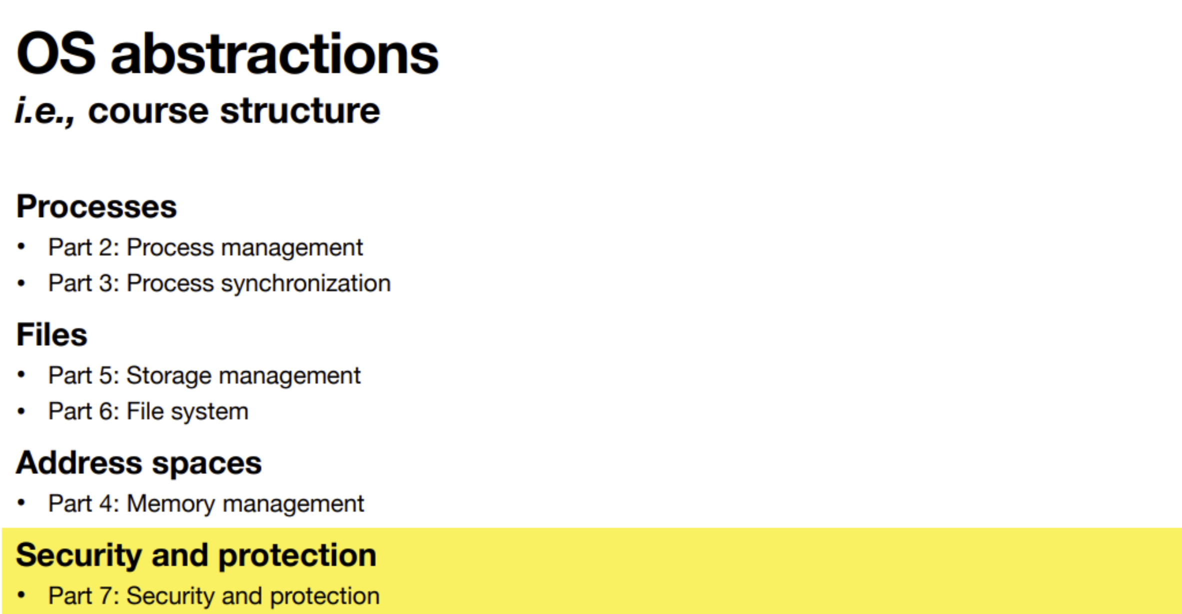
OS Lecture 3

OS Course Structures (Cont.)



Security and Protection

The OS needs to control the access of processes or users to the resources defined by the system.

It must provide means to…

- Specify the controls to be imposed.
- Enforce the controls.

Have you heard of the following attacks?

- Viruses, worms, denial-of-service (DOS) attacks, identity theft, theft of service, …

What will we learn?

- **Protection-related functions and syscalls**
  - How does the OS control access to resources?
  - What do file permissions mean?
- **Security best practices**
  - How to store and verify the user password?
- **Hacking**
  - How to gain the root privilege legally and illegally?
  - How to protect yourself from being hacked?

Process Management

Process ≠ program

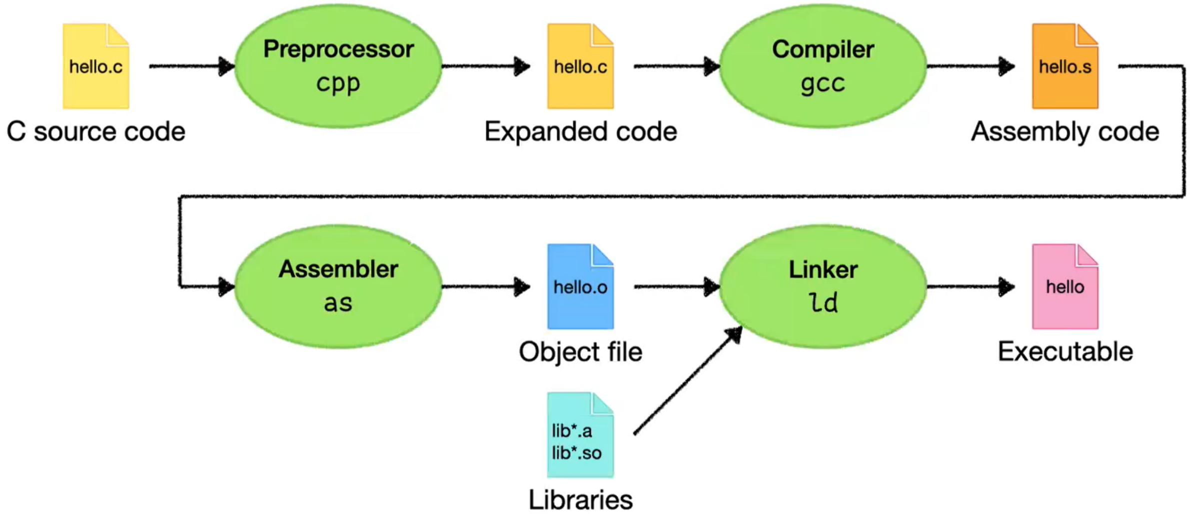
What is a program?

A **program** is just a piece of code.

But… *which* code do you mean?

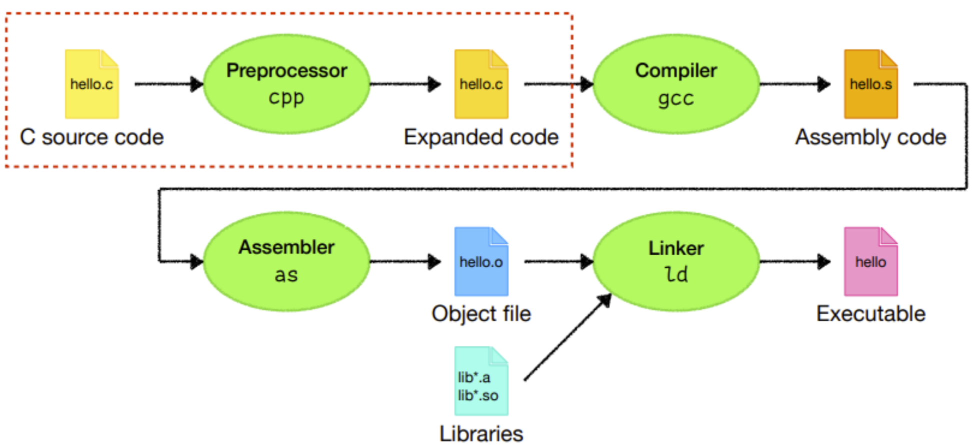
- High-level language (C, C++, Java…)
- Intermediate language (Java bytecode, LLVM IR, .NET CIL…)
- Low-level language (assembly)
- Machine code

Life of a C program

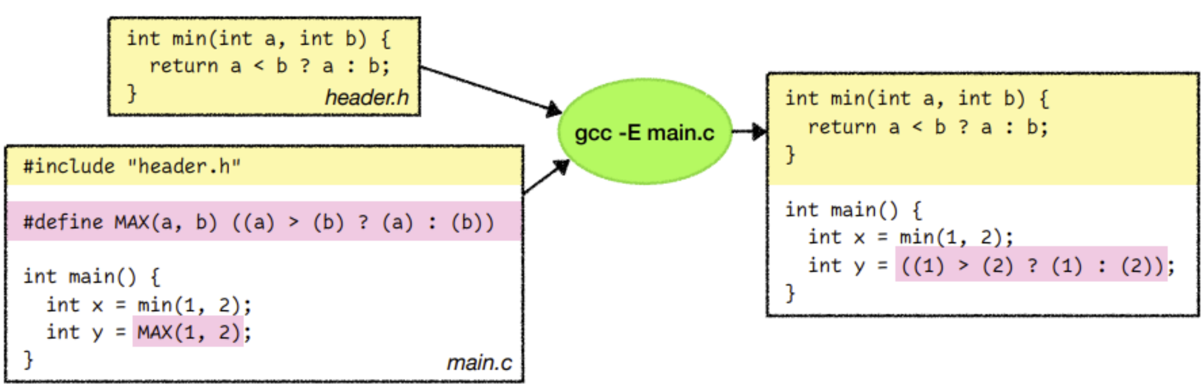


> When you run the gcc, it compiles the code and also invokes the cpp, assembler and linker

- ## Preprocessor



- The **preprocessor** expands directives such as `#include`, `#define`, `#ifdef` ...



- Example:

```
[yt2475@linserv1 proc]$ cat main.c
#include "header.h"

#define MAX(a, b) ((a) > (b) ? (a) : (b))

int main() {
  int x = min(1, 2);
  int y = MAX(1, 2);
}
[yt2475@linserv1 proc]$ cat header.h
int min(int a, int b) {
  return a < b ? a : b;
}
```

Preprocessor:

```
gcc -E main.C
```

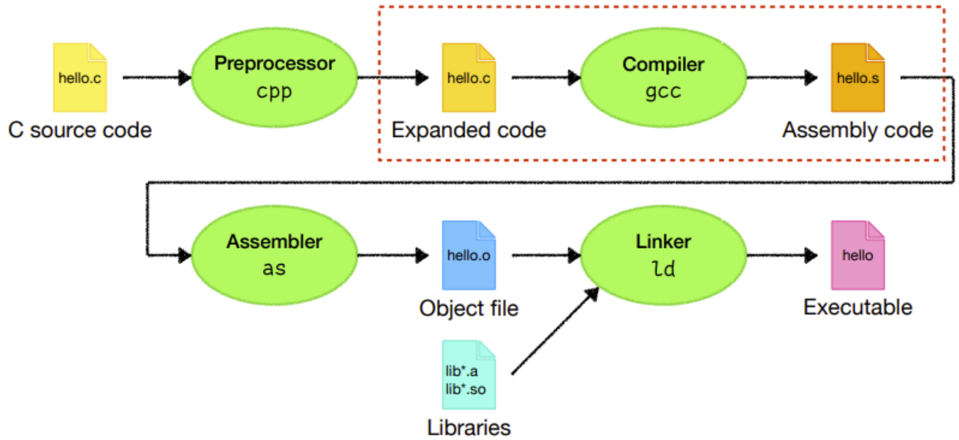
Result:

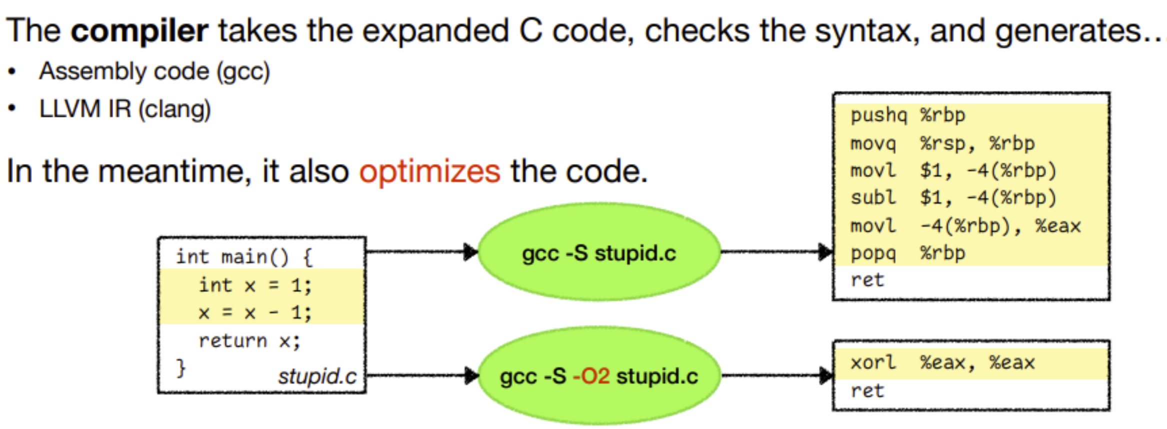
```
[yt2475@linserv1 proc]$ gcc -E main.c
# 0 "main.c"
# 0 "<built-in>"
# 0 "<command-line>"
# 1 "/usr/include/stdc-predef.h" 1 3 4
# 0 "<command-line>" 2
# 1 "main.c"
# 1 "header.h" 1
int min(int a, int b) {
  return a < b ? a : b;
}
# 2 "main.c" 2




int main() {
  int x = min(1, 2);
  int y = ((1) > (2) ? (1) : (2));
}
```

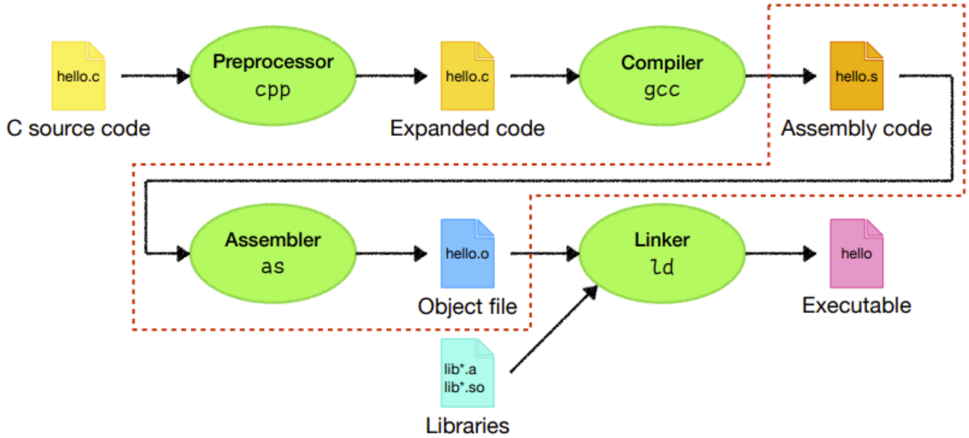
- **Compiler**





> -O2 is the code for optimization.
>
> There're different levels of optimization
>
> Why not higher level? O3 might cause bugs.

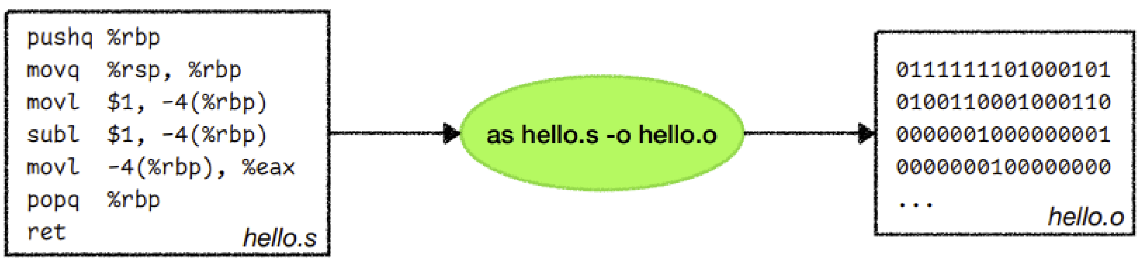
- **Assembler**



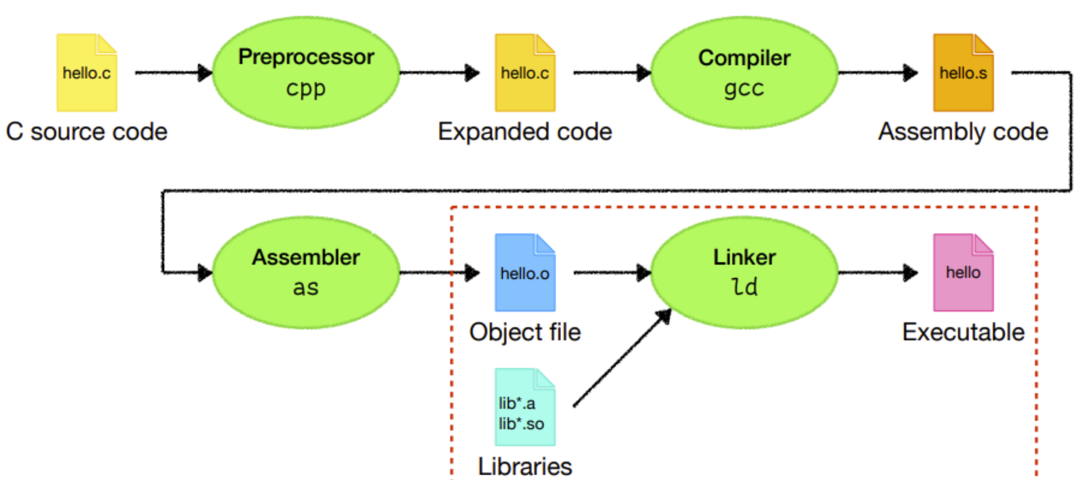
The **assembler** converts the generated assembly code to an object file.

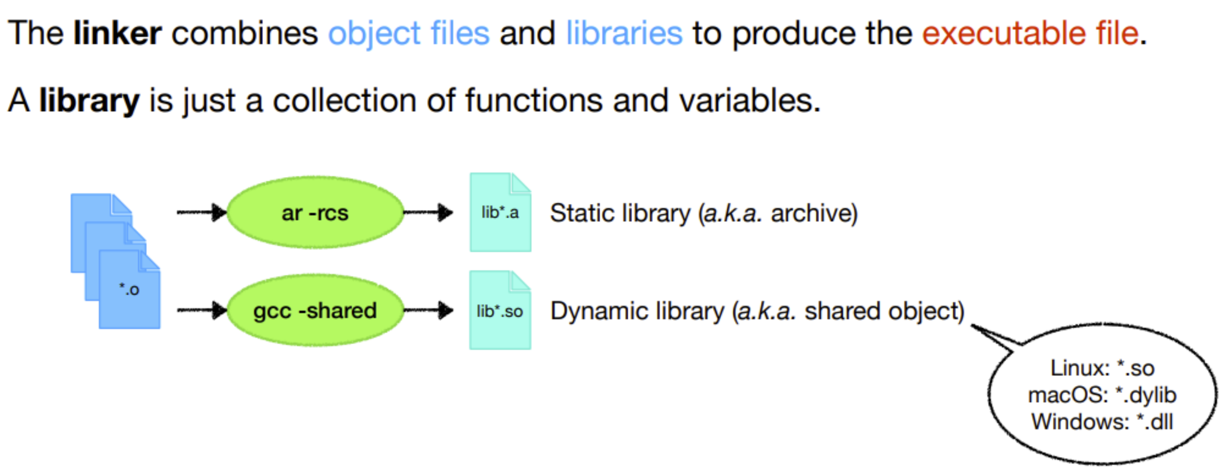
The object file contains machine code, but isn't yet executable.

> It may contains functions from other libraries, so you must link them together before execution.

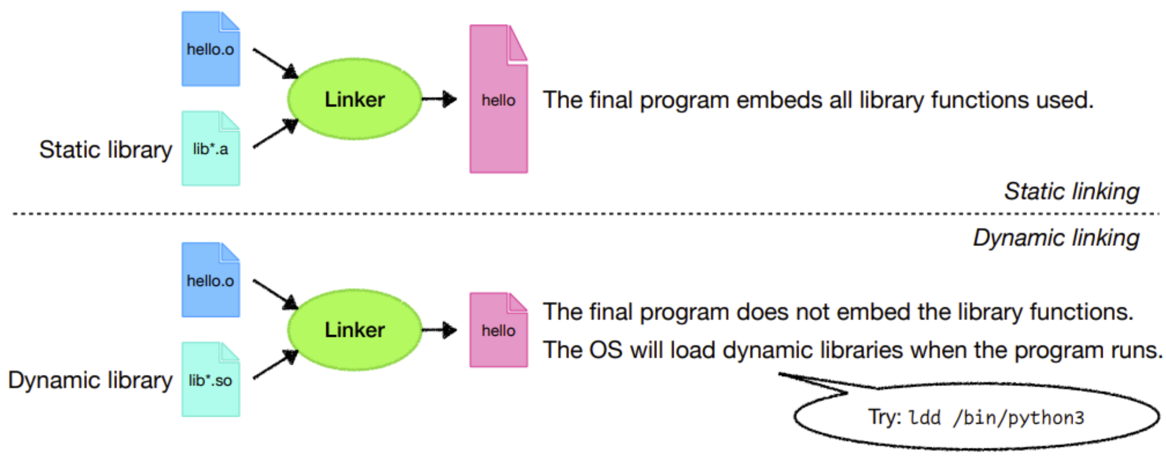


- **Linker**





- What's the difference between Static Library and Dynamic Library?
- **Static & Dynamic linking**



  - The dynamic linking is the default one, because it saves space, reuses codes, and is easy to update if there's any bugs in the library
  - The static linked file is useful for embedded systems
  - The Dynamic Library and the Static Library has different formats (*.a* and *.so*), so you can't replace one with another

Processes

The **process** is the most central concept in an operating system.

- It’s an abstraction of a running program.
- It attaches to all the memory that is allocated for the process.
- It associates with all the files opened by the process.
- It contains accounting information such as its owner, running time, memory usage…

Let’s start with some system calls.

• Process identification: `getpid()` and `getppid()`

The OS gives each process a unique identification number, the Process ID (PID).

- `getpid()` returns the PID of the calling process.
- `getppid()` returns the PID of the parent of the calling process.

```c
int main() {
  printf("My PID is %d\n", getpid());
  printf("My parent's PID is %d\n", getppid());
}
```

pid.c

```
$ ./pid
My PID is 2250
My parent's PID is 202
$ ./pid
My PID is 2436
My parent's PID is 202
$ ./pid
My PID is 2437
My parent's PID is 202
$ _
```

- Example:

```
int main() {
  printf("My PID is %d\n", getpid());
  printf("My parent's PID is %d\n", getppid());
}
[yt2475@linserv1 proc]$ gcc -o pid pid.c
[yt2475@linserv1 proc]$ ./pid
My PID is 59058
My parent's PID is 55487
[yt2475@linserv1 proc]$ ./pid
My PID is 59080
My parent's PID is 55487
[yt2475@linserv1 proc]$ ./pid
My PID is 59082
My parent's PID is 55487
[yt2475@linserv1 proc]$ ./pid
My PID is 59085
My parent's PID is 55487
[yt2475@linserv1 proc]$ ./pid
My PID is 59087
My parent's PID is 55487
[yt2475@linserv1 proc]$
```

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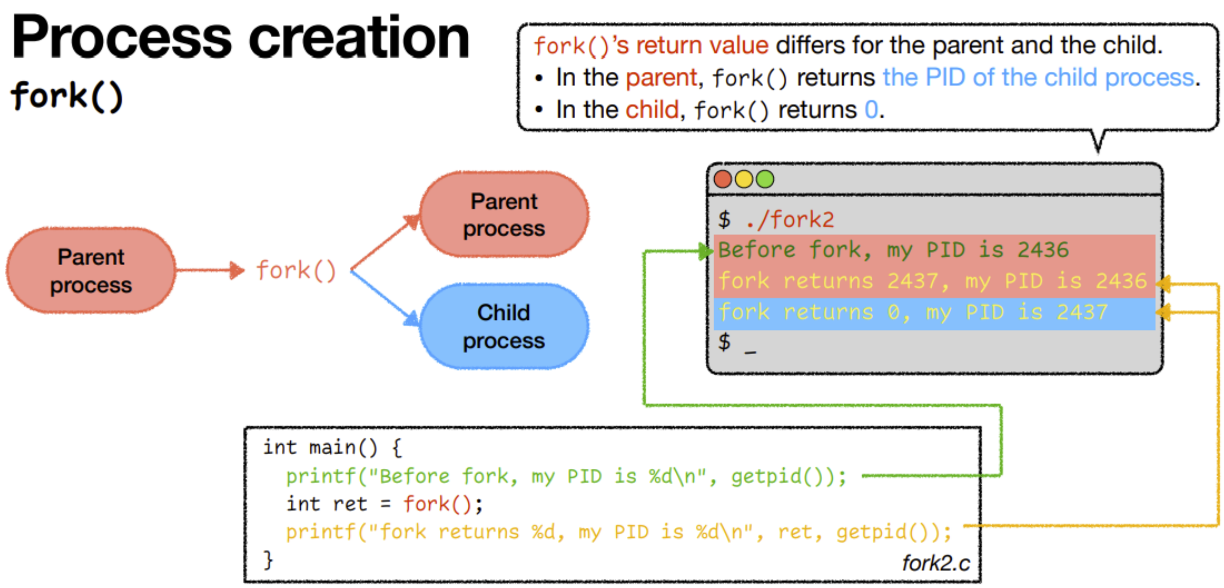
> Note that the PID each time is different, but the PPID remains the same.
>
> This is because we launch a new process every time we run the program.
>
> But the parent process is always the shell, and we didn't start a new session for the shell.

- Process creation: `fork()`

`fork()` ’s return value differs for the parent and the child.

- In the parent, `fork()` returns the PID of the child process.
- In the child, `fork()` returns 0.



How do we know the process is the parent or child?

- return value of `fork()` is different
- Example:

```
[yt2475@linserv1 proc]$ cat fork2.c
#include <stdio.h>
#include <unistd.h>

int main() {
  printf("Before fork, my PID is %d\n", getpid());
  int ret = fork();
  printf("fork returns %d, my PID is %d\n", ret, getpid());
}
[yt2475@linserv1 proc]$ gcc -o fork2 fork2.c
[yt2475@linserv1 proc]$ ./fork2
Before fork, my PID is 59685
fork returns 59686, my PID is 59685
fork returns 0, my PID is 59686
```

- `fork()` Behaves like "cloning."

The child inherits (but is independent from) the parent's…

- Program code
  - Both the parent and child share the same code.
- Program counter
  - Therefore, both the parent and the child execute from the same location after `fork()`.
- Memory
  - This includes global variables, local variables, and dynamically allocated memory.
- Opened files
  - If the parent has opened a file, then the child also has the same file opened.

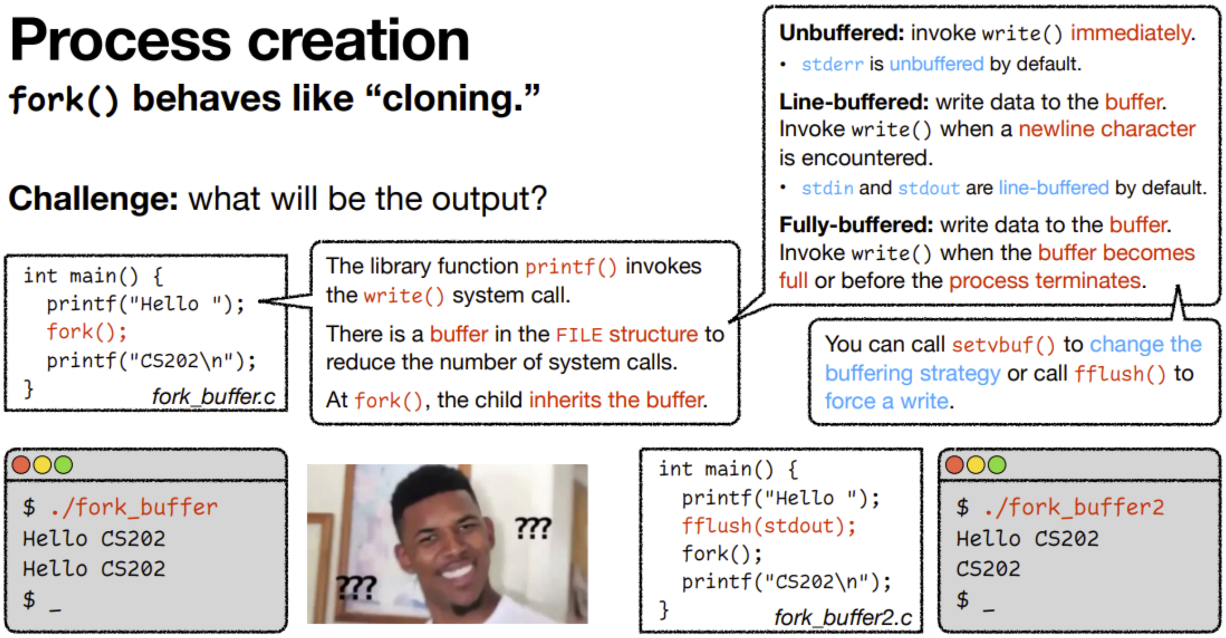
However, the child differs from the parent in a few things…

- Return value of fork()
  - The parent returns the PID of the child, or -1 if `fork()` fails. The child returns 0.
- Process ID
  - The child gets a new PID, which is not necessarily the parent's PID + 1.
- Parent
  - The child process's parent is the parent process, not the grandparent.
- Running time
  - The child's running time is reset to 0.
- File locks
  - The child does not inherit file locks from its parent.

Challenge: what will be the output?

```c
int main() {
  printf("Hello ");
  fork();
  printf("CS202\n");
}
```

fork_buffer.c



> At printf("Hello"), the Hello is not immediately printed. It's saved to a buffer, which was cloned by the forked process

- Use `setvbuf()` or `fflush()` to set the buffer
- `fflush()` force the output to standard output

```
[yt2475@linserv1 proc]$ cat fork_buffer2.c
#include <stdio.h>
#include <unistd.h>

int main() {
  printf("Hello ");
  fflush(stdout);
  fork();
  printf("CS202\n");
}
[yt2475@linserv1 proc]$ gcc -o fork_buffer2 fork_buffer2.c
[yt2475@linserv1 proc]$ ./fork_buffer2
Hello CS202
CS202
```