CS 134
Operating Systems

January 23, 2019

Overview
Brief Introduction to JOS and xv6

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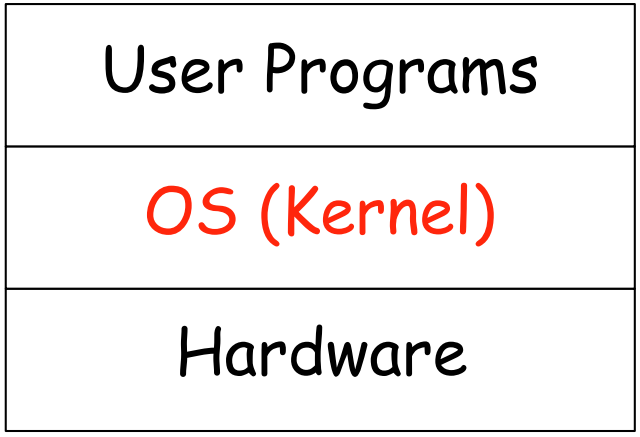
Introduction

- What will you be learning?
  - What an operating system is
    - Various capabilities provided by an OS
  - Distinction between an OS/Kernel and the rest of the system
  - How an operating system is written
  - The spectrum of services provided by an OS
    - Lightweight/small/fast
    - More capable/larger/slower
- Why?
  - All programmers interact with an OS
    - Care about what's happening internally
    - Remove black-box
    - Need to write high-performance programs
    - Need to diagnose bugs or security problems
  - Some programmers must write an OS (or modify)
- What is the structure?
  - Combination of theory and practice

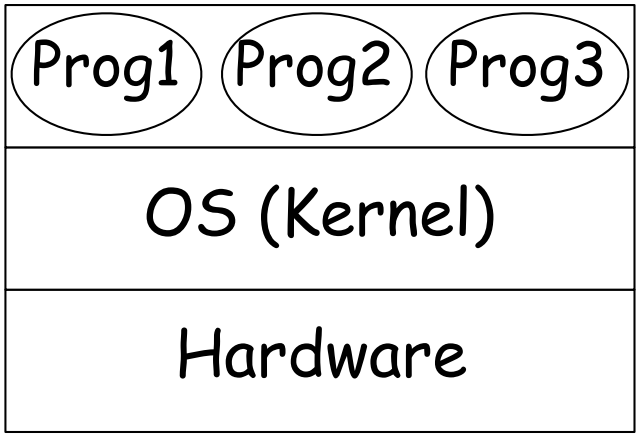
Operating System

- A level of software between programs and the raw hardware



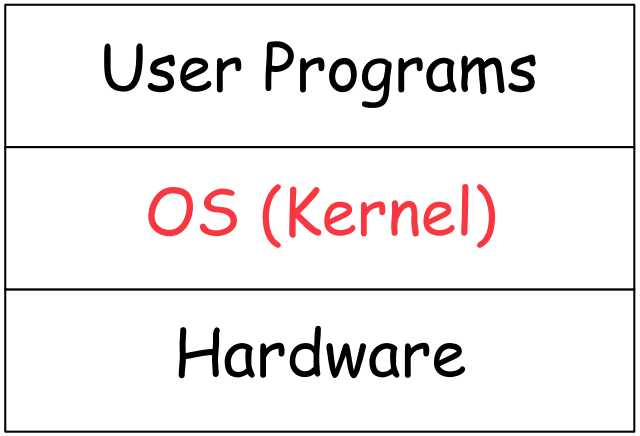
What an Operating System Does (view number 1)

- Manages resources needed by various programs
  - _____
  - _____
  - _____
  - _____
- Time multiplexing
  - _____
  - _____
  - _____
- Space multiplexing
  - _____
  - _____



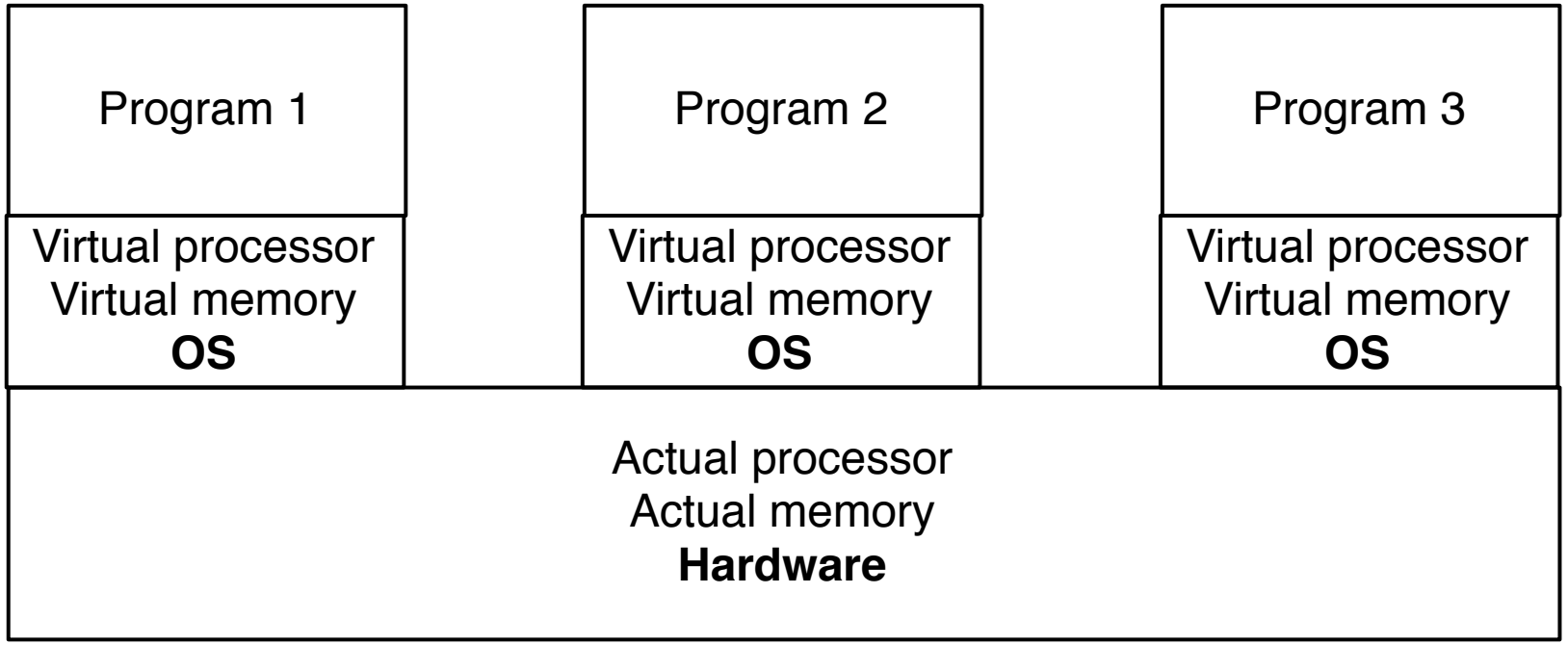
What an Operating System Does (view number 2)

- Operating system as extended machine
  - The operating system provides an interface higher than that of the raw machine
    - Level 1: write to the floppy disk controller directly
      - Start motor spinning
      - Move the disk arm
      - …
      - Stop motor spinning
    - Level 2: write to floppy disk sector-by-sector
      - Impose your own structure on the floppy.
    - Level 3: Open/close files.
      - use file system



  - Provide abstractions
    - Same low-level functions to write to IDE drive as SATA drive as USB drive
    - Same high-level functions to write to a file on disk as to a network connection

What an Operating System Does (view number 2)



The Kernel

- Uses supervisor mode of the CPU
  - Certain operations only available if processor is running in supervisor mode
    - Enable/Disable ***interrupts***
    - Change memory map
    - Change supervisor mode
- Normal applications run in user mode
  - Hardware disallows some operations
  - How to call to kernel?
  - Make System call
    - Put system call number and parameters in special location (registers?)
    - Issue special TRAP instruction
    - Causes execution to switch to kernel's trap handler (now in supervisor mode)
    - Makes call to appropriate system call handler
    - Returns to user mode with special instruction

The Kernel

- Handling input
  - I/O device generates an *interrupt*
  - Causes execution to switch to kernel's interrupt handler (now in supervisor mode)
  - Deals with that particular interrupt
  - Returns to where it was interrupted from with special instruction

The Kernel

- Services
  - Processes
  - Memory allocation
  - File system
    - Directories/filenames
    - File contents
    - Attributes about files
  - Security
  - Networking
  - …

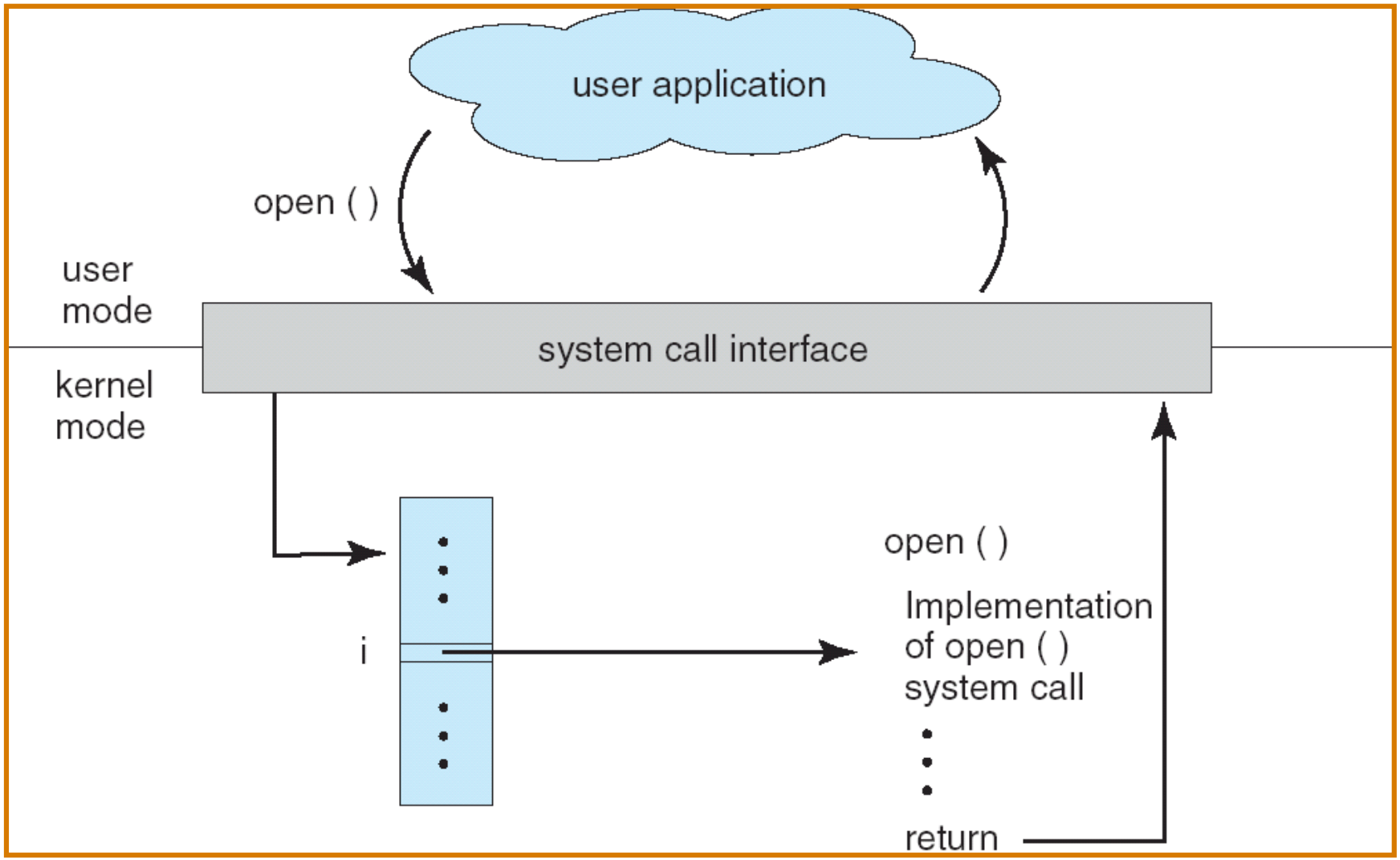
Operating System Abstractions

- System calls
  - A function that exists in the kernel, called by the application
  - For example:

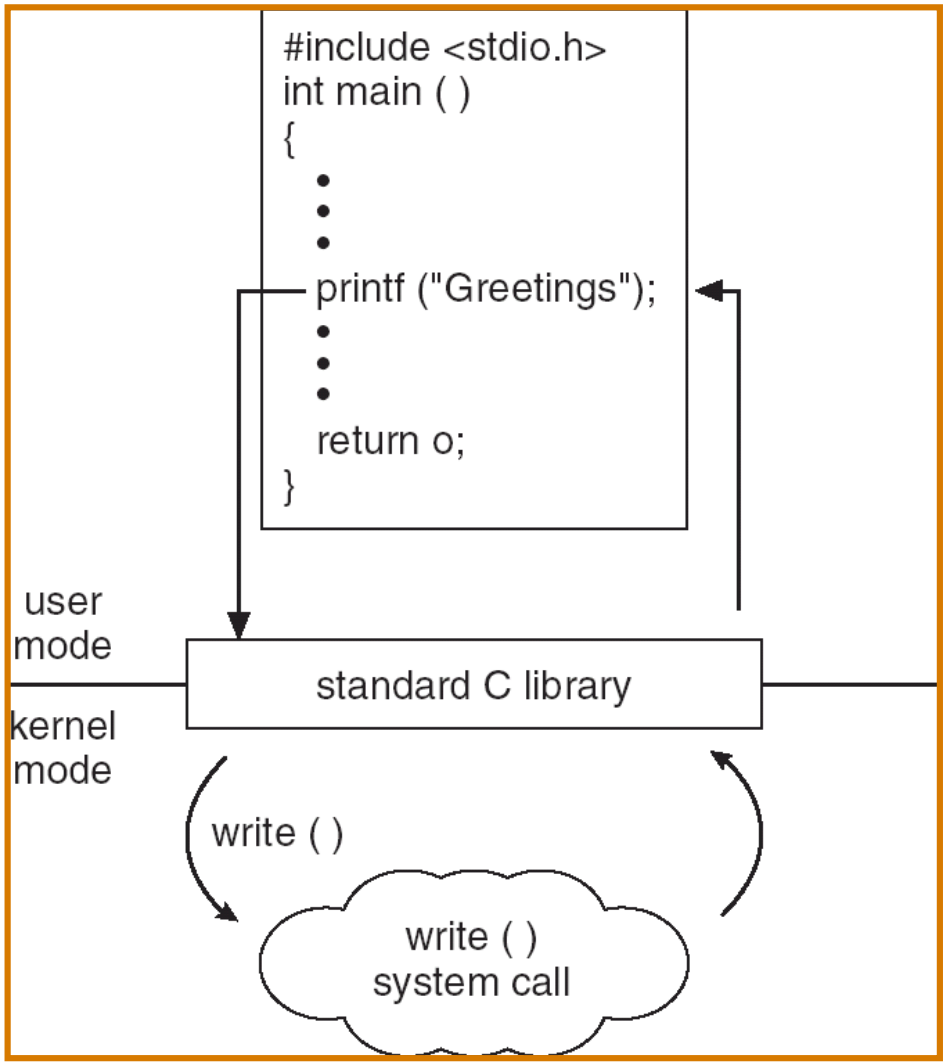
```
int fd = open('myfile.txt', 1);
write(fd, "hello, world!\n", 14);

int pid = fork();
```

API – System Call – OS Relationship



Standard C Library Example



Why is Operating System design hard?

- Difficult environment
- Want efficiency, but also portability
- Want powerful, but also simple
- Interactions between different calls
  - Example:

Lecture format

- Operating System ideas
- Detailed inspection of xv6, a traditional OS
- xv6 programming homework will motivate lectures

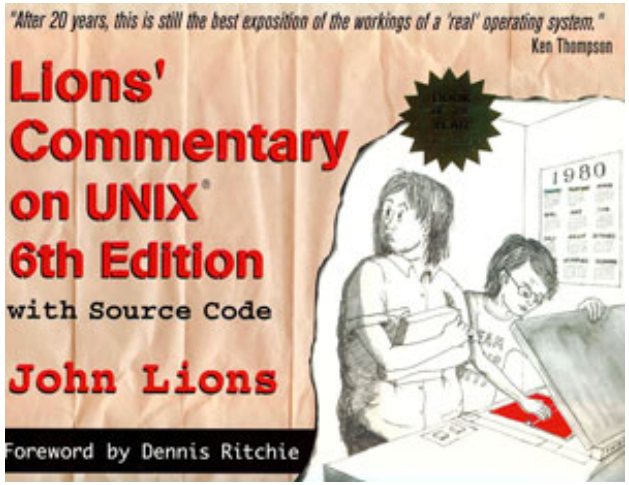
Labs

Lab 1 is out now!

- You'll be building up JOS, a small OS for x86 (exokernel style)
- Kernel interface: expose, but protect
- Unprivileged user-level library:
  - fork
  - exec
  - pipe
  - …
- Dev environment
  - GCC
  - qemu

Homeworks

- Almost all using xv6
- Dev environment
  - GCC
  - qemu
- Lions' commentary
  - Unix v6 allowed classroom use of source code
  - Unix v7+ did not
  - Lions book provided commentary + source code
  - Very widely copied (samizdat style)
- xv6: v6 for x86



xv6 vs. JOS

- Two different small x86 OSes
  - xv6: traditional, similar in spirit to Unix v6
  - JOS: exokernel style (much work done in user mode)
  - Neither one as complicated as modern Linux

```
From: torv...@klaava.Helsinki.FI (Linus Benedict Torvalds)
Date: 25 Aug 91 20:57:08 GMT
Organization: University of Helsinki

Hello everybody out there using minix -

I'm doing a (free) operating system (just a hobby, won't be big and
professional like gnu) for 386(486) AT clones.  This has been brewing
since april, and is starting to get ready.  I'd like any feedback on
things people like/dislike in minix, as my OS resembles it somewhat
(same physical layout of the file-system (due to practical reasons)
among other things).

I've currently ported bash(1.08) and gcc(1.40), and things seem to work.
This implies that I'll get something practical within a few months, and
I'd like to know what features most people would want.  Any suggestions
are welcome, but I won't promise I'll implement them :-)

                    Linus (torv...@kruuna.helsinki.fi)

PS.  Yes - it's free of any minix code, and it has a multi-threaded fs.
It is NOT protable (uses 386 task switching etc), and it probably never
will support anything other than AT-harddisks, as that's all I have :-(.
```

Labs

- Six programming labs
  - First five are solo
  - Last one can be done solo or in groups of up to 3
  - Modifying an existing operating system: Jos
    - Jos is written in C. You'll modify/extend the OS by writing Java code
    - Jos runs on x86. Rather than running on bare metal, we'll run on a Virtual Machine: QEMU

Resources

- Webpage (including announcements, schedules, etc.)
  - http://cs.hmc.edu/~rhodes/cs134
- Discussion board
  - https://piazza.com/hmc/spring2019/cs134

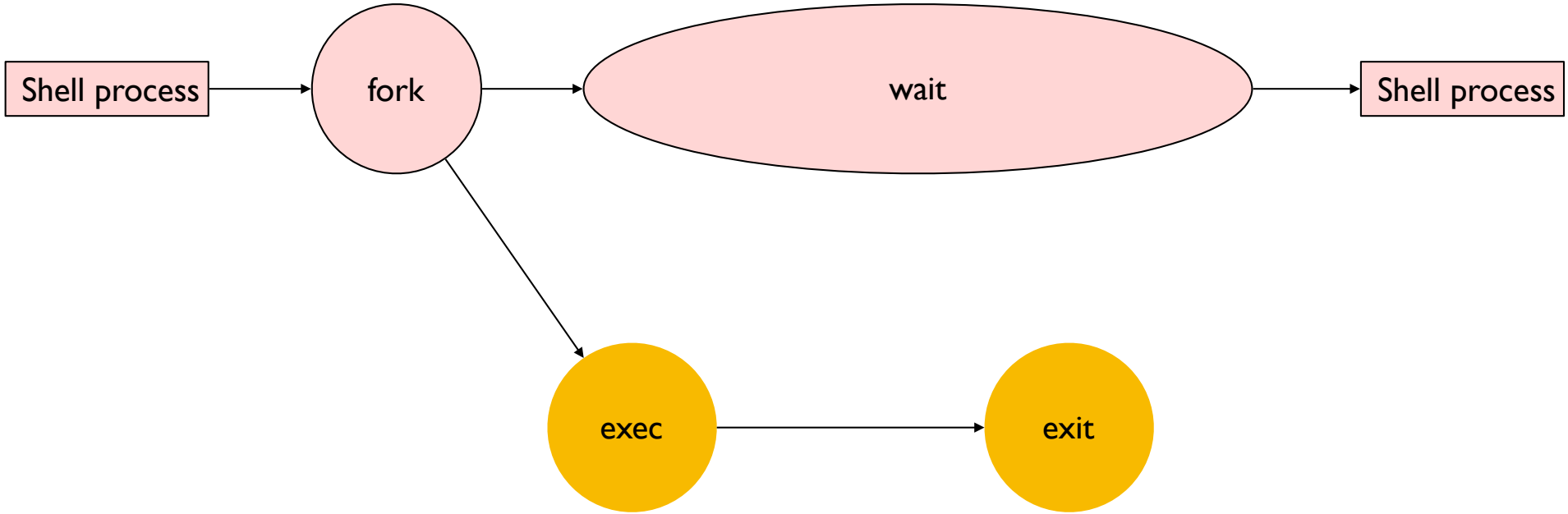
Our focus

- System calls
- Unix-like systems:
  - Linux/Posix/Mac OS

Shell

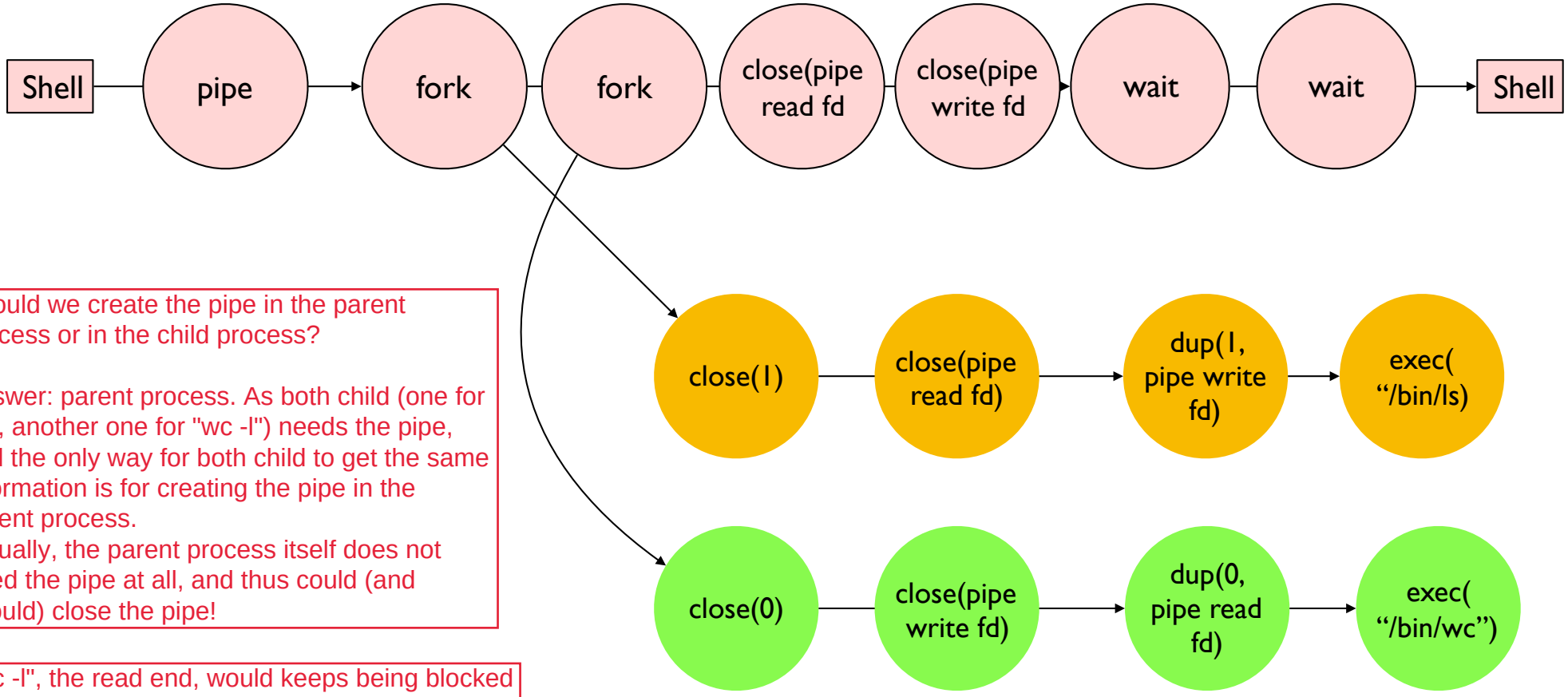
- User-level program that is the command-line interface
- Supports:
  - redirection
    - `ls > output`
    - `mail "neil@pobox.com" < my message`
    - `ls | wc -l`
- How does shell get control again after command executes?
  - Uses `fork` to run the command in a child process
    - Copies user memory
    - Copies kernel data structures (e.g., open file descriptors)
    - Child is now a clone of parent (with different process ID)
    - Both are now running the same program!
      - How make them act different?

Shell: executing a command



Shell: implementing Pipeline

`ls | wc -l`



Should we create the pipe in the parent process or in the child process?

Answer: parent process. As both child (one for "ls", another one for "wc -l") needs the pipe, and the only way for both child to get the same information is for creating the pipe in the parent process.
Actually, the parent process itself does not need the pipe at all, and thus could (and should) close the pipe!

"wc -l", the read end, would keeps being blocked for new input until it reads the EOF.
The read end would see the EOF only if all write end has been closed.