Processes

CSE 351 Winter 2024

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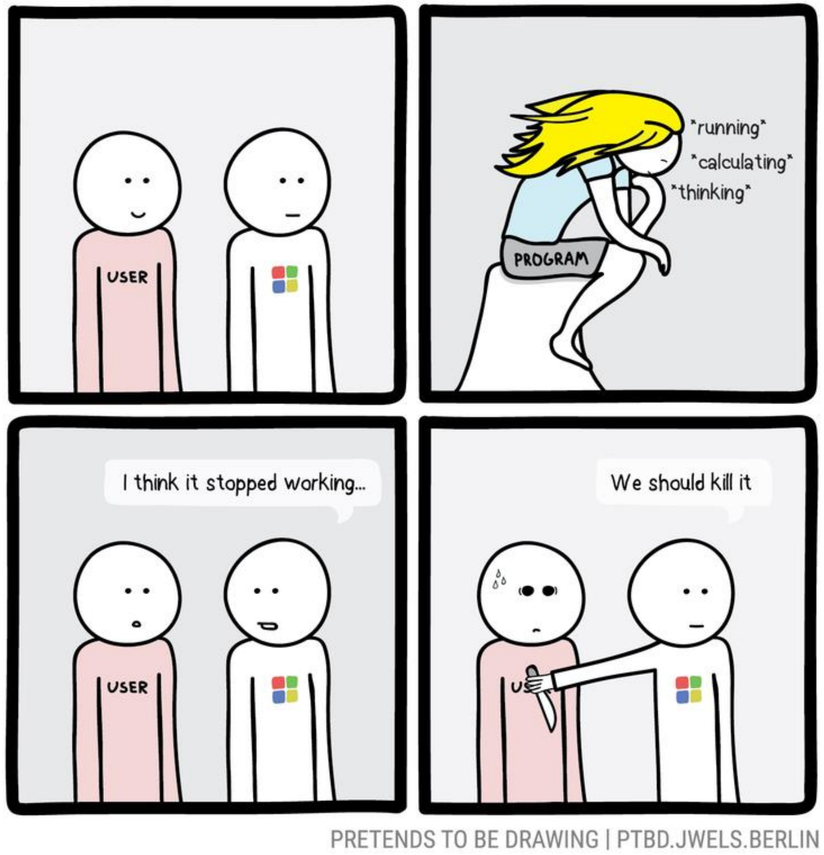

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Relevant Course Information

- HW20 due tonight, HW21 due Friday, HW22 due Monday

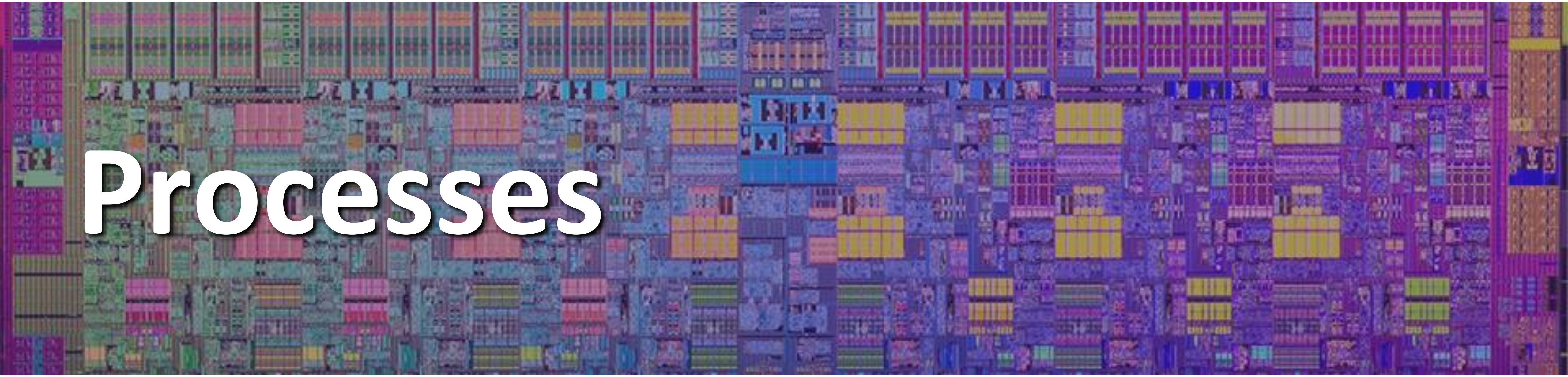
- Lab 4 due Friday
- Lab 5 due next Friday, 3/8
  - Section this week is to get your started with Lab 5
  - Can use one late day; must be submitted by Sunday, 3/10

- Final March 11-13, regrade requests only Monday, March 18

Winter 2024 Crunch

- This quarter is unusually short
  - Winter is always the shortest of the year for MWF classes due to Monday holidays
  - This year, we also lost the first Monday due to New Year's
- 29 → 26 lectures compared against 23au
  - Condensed "x86-64 Programming" from 4 lessons to 3
  - Cut "Exceptional Control Flow" (related to Processes)
  - Cutting "C and Java"
- Assignments compressed, too
  - Cut a number of homework questions throughout the quarter
  - Less time than usual to work on Lab 4 and 5
  - End topics (Processes, VM) will be stressed less than usual on Final

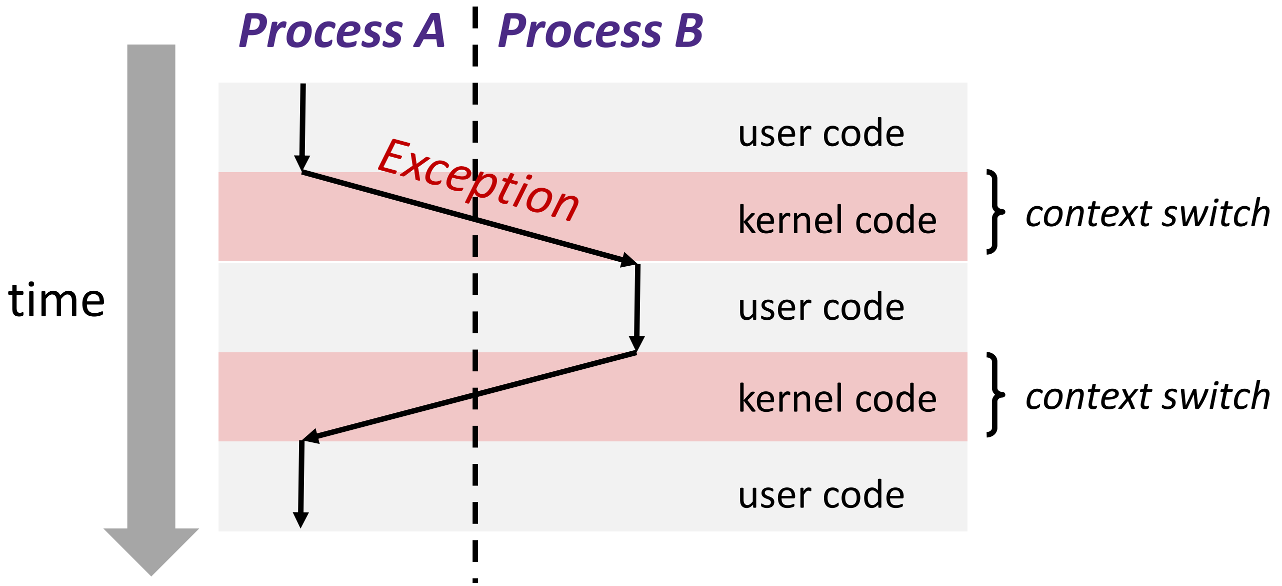
Processes

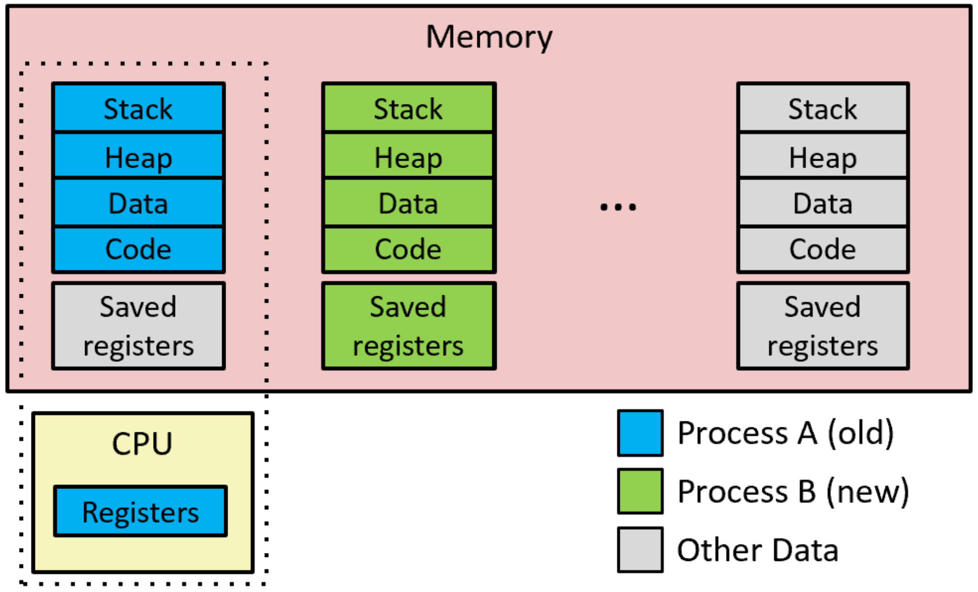


Lesson Summary (1/4)

- A ***process*** is an instance of an running program and provides two key abstractions: logical control flow and private address space

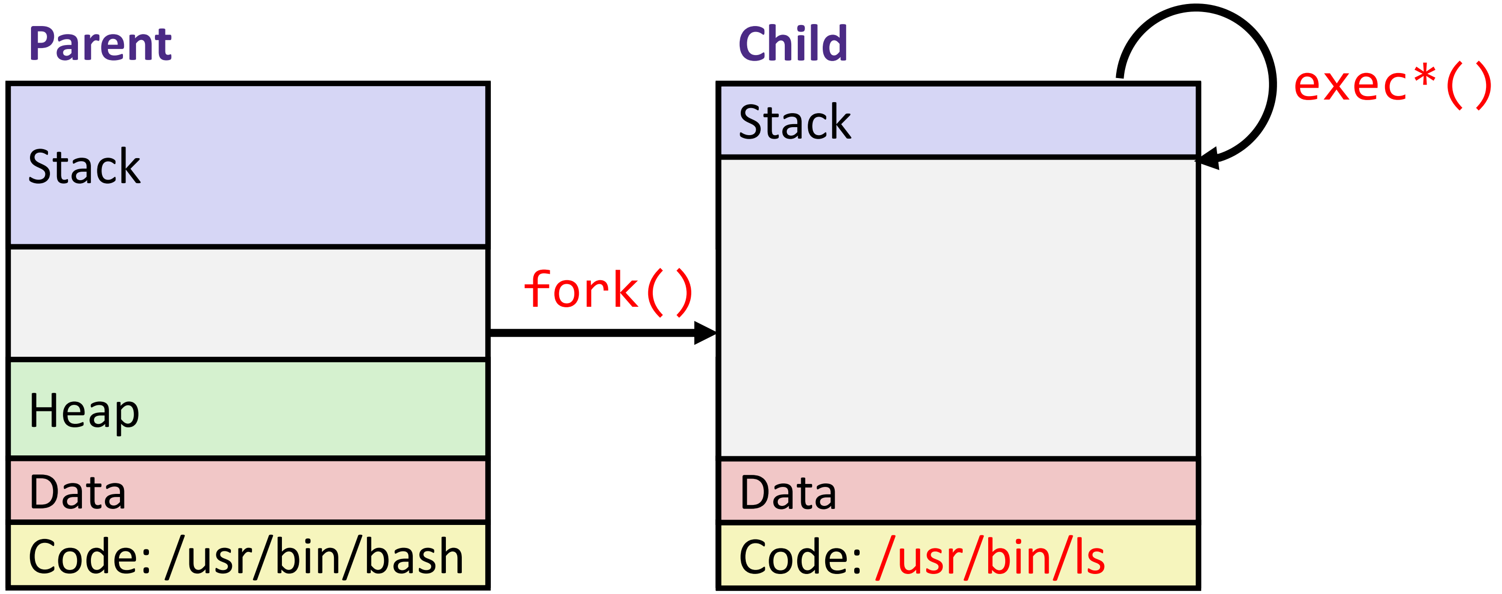
- Multiple running processes can be run *concurrently* via ***context switching***
  - Parallelism only possible with multiple CPUs/cores





Lesson Summary (2/4)

- The ***fork-exec model***
  - Every process is assigned a unique ***process ID*** (pid)
  - Every process has a parent process except for `init/system` (pid 1)
  - `fork()` returns 0 to child, child's PID to parent
  - `exec()` replaces the current process' code and address space with the code for a different program



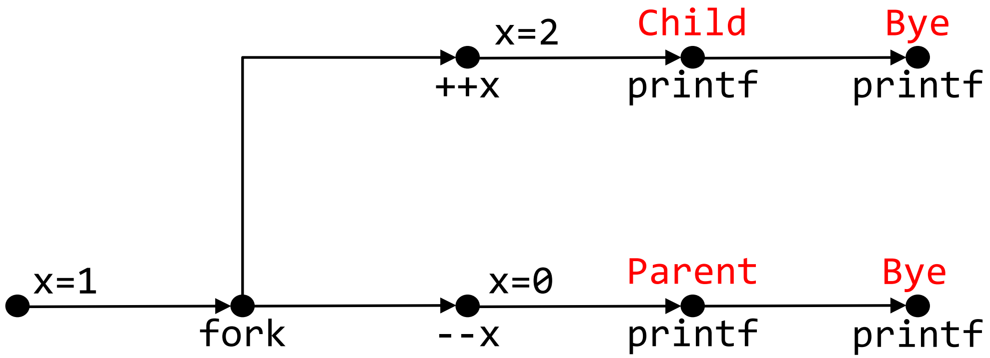
Lesson Summary (3/4)

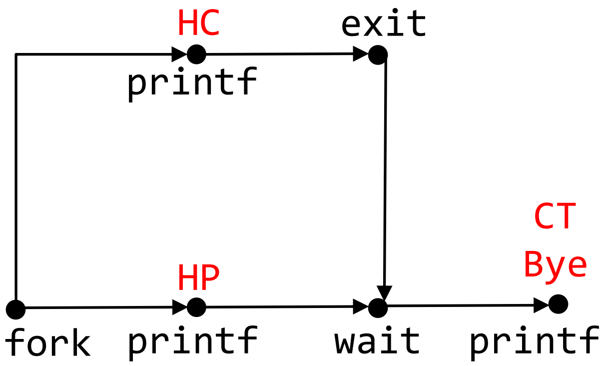
- Terminating a process
  - Return from `main()` or explicit call to `exit(status)`
  - Passes a ***status code*** (`main`'s return value or `exit`'s argument) to parent process
    - 0 for normal exit, nonzero for abnormal exit

- Processes and resources
  - A terminated (***zombie***) process still consumes system resources until ***reaped***
  - Child is reaped when parent process terminates or explicitly calls `wait`/`waitpid`
  - Orphaned children reaped by `init`/`systemd`

Lesson Summary (4/4)

- Concurrency and ***process diagrams***
  - Concurrently executing processes are scheduled non-deterministically by the operating system
  - A process graph is a useful tool for capturing the partial ordering of statements in a concurrent program
    - Vertices are program statements, directed edges capture sequencing *within a process*
    - Flexible visualization tool:

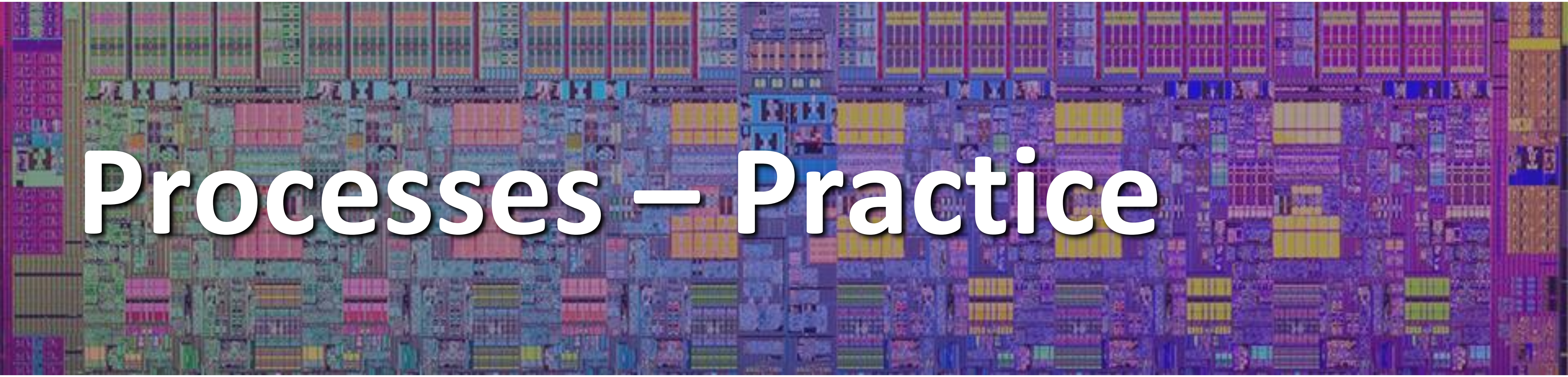




Lesson Q&A

- Learning Objectives:
  - Define the process abstraction and the role of context switching in enabling concurrency.
  - Design process graphs to determine potential orderings of concurrent execution.

- What lingering questions do you have from the lesson?
  - Chat with your neighbors about the lesson for a few minutes to come up with questions



Processes – Practice

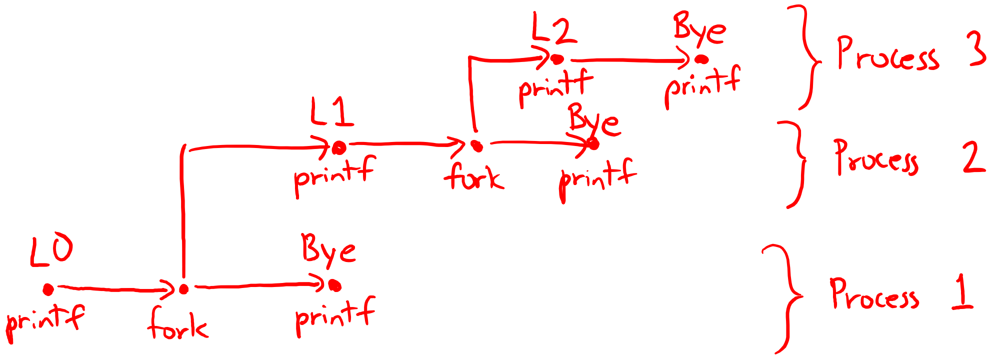
Polling Questions (1/2)

- Are the following sequences of outputs possible?

```c
void nestedfork() {
    printf("L0\n");
    if (fork() == 0) {
        printf("L1\n");
        if (fork() == 0) {
            printf("L2\n");
        }
    }
    printf("Bye\n");
}
```

Seq 1:	Seq 2:	
L0	L0	← Process 1
L1	Bye	← Process 1
Bye	L1	← Process 2
Bye	L2	← Process 3
Bye	Bye	← Process 2/3
L2 !	Bye	← Process 3/2

	Seq 1	Seq 2
A.	No	No
$\boxed{\text{B.}}$	$\boxed{\text{No}}$	$\boxed{\text{Yes}}$
C.	Yes	No
D.	Yes	Yes
E.	We're lost...	



Polling Questions (2/2)

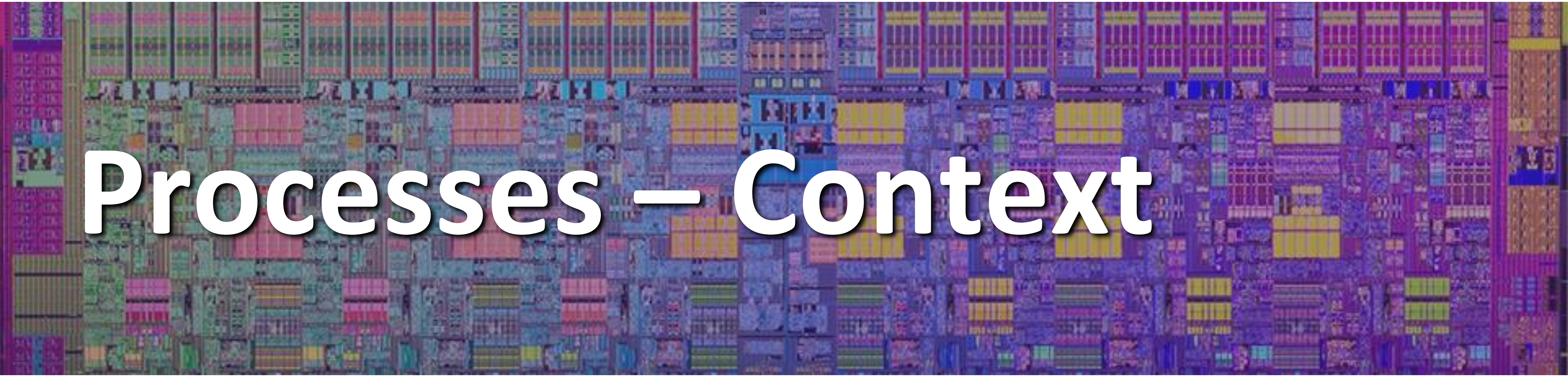
- For the following scenarios, what will the outcome be for a child process that executes `exit(0)`:

Scenario	Outcome for child		
Parent is still executing:	Alive	Reaped	Zombie
Parent has called `wait()`:	Alive	Reaped	Zombie
Parent has terminated:	Alive	Reaped	Zombie

waiting for parent to decide what to do

reaped by parent

reaped by init/systemd



Processes – Context

Processes Demos

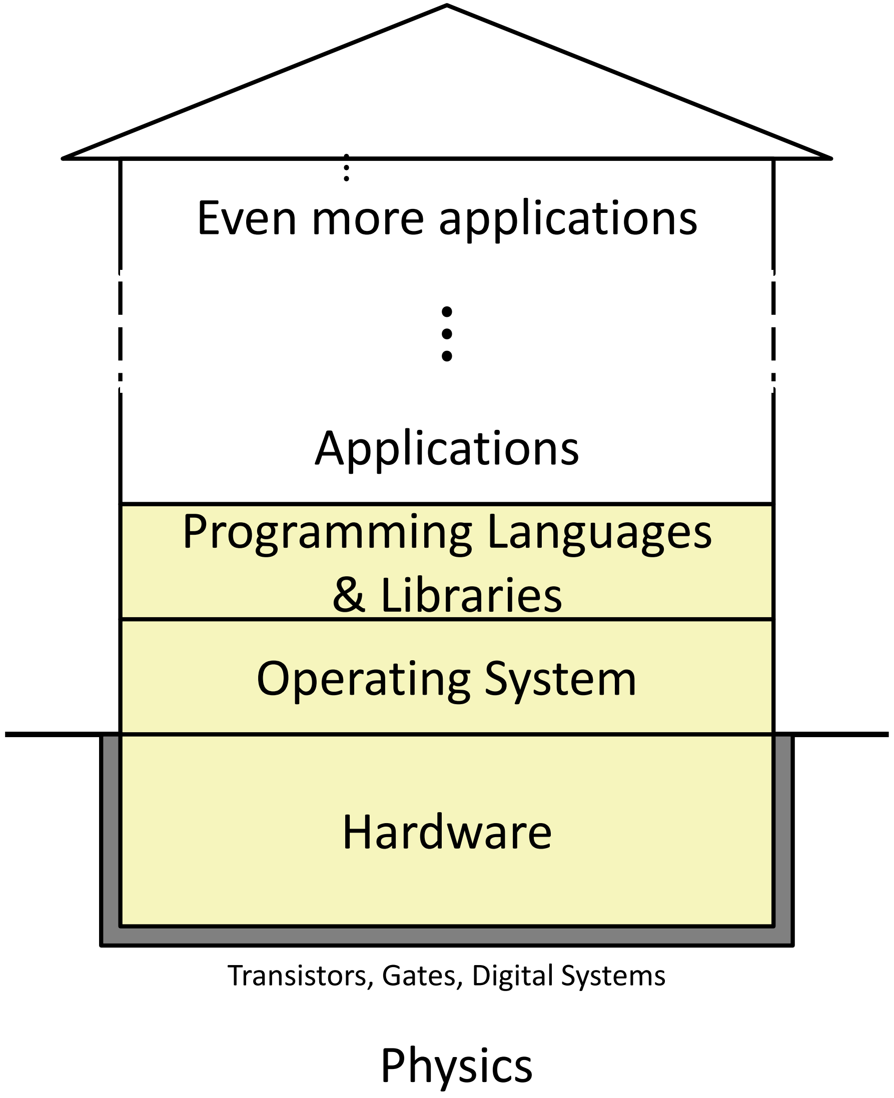
- How many processes are running on my computer right now?

- In Linux, the `ps` utility gives a snapshot of currently-running processes and `pstree` formats these as a tree
  - Can run `man ps` and `man pstree` for more info
  - Let's see a simple `pstree`
  - Let's check attu for some 351 zombie processes

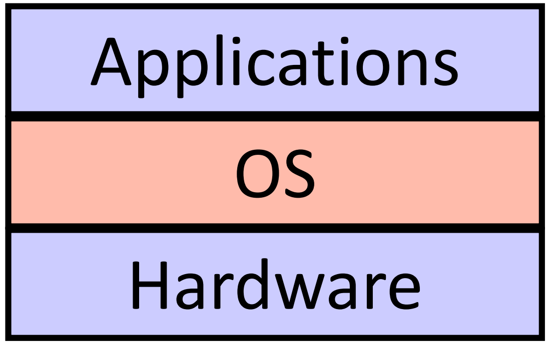
The Hardware/Software Interface

- Topic Group 3: **Scale & Coherence**
  - Caches, Memory Allocation, **Processes**, Virtual Memory

- How do we maintain logical consistency in the face of more data and more processes?
  - How do we support control flow both within many processes and things external to the computer?
  - How do we support data access, including dynamic requests, across multiple processes?



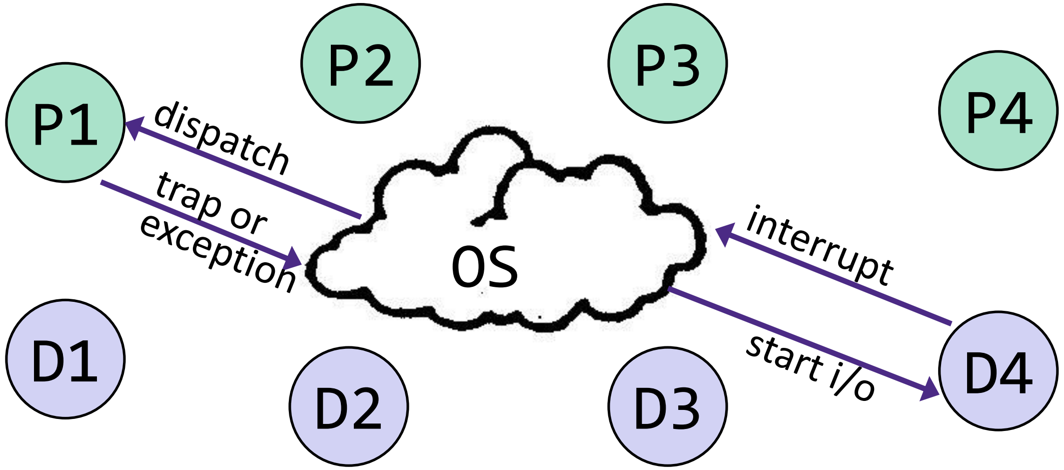
The Operating System



- “The OS is everything you don’t need to write in order to run your application”
- This depiction invites you to think of the OS as a library
  - In some ways, it is:
    - All operations on I/O devices require OS calls (`syscalls` – traps)
  - In other ways, it isn't:
    - You use the CPU/memory without OS calls
    - It intervenes without having been explicitly called

Operating System Structure

- The OS sits between application programs (P for processes) and the hardware (D for devices)
  - It <u>mediates</u> access (sharing and protection)
    - Programs request services via *traps* or *exceptions*; devices request attention via *interrupts*
  - It <u>abstracts</u> away hardware into *logical resources* and well-defined *interfaces* to those resources (ease of use)
    - *e.g.*, **processes** (CPU, memory), files (disk), programs (sequences of instructions), sockets (network)



OS Relevance in 351

- From programmer's perspective, the application benefits include:
  - Programming simplicity
    - Can deal with high-level abstractions instead of low-level hardware details
    - Abstractions are *reusable* across many programs
  - Portability (across machine configurations or architectures)
    - Device independence: 3com card or Intel card?

- Want to learn more?
  - CSE 333 will cover the application interface with the OS via system calls
  - CSE 451 will have you implementing the complex details of an operating system

Group Work Time

- During this time, you are encouraged to work on the following:
  1) If desired, continue your discussion
  2) Work on the homework problems
  3) Work on the lab (if applicable)

- Resources:
  - You can revisit the lesson material
  - Work together in groups and help each other out
  - Course staff will circle around to provide support