CSE 390B, Spring 2022

Building Academic Success Through Bottom-Up Computing

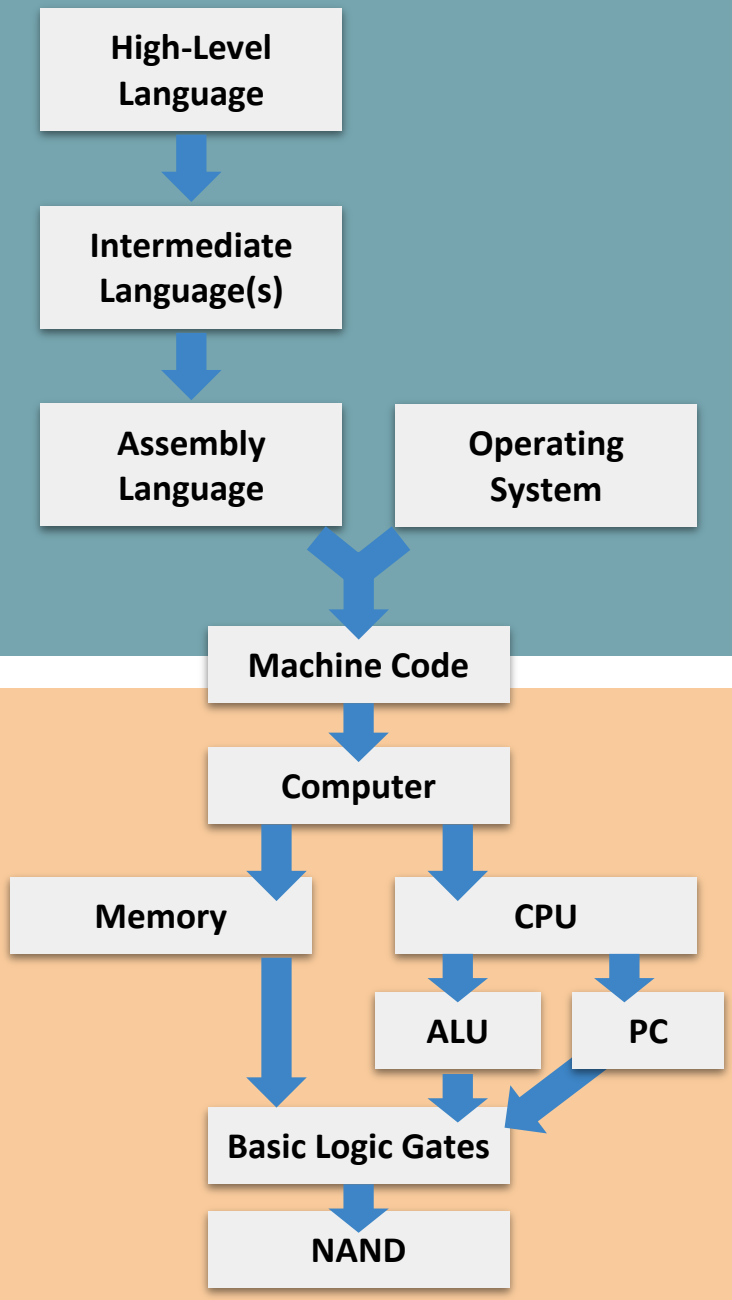
Operating Systems & Final Project Overview

The Software Stack, Operating Systems Overview, Final Project Overview

Lecture Outline

- **The Software Stack**
  - **Roadmap of Hardware and Software Components**
- Operating Systems Overview
  - Abstraction, Protection, Processes, Virtual Memory
- Final Project Overview
  - E-Portfolio Details and Presentation Logistics

Roadmap


High-Level Language
Intermediate Language(s)
Assembly Language
Operating System
SOFTWARE
Machine Code
HARDWARE
Computer
Memory
CPU
ALU
PC
Basic Logic Gates
NAND

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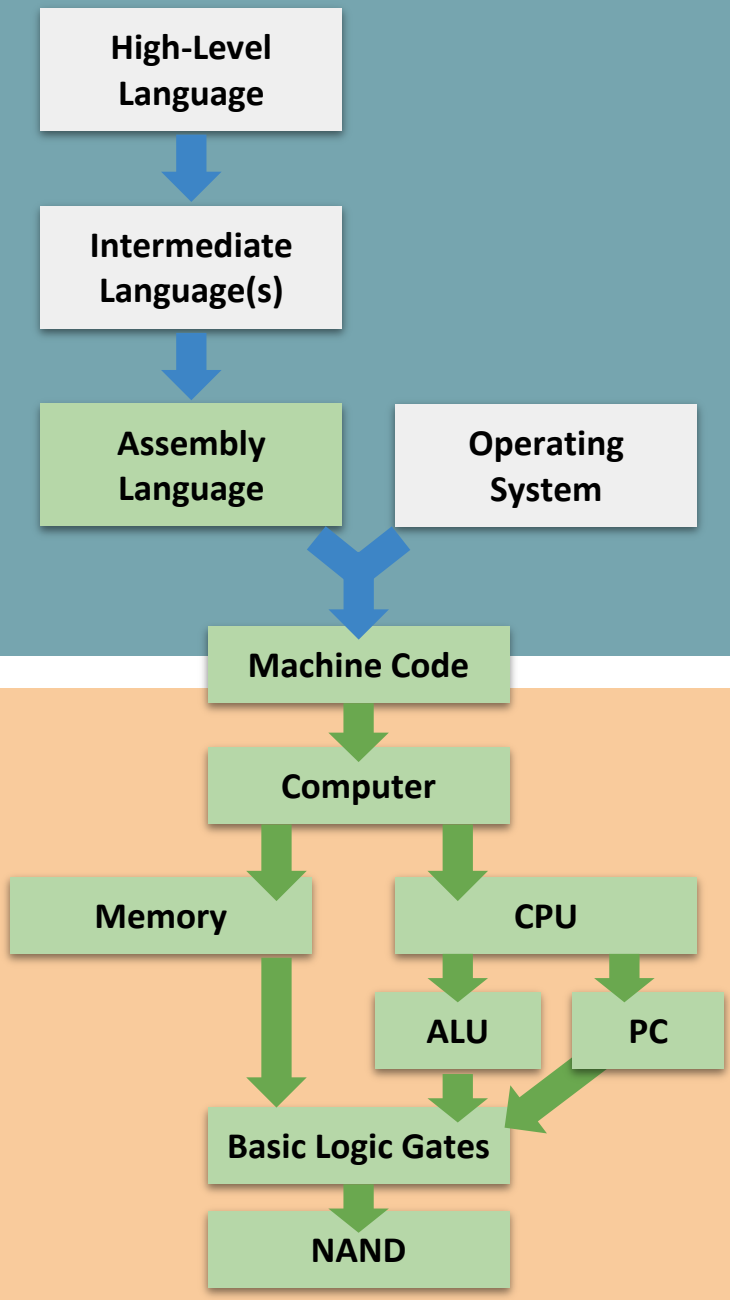
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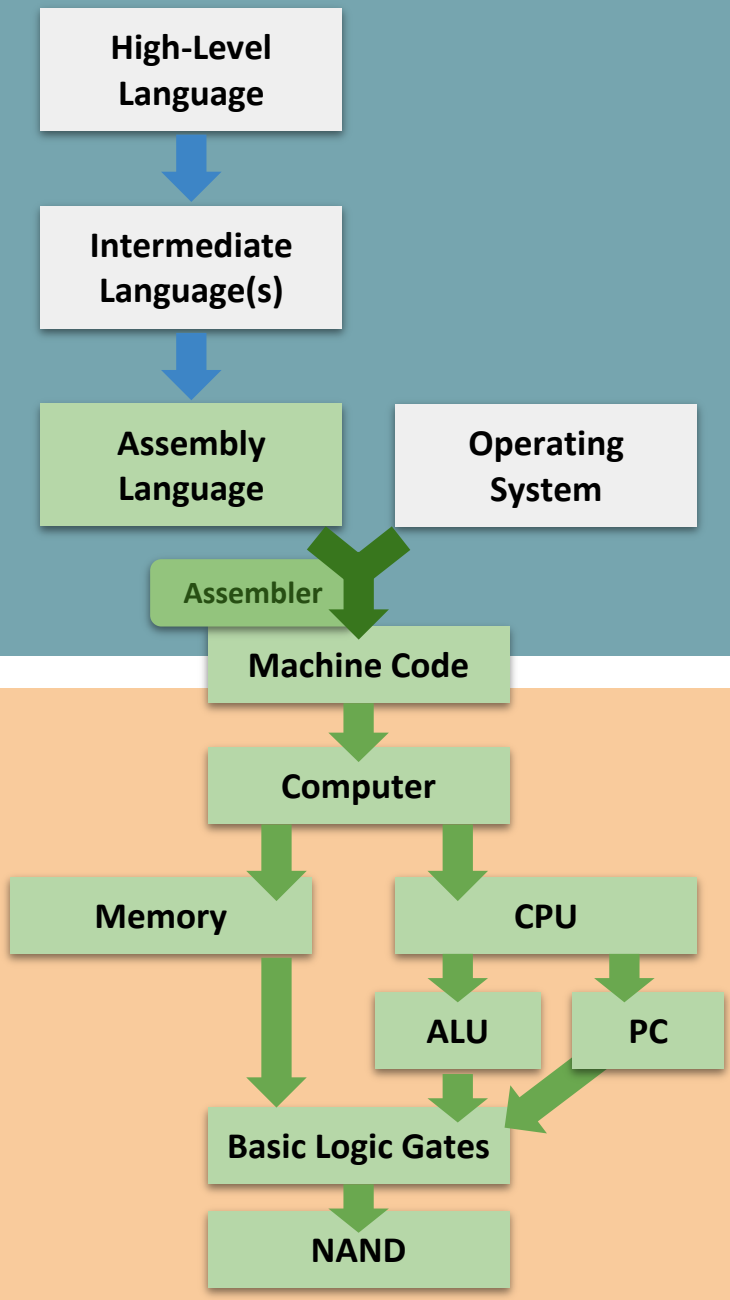

SOFTWARE

HARDWARE

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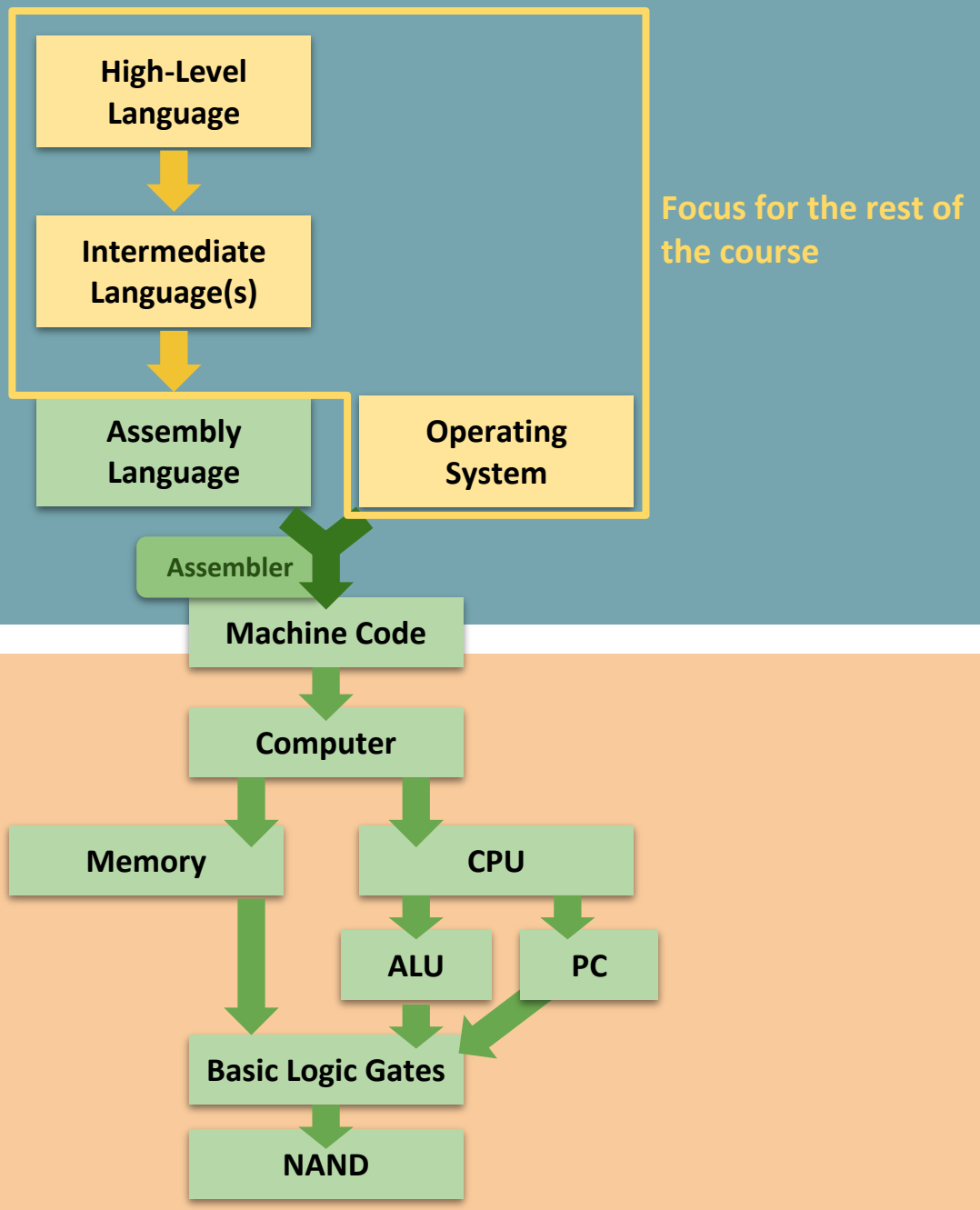
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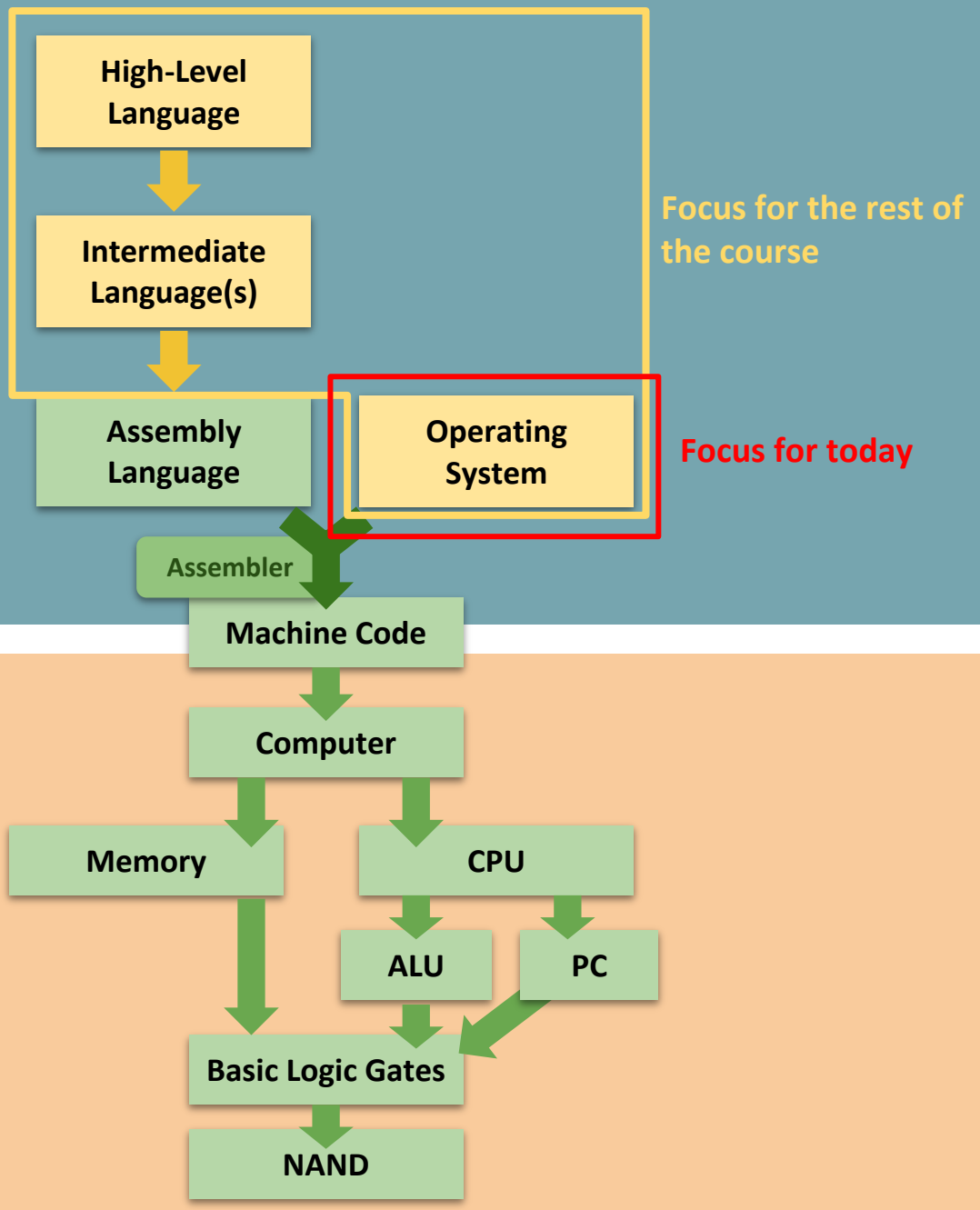
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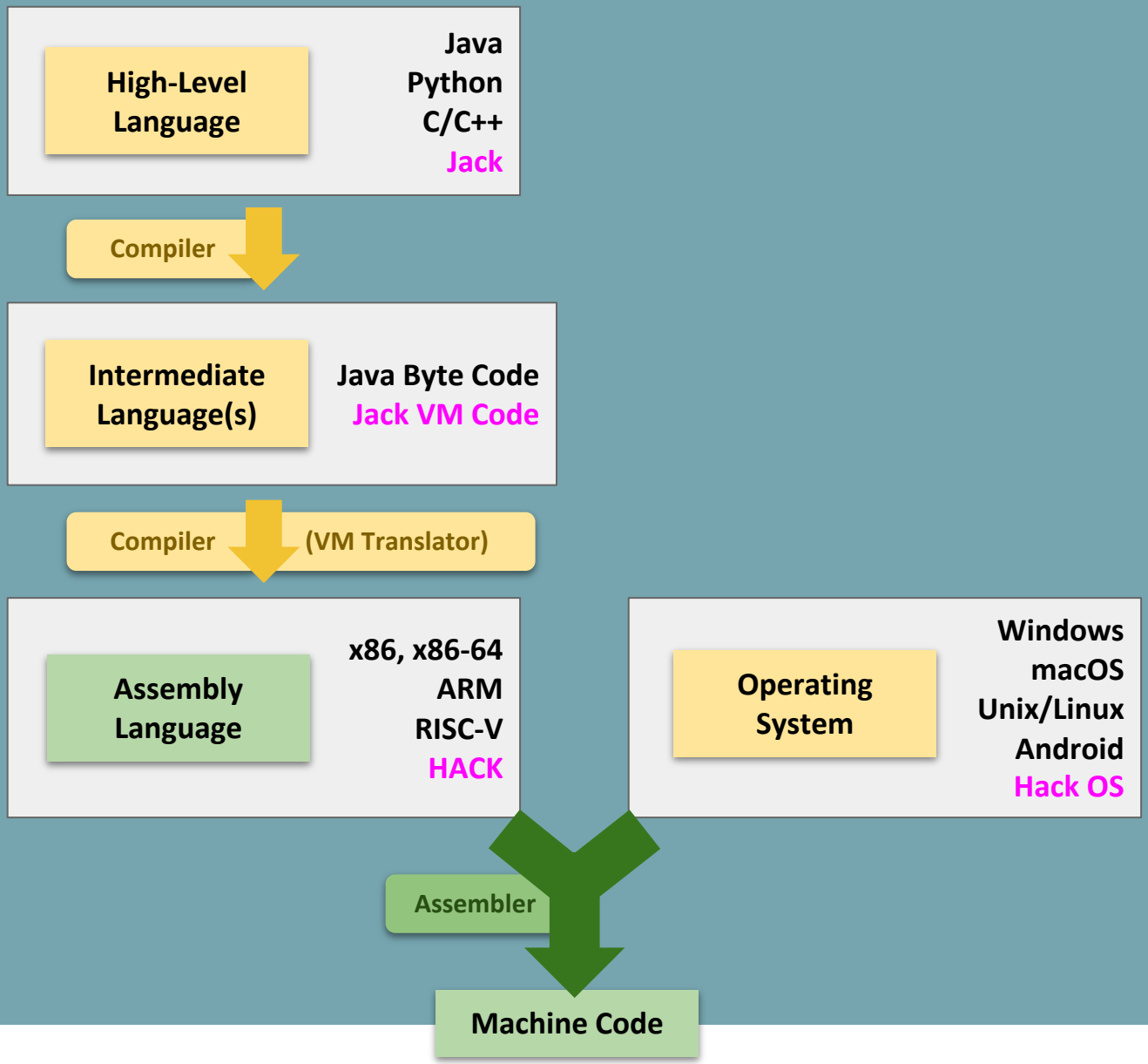
Software Overview



SOFTWARE

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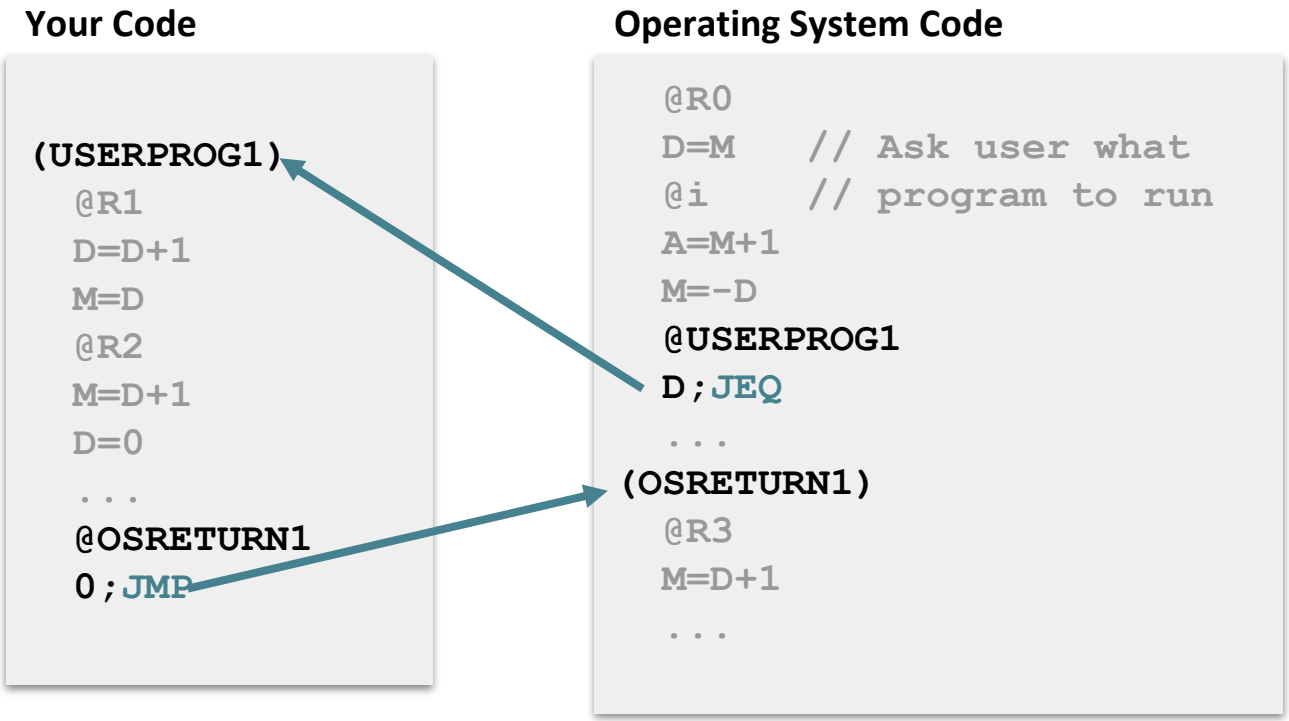
The Operating System

- The operating system (OS) is just another piece of software
  - A massive, complex piece of software
  - In the end, uses the same machine language your code does



The Operating System

- The operating system (OS) is just another piece of software
  - A massive, complex piece of software
  - In the end, uses the same machine language your code does
- OS is more trusted than the rest of the software that runs on your computer
- User programs and applications invoke (ask) the OS to perform operations they are not trusted or allowed to
  - Means the OS needs to be secure

Why an Operating System?

- Directly interacts with the hardware

- Benefit: **Abstraction**
  - Provides high-level functionality for messy hardware devices
  - OS must be ported to new hardware, but user-level programs can then be portable

- Benefit: **Protection**
  - OS is trusted to touch hardware; user-level programs are not
  - User-level programs cannot “break things”
  - Maintains security between programs and user accounts

Operating System: Abstraction

- Many abstractions provided by real-world operating systems

- File System
  - File contents = just bits in the "giant array" that is the hard drive ("permanent" storage, as opposed to temporary storage in RAM that disappears when computer is turned off)
  - OS keeps a record of which ones fall into which "files"

Operating System: Abstraction

- Many abstractions provided by real-world operating systems

- Network Stack
  - Communicating with network devices ≈ communicating with screen/keyboard memory map
  - OS handles messy, time-sensitive protocols

- Processes
  - Only one process can run at once on a CPU
  - OS switches very quickly, illusion of running both “at once”

Operating System: Protection

- The CPU has different "privilege" levels when it is executing (controlled by a register on the CPU)

- OS code and memory can only be executed by an OS privilege level
  - Your applications run at a lower level and cannot access OS code and memory

- This prevents applications from crashing entire system
  - For example, if your web browser crashes, usually it doesn't crash your entire computer
  - Also helpful for security purposes

Operating Systems: Protection

- Example: Suppose we want only the OS to be allowed to run instruction **`SET_ON_FIRE`**
  - But if the OS is just a machine code program like any other… what's the security hole?

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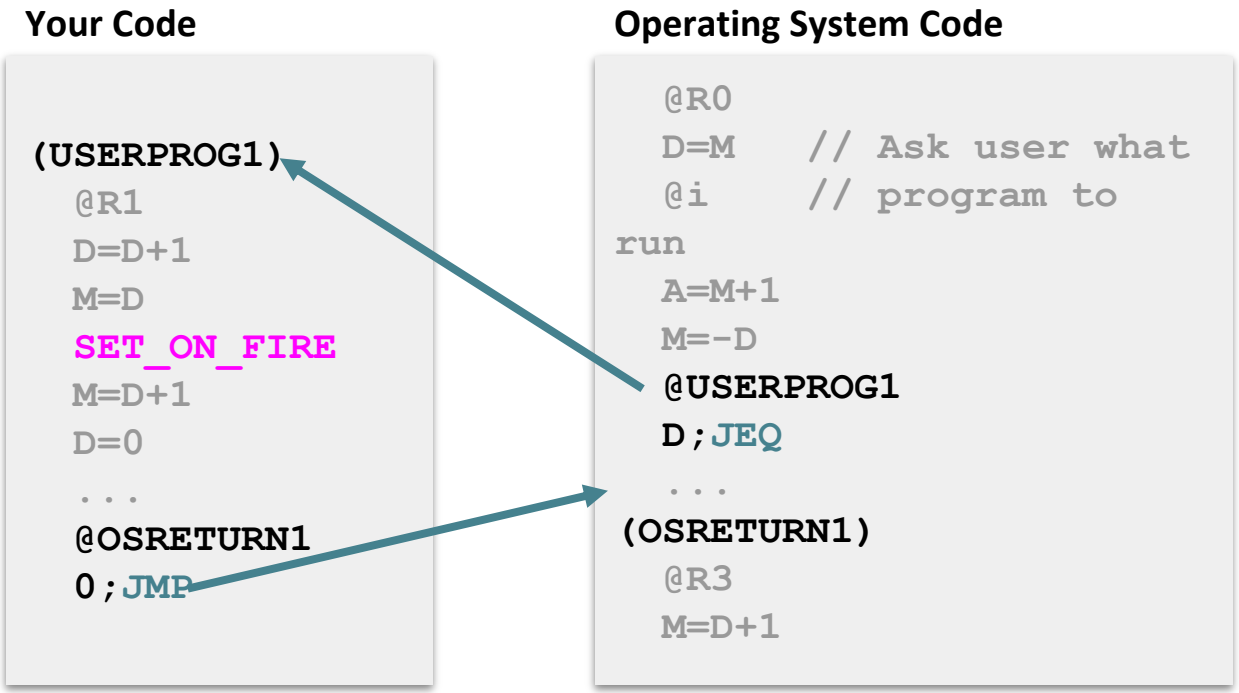
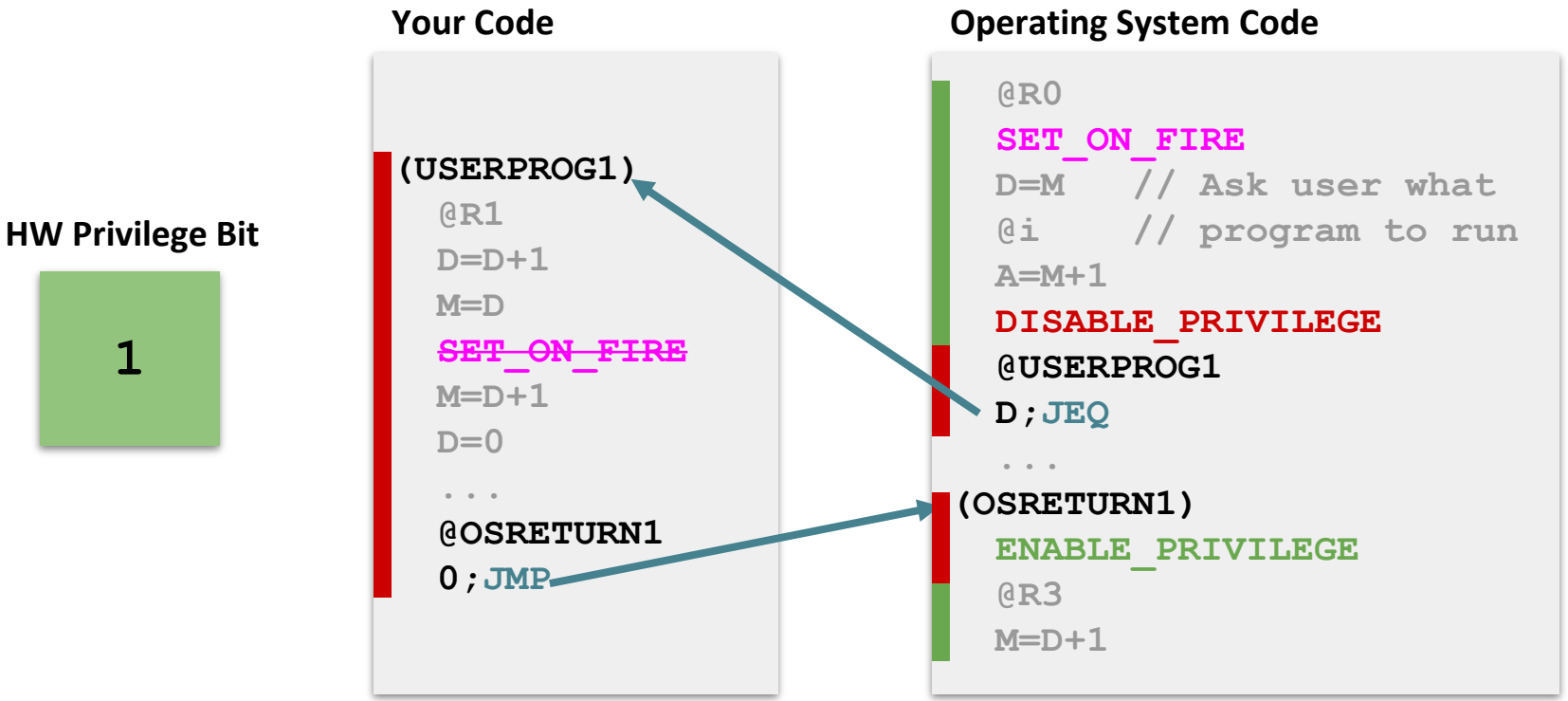


Operating Systems: Protection

- The fix: hardware bit for "privileged mode"
  - Processor checks before running SET_ON_FIRE
  - OS disables before jumping to user code, re-enables on return
    - (Processor also must check that user code can't enable privilege)



Operating System: Processes

- A "process" is an application running on your computer
  - E.g., your web browser, terminal, Microsoft Word, etc.
- Each app instance contained in one or more processes
  - The OS manages these processes
- Multiple processes are "running" at the same time, but it's just the OS quickly switching between them
- A process only has access to its memory, and cannot access the memory of other processes
  - This is helpful because if one process crashes or is malicious, it makes it more difficult to crash or corrupt other processes too

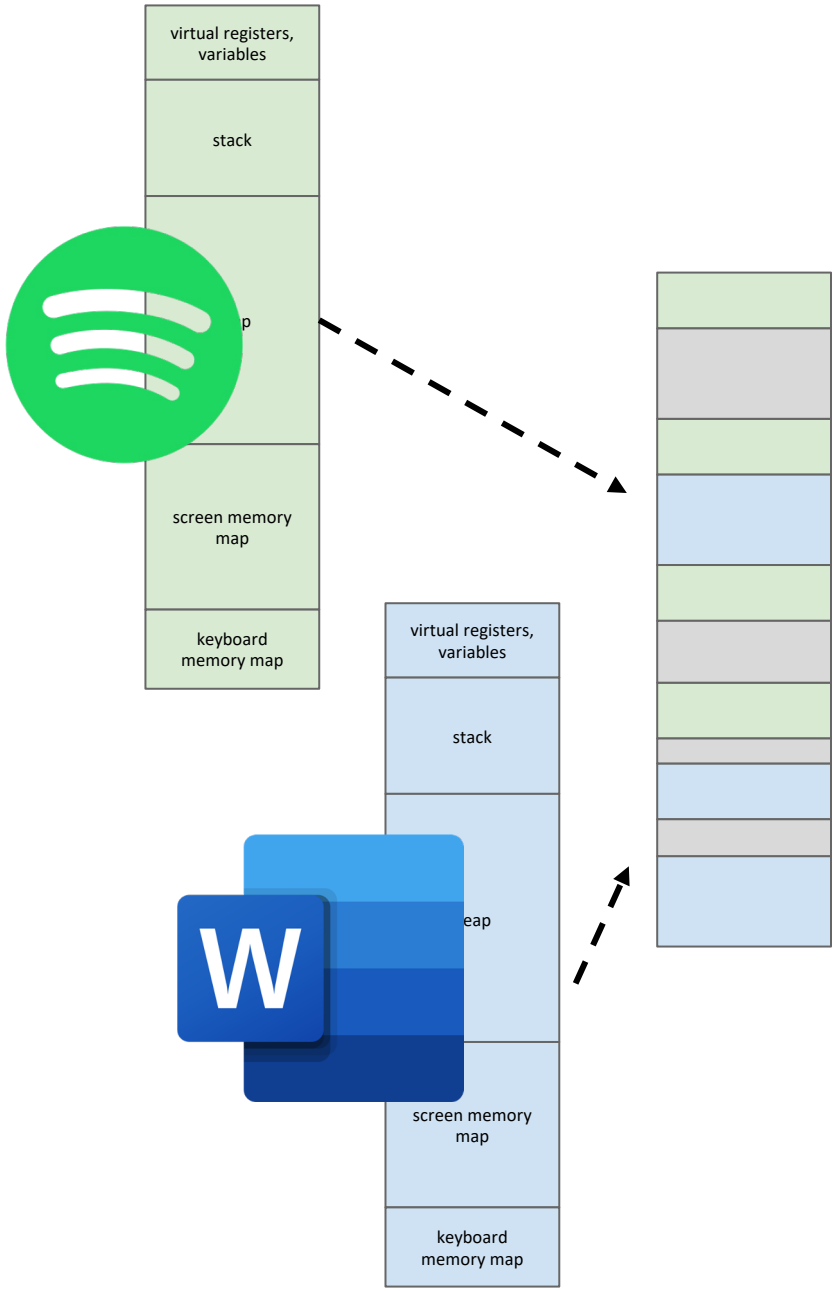
Why *Not* an Operating System?

- The Hack computer we've built is… small
  - Uses the same principles as your laptop CPU
  - But in terms of scale, closer to a microprocessor or small embedded chip

- For embedded systems, often an OS is overkill—instead, designed to be programmed with/run a single program at a time
  - Benefit: developer gets complete control over the device
  - Drawback: re-implement OS features, no protection

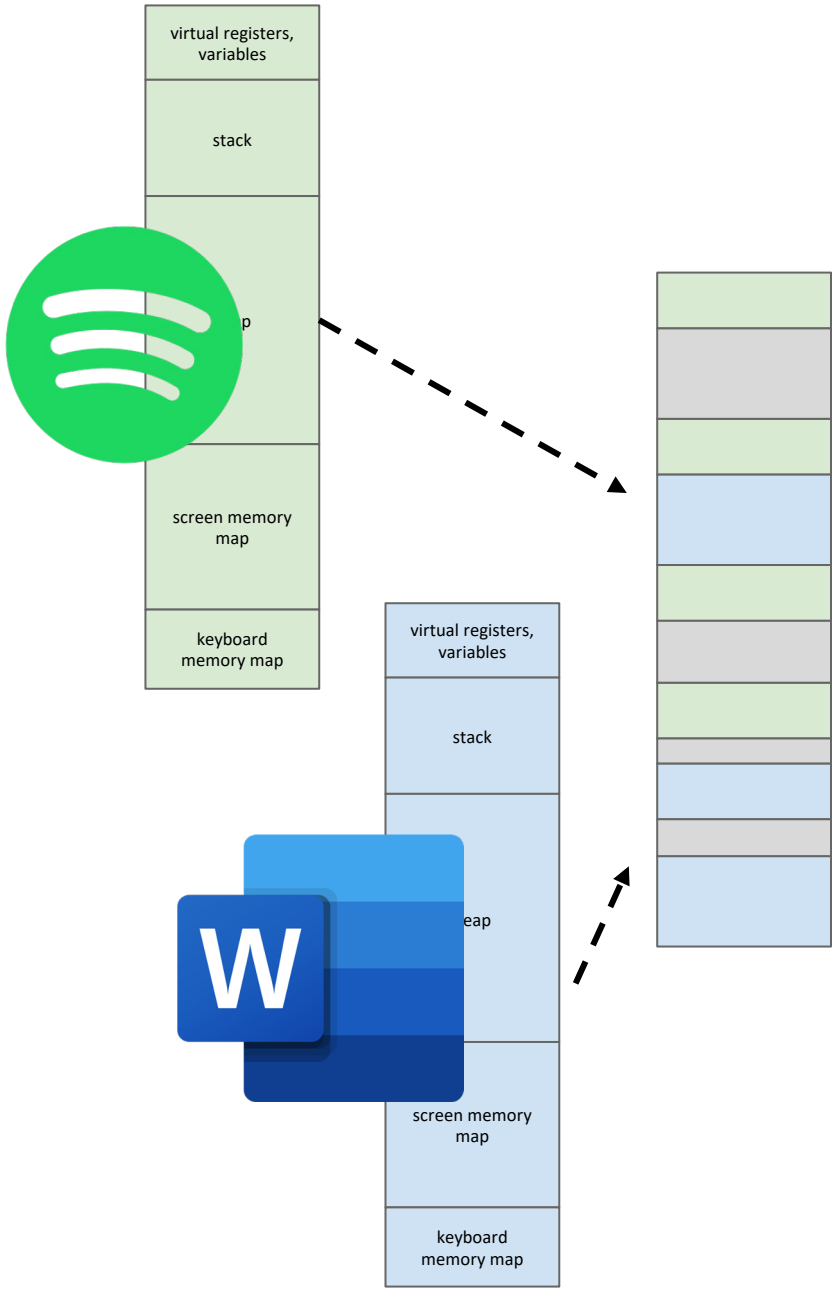
Virtual Memory

- Most OS's allow multiple processes, but shouldn't be able to modify values in another's address space
- OS provides illusion of separate address spaces via virtual memory
  - Really all one physical memory
  - OS & hardware map pieces of virtual memory to pieces of physical memory



Virtual Memory

- Benefit:
  - Security: programs only know about their own address space
    - Don't even have a way to describe address of other application's data
- Drawback:
  - Efficiency: virtual address translation is fast nowadays but still slower than directly accessing memory (what microprocessors do)



Comparison of Operating Systems

- Three different ways to do essentially the same thing
  - Everyone has their own preference
- Each have their own benefits and tradeoffs
  - Work on varying types of hardware, provide different levels of customization, different features, work better with different software, open source vs. proprietary, etc.
- You could choose to do some research next time you are deciding on a laptop, computer, or OS

Five-minute Break!

- Feel free to stand up, stretch, use the restroom, drink some water, review your notes, or ask questions
- We'll be back at:
- Research shows mid-lecture breaks reduce the decline of attention in the middle of lecture (Olmsted, 1999)

Olmsted III, John. "The Mid-Lecture Break: When Less Is More." *Journal of Chemical Education* (1999). https://pubs.acs.org/doi/abs/10.1021/ed076p525.

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Final Project E-Portfolio Overview

- You will create an E-Portfolio that is geared toward a new Allen School student
- Your E-Portfolio is a culminating project in having you reflect on the **metacognitive skills** you've learned and **providing advice** for entering the program
- During our final class, you will give an 8–10-minute presentation on your E-Portfolio

Final Project E-Portfolio Components

- Part I: Outline of E-Portfolio
  - Final project check-in and feedback during next Tuesday's class
  - Due next Thursday (6/2) at 11:59pm PDT
- Part II: Final E-Portfolio Submission
  - Due Tuesday of finals week (6/7) at 4:00pm PDT
- Part III: E-Portfolio Presentations
  - During the scheduled CSE 390B final (Tuesday, 6/7 at 4:30pm PDT)
  - We'll split up into small groups with your TA

Final Project Ideas Brainstorming

- Brainstorm individually for five minutes:
  - Looking back on this quarter, what metacognitive skills impacted you the most?
  - What were some concrete examples of yourself demonstrating these metacognitive skills?
  - What was one technical topic from CSE 390B that helped you connect the dots?
- Discuss in groups of 3-4 for five minutes

Lecture 17 Wrap-up

- Thursday's Lecture: Procrastination, Stress Response Cycle, & Computer Networks
  - Reading: Feminist Survival Project Episode 2

- Upcoming Project Reminders
  - Project 7, Part II (Professor Meeting Report) due this Thursday (5/26) at 11:59pm PDT
  - Project 8 (Debugging & Implementing a Compiler) due next Tuesday (5/31) at 11:59pm PDT

- Check Canvas for late updated late days through Project 5