CSE 390B, Spring 2023

Building Academic Success Through Bottom-Up Computing

Finals Preparation & Operating Systems

Gearing up for Finals Week, The Software Stack, Overview of Operating Systems, Final Project Overview

Lecture Outline

- **Gearing up for Finals Week**
  - **Study Plan Outline and Tips for Success**
- The Software Stack
  - Roadmap of Hardware and Software Components
- Overview of Operating Systems
  - Abstraction, Protection, Processes, Virtual Memory
- Final Project Overview
  - E-Portfolio Details and Topics Brainstorming

Gearing up for Finals Week

- Revisit and reassess your goals each day
  - Break-up into different levels—safe, solid, reach
- Have an accountability buddy
  - Study groups or working sessions—having someone who can help you stay motivated, accountable, and avoid procrastination
- Recall Bloom's Taxonomy
  - How is your preparation involving higher level thinking skills?
- Stick to a routine
  - Provides normalcy & structure for maintaining sleep and wellness

Developing a Plan for Finals Week

- First, list the commitments that you have for finals week (final exams, final projects, presentations, etc.)

- Then, outline the steps that you'll need to follow to complete those tasks
  - Be specific with these steps — instead of "review derivatives," add detail about the **how**: "Review lecture slides and examples on derivatives and redo five derivative problems on WebAssign"

- Lastly, add dates to when you will work on and complete each of the steps (be realistic here!)
  - Add these to your calendar

Planning for Success on Finals Week

In groups, discuss the following questions:

- What are some metacognitive strategies that you plan on using to succeed in finals week?
  - How can you stay disciplined or keep yourself accountable in applying these metacognitive skills?
- In terms of academic and metacognitive subjects, what are your strengths and weaknesses going into finals?
  - How can you cultivate your strengths and improve the areas you are weaker in?

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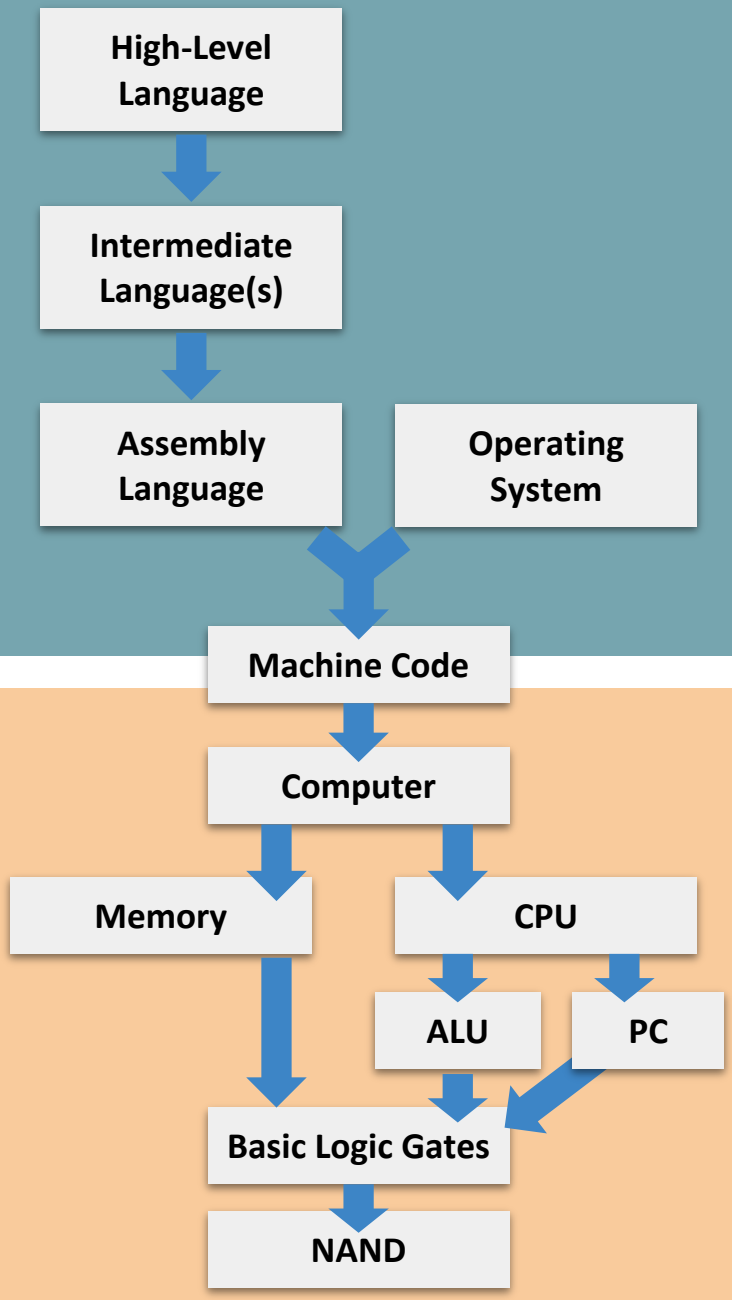
Roadmap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Intermediate Language(s)
Assembly Language
Operating System
SOFTWARE
Machine Code
HARDWARE
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ALU
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Basic Logic Gates
NAND

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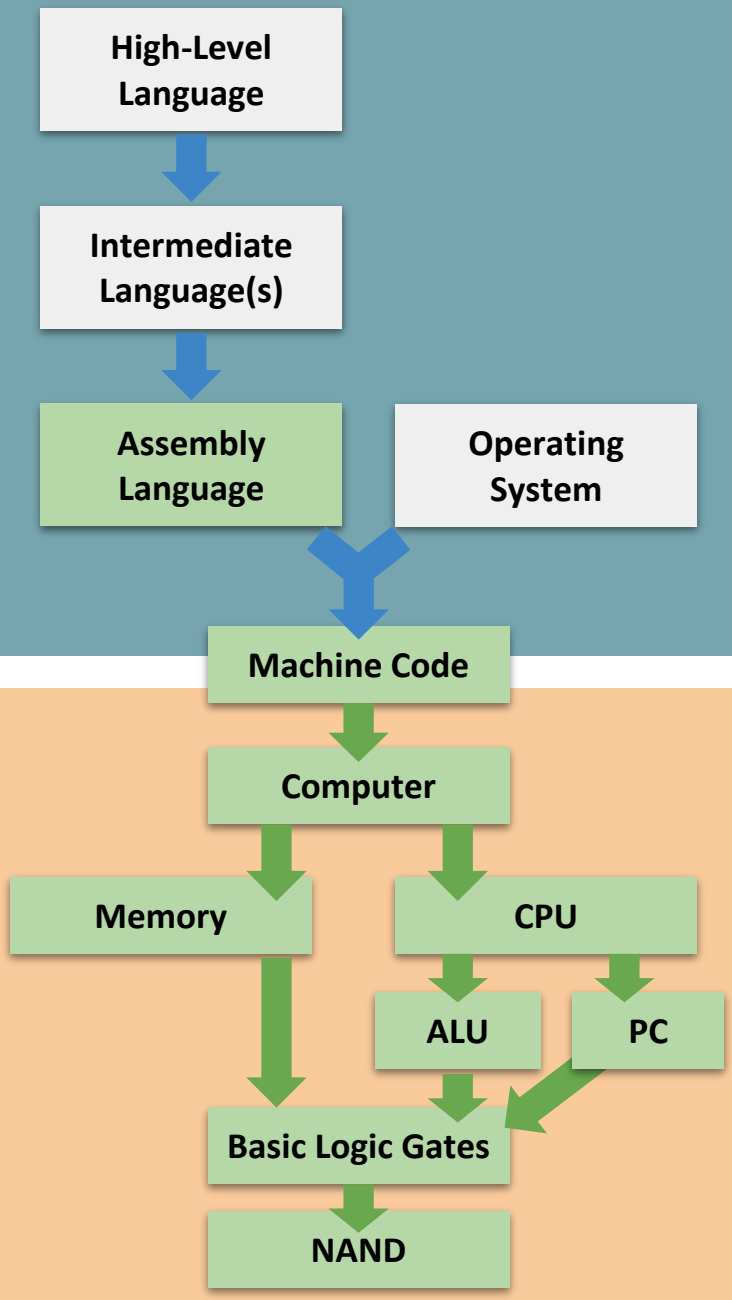
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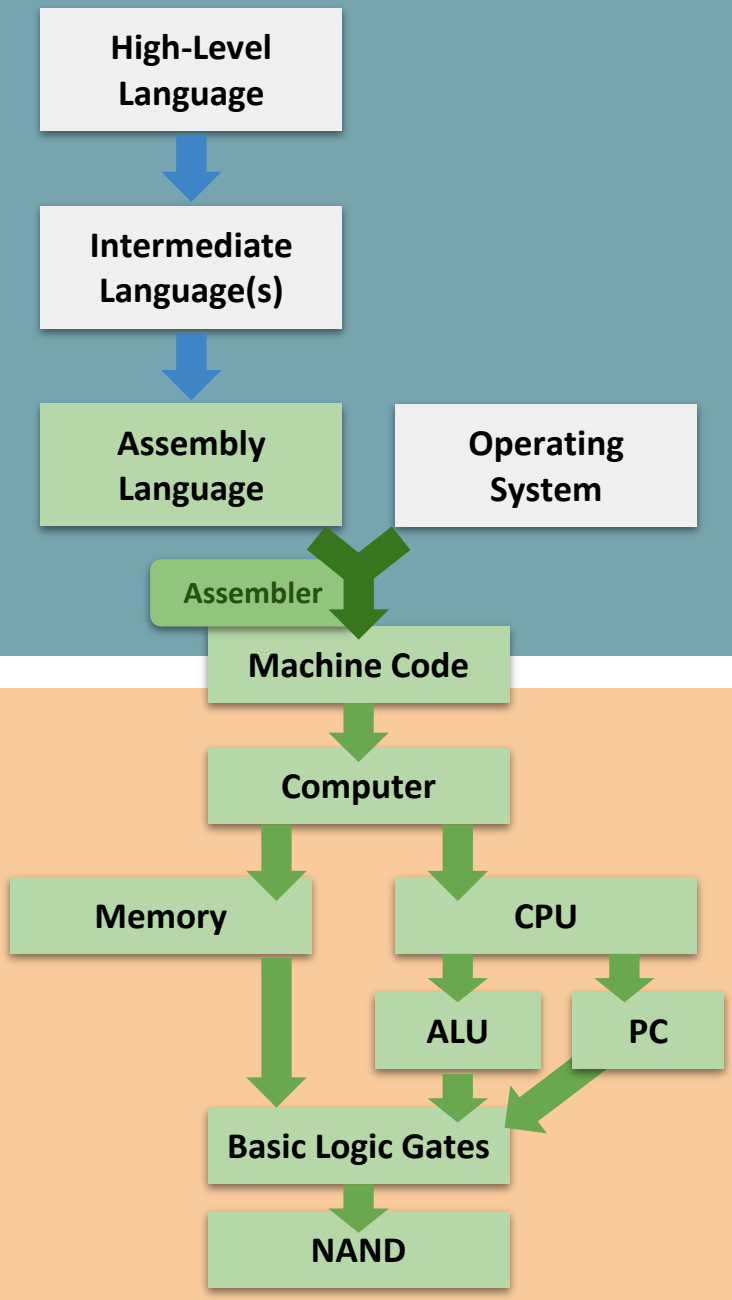
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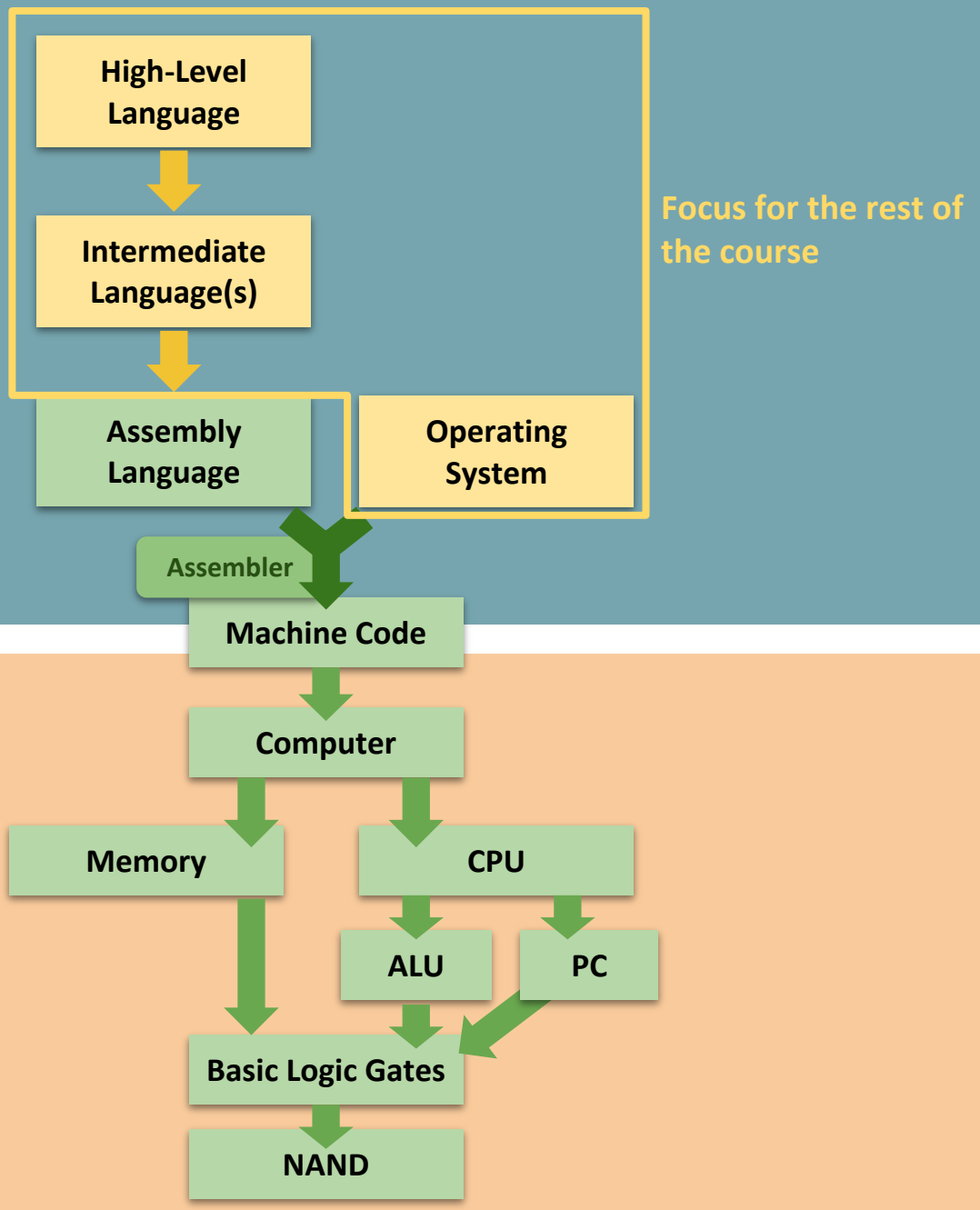
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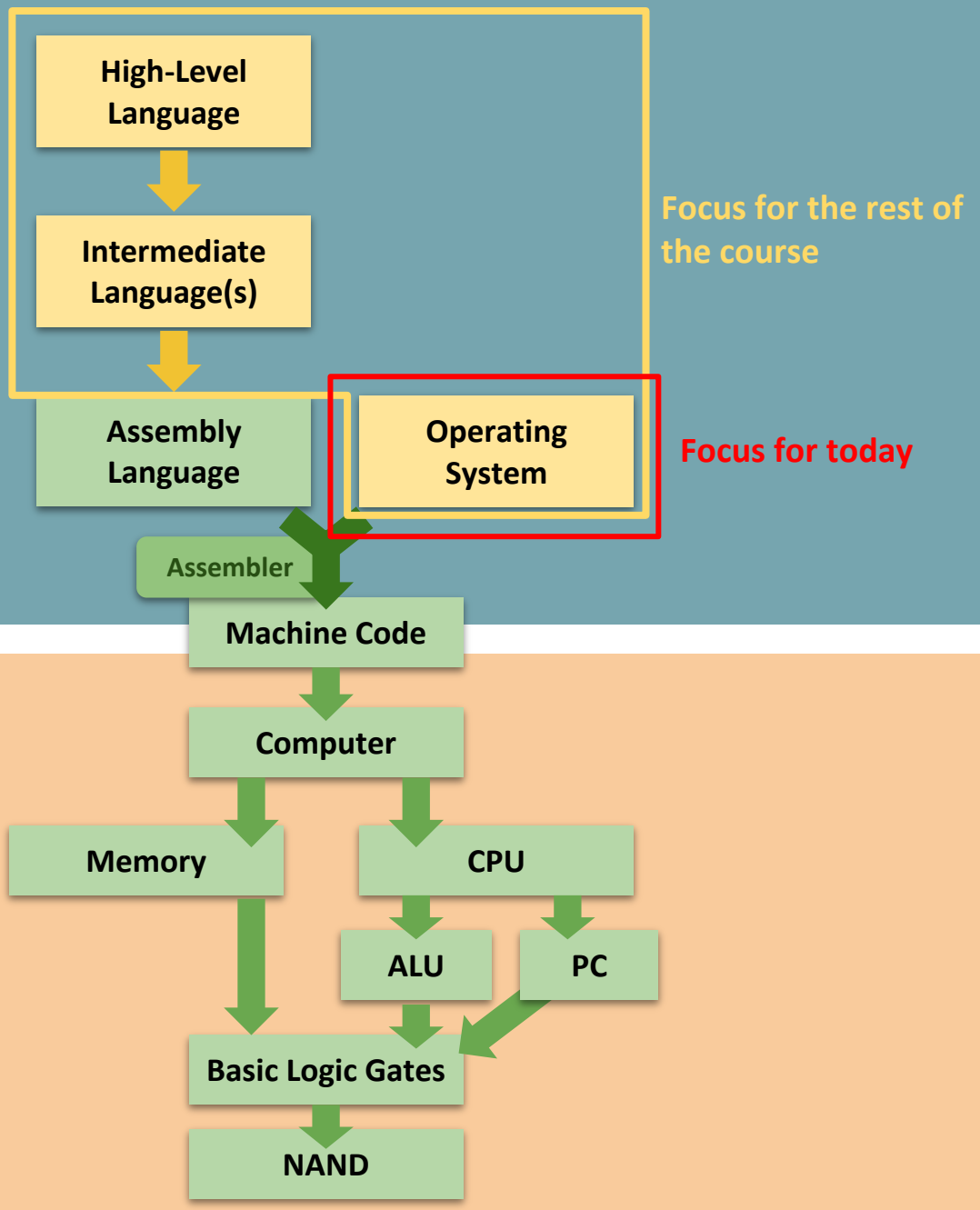
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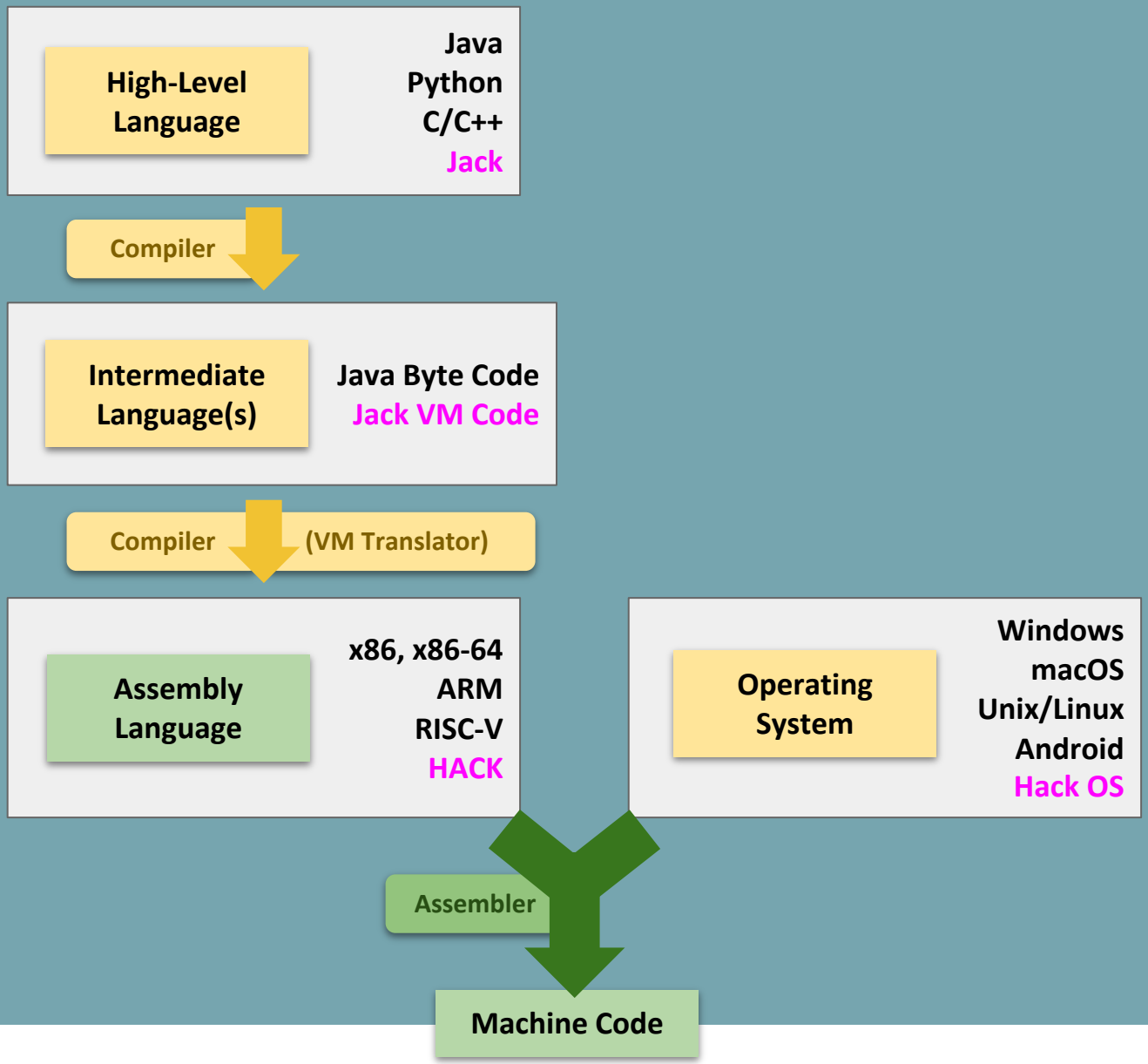
Software Overview



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
- 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
  - Prevents user-level programs from causing errors in the hardware
  - Maintains security between programs and user accounts

Operating Systems: 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 Systems: Abstraction

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- 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
  - Operating systems can manage resource sharing
  - OS switches very quickly, illusion of running both “at once”

Operating Systems: 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 higher 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?

Operating Systems: Protection

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Your Code

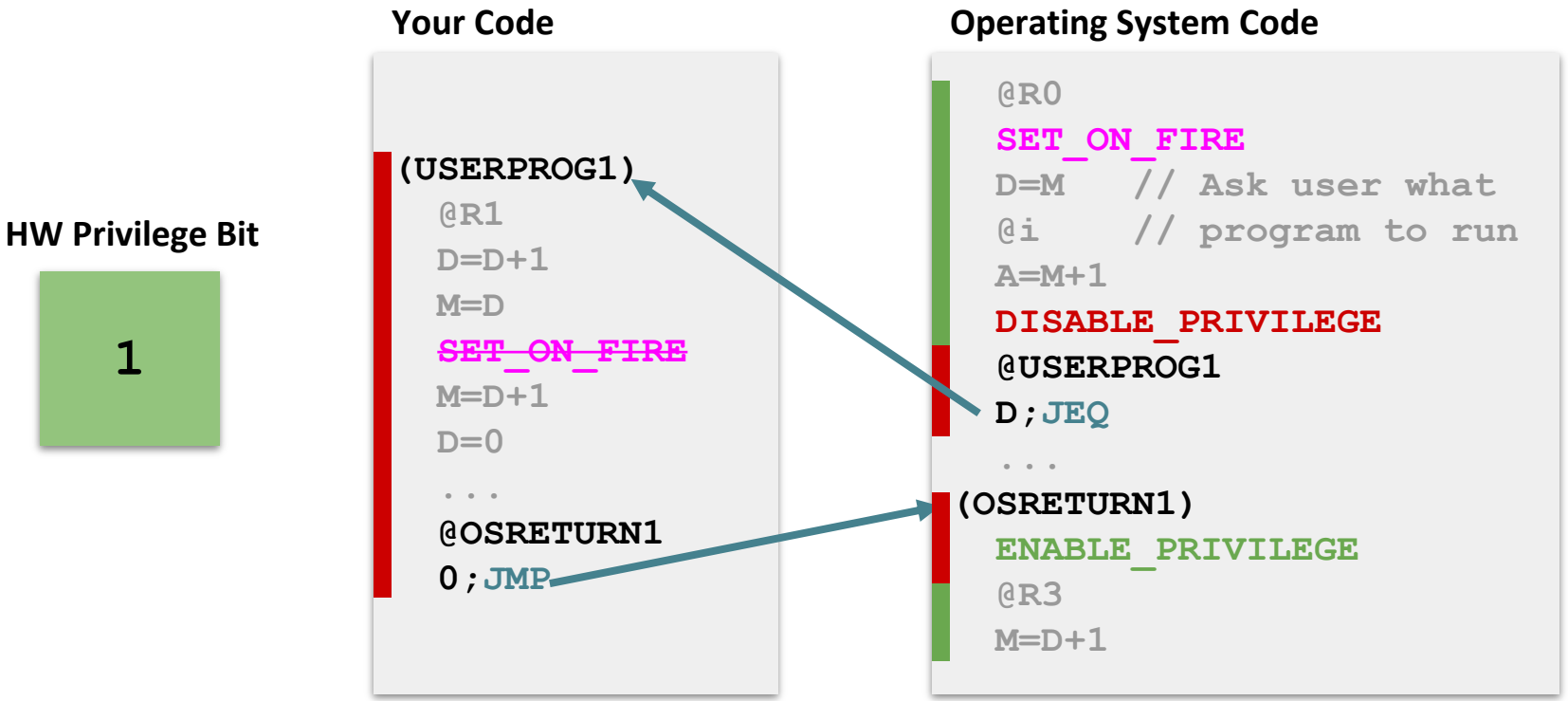
```
(USERPROG1)
  @R1
  D=D+1
  M=D
  SET_ON_FIRE
  M=D+1
  D=0
  ...
  @OSRETURN1
  0;JMP
```

Operating System Code

```
  @R0
  D=M    // Ask user what
  @i     // program to
run
  A=M+1
  M=-D
  @USERPROG1
  D;JEQ
  ...
(OSRETURN1)
  @R3
  M=D+1
```

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

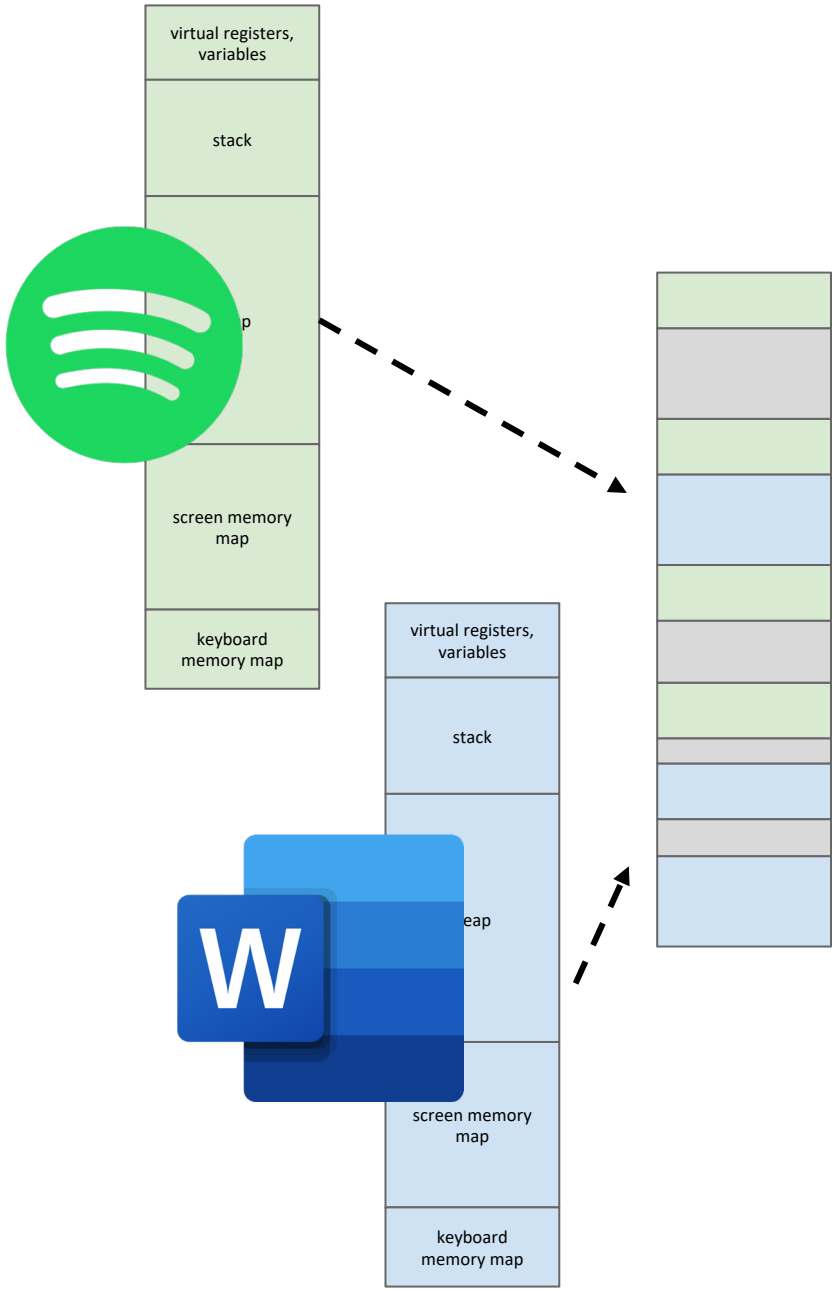
Why *Not* an Operating System?

- 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
  - Pro: developer gets complete control over the device
  - Con: re-implement OS features, no protection

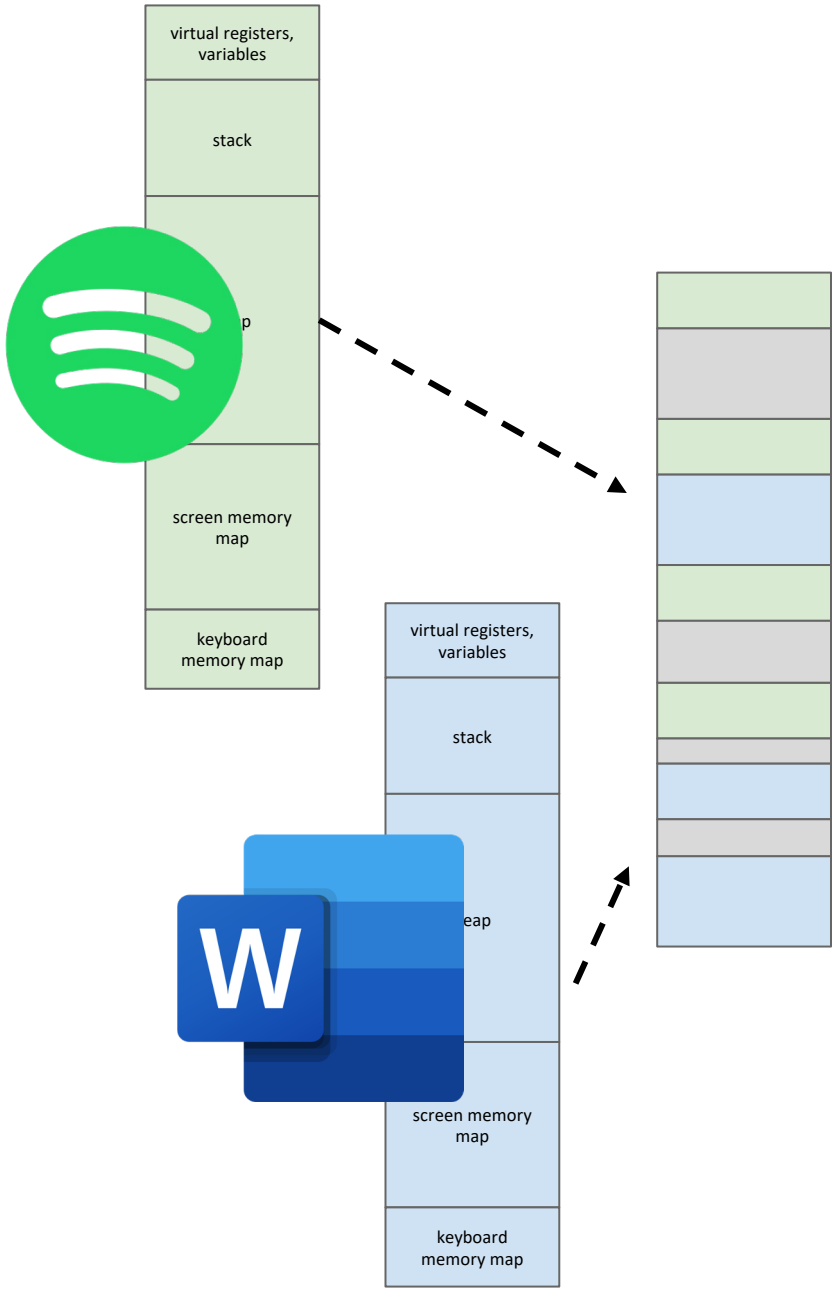
Virtual Memory

- 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 of security**: Programs only know about their own address space
  - Don't even have a way to describe address of other application's data
- **Drawback is efficiency**
  - Virtual address translation is fast nowadays, but still slower than directly accessing memory



Comparison of Operating Systems

- Three different ways to do essentially the same thing
  - Everyone has their own preference
- Each has 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

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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 a short presentation on your E-Portfolio

Final Project Due Dates

- Part I: E-Portfolio Outline
  - Due next Tuesday (5/30) at 11:59pm
- Part II: Final E-Portfolio
  - Due Tuesday of finals week (6/6) at 4:00pm
- Part III: E-Portfolio Presentations
  - During the scheduled CSE 390B final
  - CSE 390B Final Time: Tuesday, 6/6 from 4:30-6:20pm
  - CSE 390B Final Location: CSE2 G01 (same as usual classroom)

Reflection on Metacognitive Skills

Individually first, take some time to reflect on the following questions, and then discuss in groups:

- Which two metacognitive topics would you consider including in your E-Portfolio and why?
  - Reflect on which ones you've grown the most in, have impacted you the most, were most challenging to grow in, etc.
- What are some examples of yourself demonstrating those two metacognitive skills?
  - Please be specific here! Aim to share these skills as if you are telling a story and showing concrete applications of these skills

Reflection on a Technical Skill

Individually first, take some time to reflect on the following questions, and then discuss in groups:

- What technical topic from CSE 390B would you consider including in your E-Portfolio and why?
  - Reflect on technical skills that helped connect the dots, were most interesting to you, most challenging for you to grasp, etc.
- What is the impact of having knowledge of that technical skill? In other words, why is that technical skill useful?
  - Please be specific here as well — think about how this technical skill would be useful in an academic or personal setting

Post-Lecture 17 Reminders

- Project Reminders
  - **Project 7, Part II: Professor Meeting Report due this Thursday (5/25) at 11:59pm**
  - Project 8: Debugging & Implementing a Compiler due next Tuesday (5/30) at 11:59pm
  - Final Project, Part I: E-Portfolio Outline due next Tuesday (5/30) at 11:59pm

- Preston has office hours after class in CSE2 152
  - Feel free to post your questions on the Ed board as well