

Relevant Course Information

- ❖ HW21 due tonight, HW22 due Monday, HW23 due Wednesday
- ❖ Lab 4 due tonight
- ❖ Lab 5 due next Friday (3/8)
 - The most significant amount of C programming you will do in this class – combines lots of topics from this class: pointers, bit manipulation, structs, examining memory
 - Understanding the concepts *first* and efficient *debugging* will save you lots of time
 - Light style grading
 - Only 1 late day can be used for Lab 5
- ❖ No lessons for Lectures 25 and 26 – “normal” lectures

Take-Home Final Exam

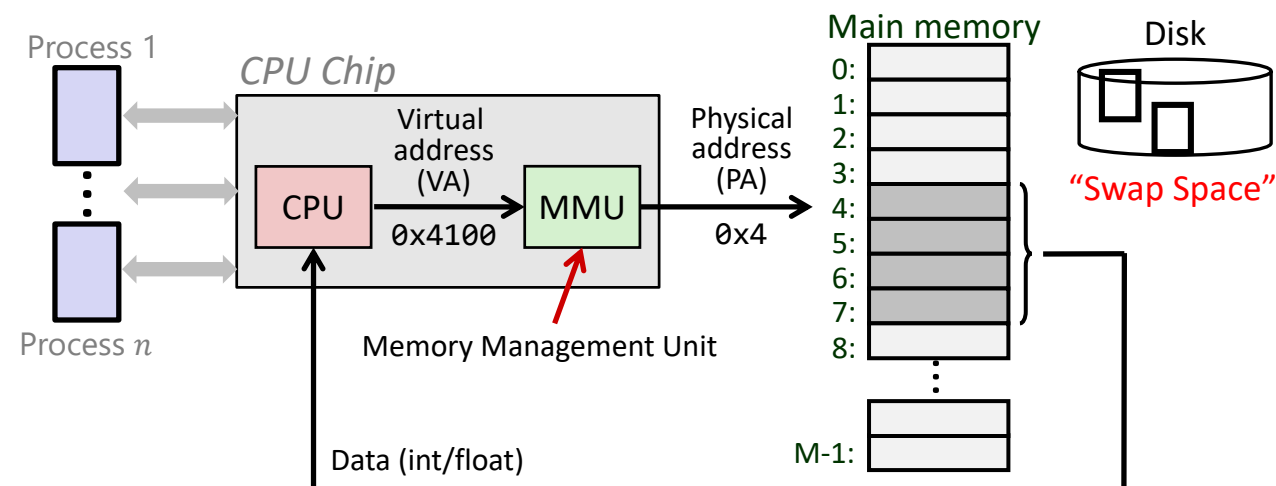
- ❖ First three days of Finals Week (3/11-13)
 - Structure will be very similar to the midterm
 - Not cumulative: focused on post-midterm material
 - *Hybrid* final review session planned for 3/8 (room TBD)
 - Justin will hold virtual support hours on 3/12 and 3/13
 - Regrade requests Monday, 3/18

A detailed, colorful micrograph of a microchip die, showing a complex grid of circuitry and various colored regions (purple, blue, yellow, green, red) representing different functional blocks.

Virtual Memory I

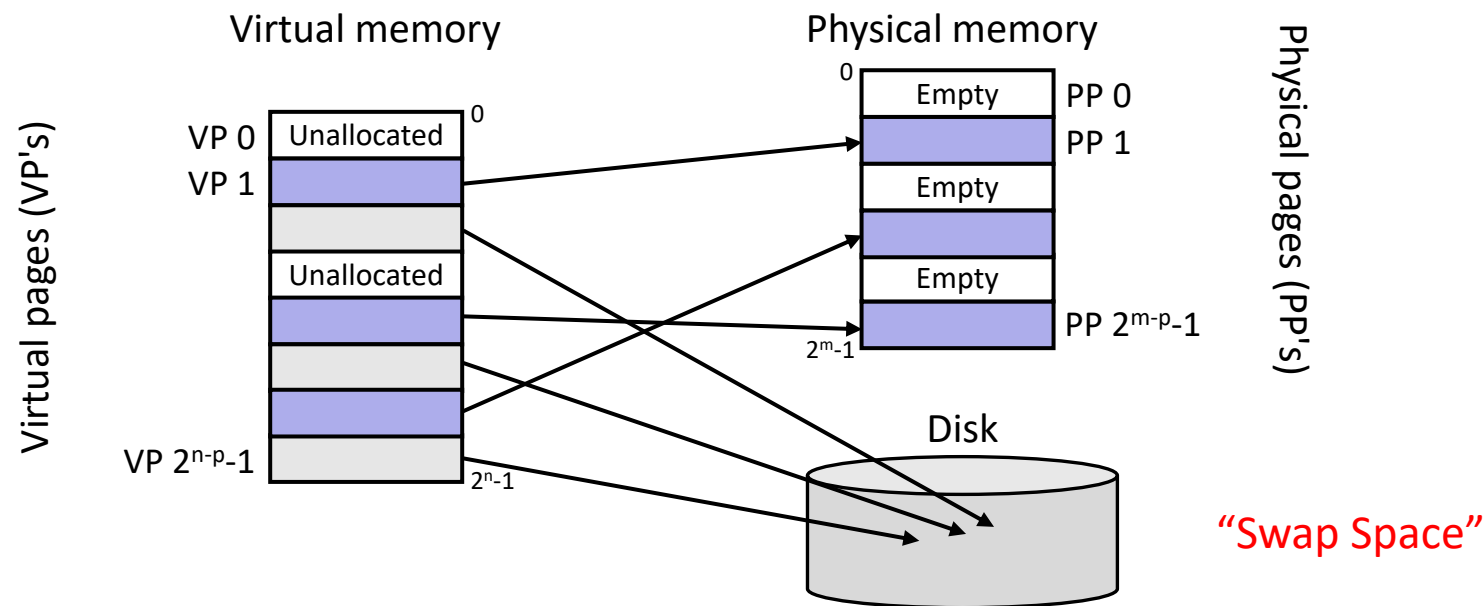
Lesson Summary (1/2)

- ❖ **Virtual memory** is software's perspective (e.g., memory layout), **physical memory** is hardware's perspective (e.g., memory hierarchy)
- ❖ Virtual memory manages the memory for multiple concurrently running processes (implements *protection* and *sharing*)
 - Each process has its own virtual address space that gets mapped into parts of the physical address space
 - When run out of physical address space, put least recently used data in disk



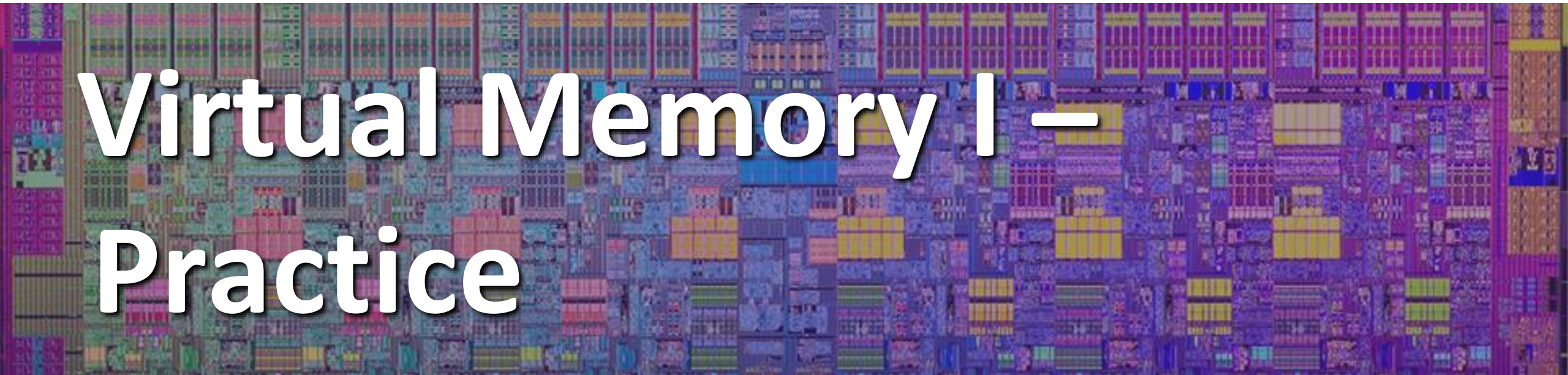
Lesson Summary (2/2)

- ❖ Can think of physical memory as a cache of virtual memory
 - Data is transferred between physical memory and swap space (disk) in **pages**
 - Physical memory has caching parameters and properties
 - Large page size, fully associative, write-back, replacement policy
 - Caveats: virtual pages may not exist, data doesn't have to exist in both physical memory and disk



Lesson Q&A

- ❖ Learning Objectives:
 - Explain the benefits behind why virtual memory is used instead of only physical memory address space.
 - Describe the relationships between virtual memory parameters and policies.
- ❖ 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

A detailed, colorful microchip die image serves as the background for the title. The die is densely packed with various colored regions (purple, blue, yellow, green, red) representing different functional blocks and interconnects.

Virtual Memory I – Practice

Polling Questions (1/2)

- ❖ On a 64-bit machine currently running 8 processes, how much virtual memory is currently available?

- ❖ True or False: A 32-bit machine with 8 GiB of RAM installed would never use all of it (in theory).

Polling Questions (2/2)

- ❖ How many bits wide are the following fields?
 - 16 KiB pages
 - 48-bit virtual addresses
 - 16 GiB physical memory

	VPN	PPN
(A)	34	24
(B)	32	18
(C)	30	20
(D)	34	20

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