CS 415
Operating Systems
Wrap-up and Final Review

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UNIVERSITY OF OREGON

Logistics

- ❑ Discuss remaining topics
    - ❍ Multi-object synchronization
    - ❍ I/O topic
- ❑ Review for final exam
- ❑ Project 3 due Friday, December 1, 11:59pm
- ❑ Final on Tuesday, December 5, 12:30-14:30
- ❑ Extended office hours
    - ❍ Friday, December 1: 14:00-15:00
    - ❍ Monday, December 4: 12:00-14:00

Final Exam

- ❑ Format
  - ❍ Closed book, but can have 2 page of note (front and back)
  - ❍ No computers, phones, tablets, or electronic devices
- ❑ No programming will be required in any answer
- ❑ Structure (very similar to midterm)
  - ❍ Multiple sections (each on a topic)
  - ❍ Each section has two parts
  - ❍ Part 1: Concepts
    - ◆ each question is intended to take limited time to answer
    - ◆ includes true/false, multiple choice, short answer, …
  - ❍ Part 2: Problems
    - ◆ intended to involve a bit more thinking and more time
    - ◆ include more "essay" answers (i.e., more writing

What did we cover this term? (Before Midterm)

Topic	Lecture
❑ *Overview*	
○ Chapter 1 – Introduction	1: Introduction
○ Chapter 2 – Operating System Structures	2: OS architecture / System Calls
❑ *Process Management*	
○ Chapter 3 – Processes and IPC	3: Processes 4: IPC
○ Chapter 4 – Threads	5: Threads
○ Chapter 5 – CPU Scheduling	6: Scheduling
❑ *Process Synchronization*	
○ Chapter 6 – Synchronization Tools	7: Synchronization
○ Chapter 7 – Synchronization Examples	
○ Chapter 8 – Multi-Resource Allocation	8: Deadlocks

covered on midterm

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What did we cover this term? (After Midterm)

Topic	Lecture
❑ *Process Synchronization*	
○ Chapter 8 – Multi-Resource Allocation	8: Deadlocks
❑ *Memory*	
○ Chapter 9 – Main Memory	9: Memory
○ Chapter 10 – Virtual Memory	10: Paging
	11: VM
❑ *File System*	
○ Chapter 13 – File System Interface	12: File system theory
○ Chapter 14 – File System Implementation	13: File system
○ Chapter 15 – File System Internals	Implementation
❑ *Storage Management*	
○ Chapter 12 – I/O Systems	14: I/O Systems

What topics are "fair game" for final?

❑ No specific questions on topics before the midterm
  ❍ You must have an understanding of these topics

❑ Emphasis will be on materials after midterm!!!
  ❍ Also include multi-resource allocation (deadlocks)
  ❍ Memory management
    ◆ main memory
    ◆ virtual memory
  ❍ File systems
    ◆ theory
    ◆ implementation
  ❍ I/O system

Study Advice

❑ Read book

❑ Review lectures slides and Zoom recordings

   o Please DO NOT print lecture slides – save the forest!

❑ Think about concepts

❑ You do not need to know <u>specific</u> details that pertain to <u>specific</u> operating systems, as described in the OSC book

Deadlocks

❑ Understand the issues with multi-resource synchronization

❑ What is the multi-resource deadlock problem?

❑ What are the solution approaches:

    ○ Deadlock prevention

    ○ Deadlock avoidance

        ◆ Banker's algorithm

    ○ Deadlock detection and recovery

❑ Easy topic to write a problem for this topic

Main Memory
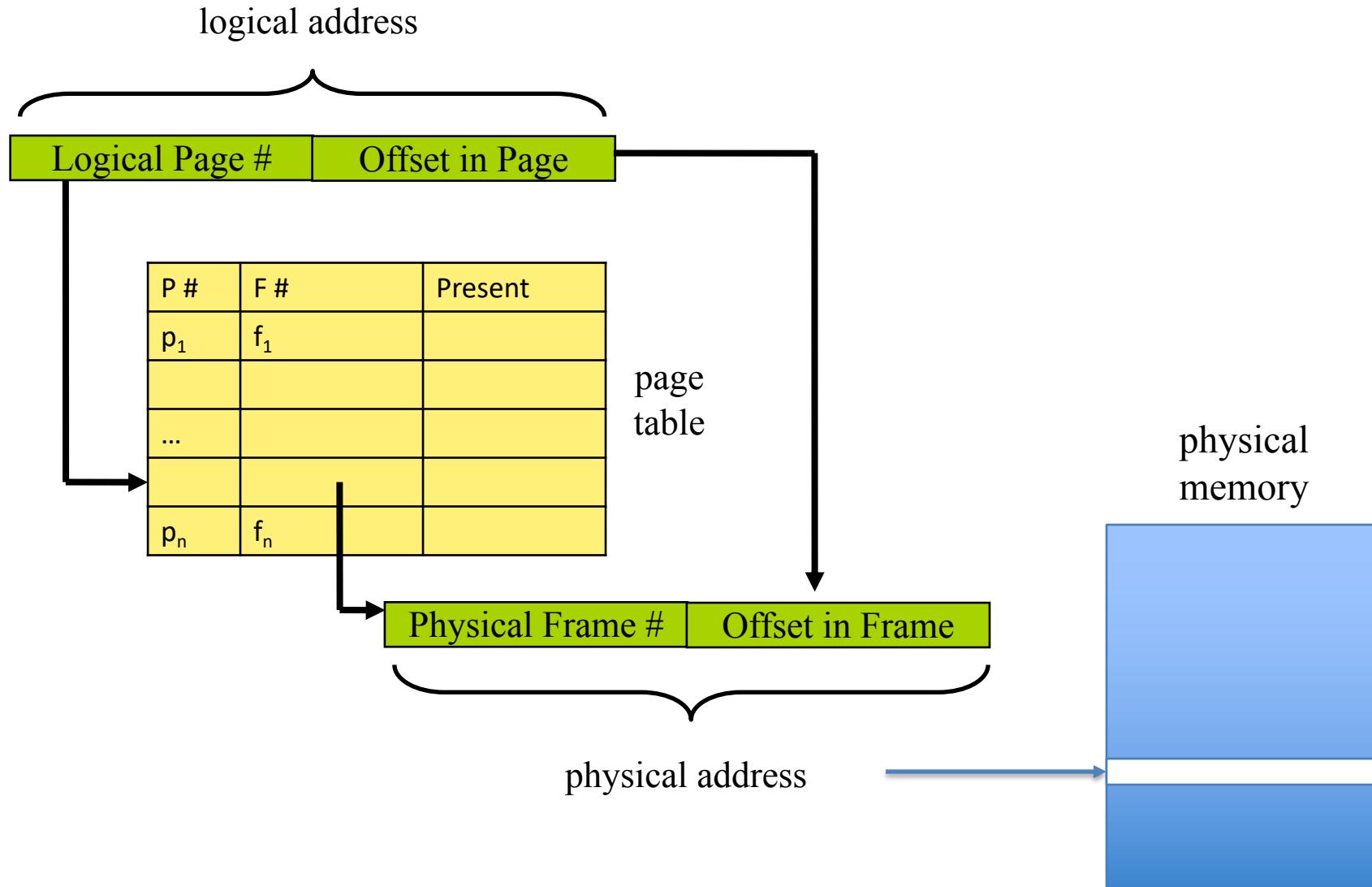
❑ Swapping
❑ Allocation
  ❍ Contiguous versus non-contiguous
    ◆ segmentation, paging, …
  ❍ Algorithms
❑ Fragmentation
  ❍ Type: internal, external
❑ Memory address translation
  ❍ Memory access time
❑ Paging
  ❍ Page table, entries, …
  ❍ TLB (translation lookaside buffer)

Page-based Memory Allocation

❑ Programs are provided with a logical address space

❑ Role of the OS to fetch data from either physical memory or disk

  ○ Done by a mechanism called (demand) paging.

❑ Divide the logical address space into units called (logical) "pages" each of which is of a fixed size (usually 4K or 8K)

  ○ Example: 1M virtual address space has 256 4K pages

❑ Divide physical address space into (physical) "frames" each the same size as a page

  ○ Examples: we might have only 32 4K-sized pages

Address Translation – Page Tables

logical address

Logical Page #	Offset in Page

P #	F #	Present
p_1	f_1	
...		
p_n	f_n	

page table

physical memory

Physical Frame #	Offset in Frame

physical address

Virtual Memory

- ❑ What is virtual memory?
- ❑ Page fault handling
  - ○ Performance estimations
  - ○ Memory initialization
- ❑ Page replacement
  - ○ Algorithms
  - ○ Belady's anomaly
- ❑ Aspects of virtual memory
  - ○ When to update: copy-on-write
  - ○ Sharing: shared pages between processrs
  - ○ Use with I/O: memory-mapped files
- ❑ Thrashing
- ❑ Working sets

Page Fault Handling

❑ If there is a reference to a page, first reference to that page will trap to operating system:

  ○ Page fault

❑ Operating system looks at another table to decide:

  ○ Invalid reference? Yes, abort

  ○ Just not in memory?

❑ Get empty frame

❑ Swap page into frame

❑ Reset tables

❑ Set validation bit = *v* (valid)

❑ Restart the instruction that caused the page fault

File Systems

❑ File system concepts
  ○ File system layers
  ○ Files, directories, file systems,
  ○ Operations and usage
  ○ Remote file systems (did not really cover)

❑ File system implementation
  ○ What's on the disk?
  ○ What's in memory?
  ○ Control blocks

❑ File system usage
  ○ File allocation
  ○ Getting a file caching
  ○ Free space management
  ○ Recovery (did not really cover)

I/O Systems

❑ I/O hardware

　○ Devices

　○ Controllers

❑ Interfacing with I/O devices

　○ Polling, interrupts

　○ DMA

❑ Types of I/O operation

　○ Blocking / Nonblocking

　○ Synchronous / Asynchronous

❑ I/O system structure in OS

Course Grading

❑ All scores (exams, projects, labs) are used to determine the final score based on scoring model

❑ A curve of the final scores will be used to determine the letter grade

Planning your UO Career

❑ If you are interested in what you have learned in this class and want to study more about systems, think about these courses (unless you are graduating):

- ○ CIS 429/529: Computer Architecture
- ○ CIS 432: Networking
- ○ CIS 433: Computer and Network Security
- ○ CIS 431/531: Parallel Computing

❑ Also, take a look at seminars and reading groups

❑ Think about your future and what you want to do

- ○ Take advantage of resources you have at your disposal
- ○ Consider working with a professor on a systems project!

Thanks to ...
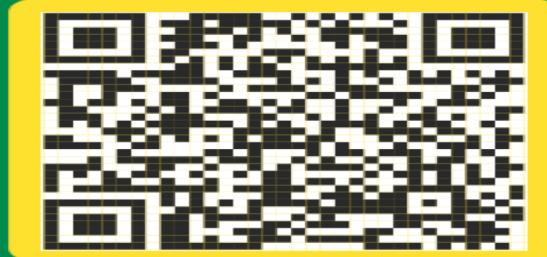
- ❑ Teaching Assistants
  - ○ Alex
  - ○ Dewi
- ❑ You!
  - ○ CIS 415 is not an easy course
  - ○ It takes a lot of effort
  - ○ I hope you learned something from it all
- ❑ Good luck next Tuesday!
- ❑ I hope you all have a nice holiday!
- ❑ Stay healthy
- ❑ It was a pleasure being your instructor