

CSE 120

Principles of Operating Systems

Fall 2023

Final Review

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Review Q&A Session

- Monday (Dec 11) at 3pm
 - ◆ To bypass room scheduling hassles, we'll do it over zoom
 - ◆ Same format at the midterm review
 - ◆ Bring your questions and I will answer them
- Replaces my Monday office hours

Related Courses

- If you enjoy CSE 120 topics, you might find some other courses interesting going forward
- CSE 123: Networking (WI24)
- CSE 124: Networked Services (likely FA24 or WI25)
- CSE 125: Software System Design & Impl. (SP24)
- CSE 127: Computer Security (WI24, SP24)

Overview

- Final mechanics
- Memory management
- Paging
- Page replacement
- File systems
- Protection
- The End

Final Mechanics

- Tue Dec 12 8–11am in MOS 0113
- Most of the final covers material after the midterm
 - ♦ Lectures Nov 2 – Nov 28: VM, file systems, protection
 - ♦ Projects 2 & 3, Homeworks 3 & 4
- Some material on concurrency, synchronization
 - ♦ Synch primitives, synch problems
- Based upon lecture material, homeworks, and project
- **Closed book, one double-sided 8.5"x11" page of notes**
 - ♦ Can be typed or hand-written, must be single layer
 - ♦ No devices (calculators) or any other materials
 - » We do expect everyone to be familiar with binary, hex notation
- **Obligatory: Please, do not cheat**

Study Strategy

- Quickly review slides for lectures 10/3–10/26, hw #1-2
 - ◆ Good for context
 - ◆ Will be surprised how much sense it makes now
- Review **synchronization primitives and problems**
- Focus on lectures 11/2–11/28, hw #3-4, projects #2-3
 - ◆ Remaining lectures not on the final

Memory Management

- Why is memory management useful?
 - ♦ Why do we have virtual memory if it is so complex?
- What are the mechanisms for implementing MM?
 - ♦ Physical and virtual addressing
 - ♦ Partitioning, paging, and segmentation
 - ♦ Page tables, TLB
- What are the policies related to MM?
 - ♦ Page replacement
- What are the overheads related to providing memory management?

Virtualizing Memory

- What is the difference between a physical and virtual address?
- What is the difference between fixed and variable partitioning?
 - ◆ How do base and limit registers work?
- What is internal fragmentation?
- What is external fragmentation?
- What is a protection fault?

Paging

- What are the advantages/disadvantages of paging?
- What are page tables?
- What are page table entries (PTE)?
- Know these terms
 - ◆ Virtual page number (VPN), physical page number (PPN)/page frame number (PFN), offset
- Know how to break down virtual addresses into page numbers, offset
- How have you implemented paging in Nachos?

Page Table Entries

- What is a page table entry? (In Nachos?)
- What are all of the PTE bits used for?
 - ◆ Modify (dirty)
 - ◆ Reference (used)
 - ◆ Valid
 - ◆ Protection

Segmentation

- What is segmentation?
- How does it compare/contrast with paging?
- What are its advantages/disadvantages with respect to paging?
- What is a segment table?

Page Tables

- Page tables introduce overhead
 - ◆ Space for storing them
 - ◆ Time to use them for translation
- What techniques can be used to reduce their overhead?
- How do two-level (multi-level) page tables work?

TLBs

- What problem does the TLB solve?
- How do TLBs work?
- Why are TLBs effective?
- How are TLBs managed?
 - ◆ What happens on a TLB miss fault?
- What is the difference between a hardware and software managed TLB?

Page Faults

- What is a page fault?
- How is it used to implement demand paged virtual memory?
- What is the complete sequence of steps, from a TLB miss to paging in from disk, for translating a virtual address to a physical address?
 - ♦ What is done in hardware, what is done in software?

Advanced VM Topics

- What is shared memory?
- What is copy on write?
- What are memory mapped files?

Page Replacement

- What is the purpose of the page replacement algorithm?
- What application behavior does page replacement try to exploit?
- When is the page replacement algorithm used?
- Understand
 - ♦ Belady's (optimal), FIFO, LRU, Approximate LRU, LRU Clock
- What is thrashing?

Disk

- Can skip physical disk structure, characteristics
 - ◆ High-level point is that accessing disks is very slow relative to accessing memory

File Systems

- Topics
 - ◆ Files
 - ◆ Directories
 - ◆ Sharing
 - ◆ Implementation
 - ◆ Buffer Cache
- What is a file system?
- Why are file systems useful (why do we have them)?

Files and Directories

- What is a file?
 - ◆ What operations are supported?
 - ◆ What characteristics do they have?
 - ◆ What are file access methods?
- What is a directory?
 - ◆ What are they used for?
 - ◆ What is a directory entry?

File Buffer Cache

- What is the file buffer cache, and why do operating systems use one?
- What is the difference between caching reads and caching writes?
- What are the tradeoffs of using memory for a file buffer cache vs. VM?
- How can we use the file buffer cache for read ahead?

File System Implementation

- How do we manage information on disk?
 - ◆ What are advantages of using disk blocks?
 - ◆ What kind of fragmentation does it have?
- What are bitmap blocks used for?
- What is the superblock?

File System Layouts

- What are file system layouts used for?
- What are the general strategies?
 - ♦ Contiguous, linked, indexed?
- What are the tradeoffs for those strategies?
- What is an inode?
 - ♦ How are inodes different from directories?
- How are inodes and directories used to do path resolution, find files?

File Operations

- How do soft links work?
- How do hard links work?
- How does create work?
- How does delete work?
- How does rename work?
- How do we stitch together multiple file systems into a single, global name hierarchy?

Protection

- What are the principles of protection?
- How is user identity used in protection?
- What is file protection used for?
 - ◆ What are access control lists (ACLs)?
 - ◆ How are they represented, implemented?
- How does protection work with running processes?
 - ◆ How do we check whether a process is allowed to use files, memory?
 - ◆ What are capabilities?
 - ◆ How do we derive capabilities from ACLs?
 - » Why open, then read/write?
 - ◆ What are advantages/disadvantages of ACLs & capabilities?

Final Thoughts

- Any remaining questions?
- Just a few final things...

The End

- Congratulations on finishing CSE 120!
 - ◆ It's a challenging course, but I hope you found it worthwhile
 - ◆ ... and that you now look at OSeS in a completely new way
- **Good luck, and thanks for a great class!**