

CS 318 Principles of Operating Systems

Fall 2018

Lecture 22: Final Review

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WHITING SCHOOL
of ENGINEERING

Administrivia

- **Lab 4**
 - Deadline is next Monday (12/10) 11:59pm
 - Most groups should still have late hour remaining
- **Extra office hour today for Lab 4 from 3-4pm**
- **If a member in your team isn't being responsible, please let me know. I'll handle the case.**
 - Don't suffer in silence for fear of not being nice.
 - This is about fairness.
- **Homework 4 and 5 are released**
 - Do them to prepare for the final exam

Course Plug

- **If you enjoy CS 318 topics, consider the advanced OS course 😊**
 - **601.718: Advanced Operating Systems**
 - Studying different system structures and different operating systems from design point of view by reading classic and recent papers
 - Focus more on reading, design, and research
 - Less load on coding
 - Not offered this Spring but will be next Spring
 - Syllabus of last offering: <https://cs.jhu.edu/~huang/cs718/spring18/syllabus.html>

Final Mechanics

- **Date & Location: Dec. 21st (Friay), 9am-12pm @ classroom**
- **Closed book, *one double-sided 8.5”x11” page of notes***
- **Bulk of the final covers material after midterm**
 - Memory management, file systems, advanced topics
- **Some material on concurrency, synchronization**
 - Synch primitives, basic synch problems
- **Based upon lecture (textbook), homework, and project**
 - Same format as midterm exam
- **Again, please, do not cheat**

Overview

- Final mechanics
- **Memory management**
- **Paging**
- **Page replacement**
- **Disk I/O**
- **File systems**
- **The End**

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 (1)

- **What are the issues with physical addressing?**
 - Protection, transparency, resource exhaustion
- **What are the goals of virtual memory?**
- **What are the advantages of virtual memory?**
- **What is the difference between a physical and virtual address?**
- **Which component does the translation and management?**

Virtualizing Memory (2)

- **How does load-time linking work?**
 - What are its advantages and disadvantages?
- **How does partitioning work?**
 - Fixed-sized partitioning (base)
 - Variable-sized partitioning (base + bound registers)
 - What are its advantages and disadvantages?
- **What is internal fragmentation?**
- **What is external fragmentation?**

Segmentation

- **What is segmentation?**
- **What is a segment table?**
- **How is virtual address translated with segmentation?**
- **What are its advantages and disadvantages?**
- **How does it compare/contrast with paging?**
- **How can paging and segmentation be combined?**

Paging

- **How is paging different from partitioning?**
- **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 Pintos?**

Page Table Entries

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

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?**
- **Know how to break down virtual addresses into page directory, page numbers, offset**

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 Mem Management

- **What is shared memory?**
- **What is copy on write?**
 - Why is CoW useful?
- **When is copy on write used?**
- **What are memory mapped files?**
 - What is the benefit of memory mapped file?
 - What is its drawback?

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, Working Set, Page Fault Frequency
- **What is thrashing?**

Dynamic Memory Allocation

- **What does dynamic memory allocator do and what it cannot do?**
- **What are the decisions to make?**
- **What is the strategy of a best-fit and first-fit allocator, respectively?**
 - What the potential problems for them
- **Why is buddy allocator proposed?**
- **Why is slab allocator proposed?**

Disk

- **Understand the memory hierarchy concept, locality**
- **Physical disk structure**
 - Platters, surfaces, tracks, sectors, cylinders, arms, heads
- **Disk interface**
 - How does the OS make requests to the disk?
- **Disk performance**
 - What steps determine disk request performance?
 - What are seek, rotation, transfer?
- **Disk scheduling: FCFS, SSTF, SCAN, C-SCAN**

File Systems

- **Topics**
 - Files
 - Directories
 - Sharing
 - Protection
 - Layouts
 - 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?
 - How are they implemented?
 - What is a directory entry?
- **How are directories used to do path name translation?**

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?**
- **How do those strategies reflect file access methods?**
- **What is an inode?**
 - How are inodes different from directories?
 - How are inodes and directories used to do path resolution, find files?

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?**

Protection

- **What is file protection used for?**
- **How is it implemented?**
- **What are access control lists (ACLs)?**
- **What are capabilities?**
- **What are the advantages/disadvantages of each?**

Advanced Topics

- **What is FFS, and how is it an improvement over the original Unix file system?**
- **What is LFS, and how is it an improvement over FFS?**
- **What is RPC, how is it implemented and what are the complications to make it work in reality?**
- **What are the design considerations for mobile OS, and how does Android manage apps in terms of processes?**
- **What is the measure for reliability, and how to systematically find bugs in system software?**

Summary

- **Any remaining questions?**

Concluding Remarks

- Congratulations on surviving CS 318!



Concluding Remarks

- **It's a challenging course**
 - It takes courage and hard core to carry it through
- **But I hope you found it worthwhile**
 - ... and that you look at OSeS in a completely new way

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Acknowledgement

- **Thank you for being the guinea pigs**
 - **Please fill out the course survey so the course can be improved next time**
- **Special thanks to students who regularly attend the class**
 - It means a lot and makes the lecture more fun to present
- **Appreciate the tremendous help from Chang, Will and Zach**
 - This is a challenging course for both students and the CAs
 - They spread the much of the load to make the course possible

Take-Away Messages

- **The devil is in the detail**
 - building systems needs elegant ideas, but just having ideas is far from enough
- **Never underestimate the power of abstraction & indirection**
 - “All problems in computer science can be solved by another level of indirection”



Take-Away Messages

- **The devil is in the detail**
 - building systems needs elegant ideas, but just having ideas is far from enough
- **Never underestimate the power of abstraction & indirection**
 - “All problems in computer science can be solved by another level of indirection”
- **Hack like a champion**
 - You’ve gone through the dark side, and few software is as complex as the OS
 - Dare to modify/reinvent any “mysterious” software if it doesn’t satisfy your need
 - “Every good work of software starts by scratching a developer's personal itch.”
- **System thinking**
 - Even if you forget how OS works, I hope you develop the habit of system thinking

The End

Good luck, and thanks for a great semester!