CSE 120
Principles of Operating Systems

Fall 2020

Final Review

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Additional Review Session

- Monday (Dec 14) 3pm
  - Bring your questions and I will answer them
  - I'll post the zoom link on piazza

- 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 (wi21, sp21)
- CSE 124: Networked Services (likely fa21)
- CSE 125: Software System Design & Impl. (sp21)
- CSE 127: Computer Security (wi21, sp21)

Overview

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

Final Mechanics

- Morning 8–11am or Night 8–11pm
- Most of the final covers material after the midterm
  - Lectures Nov 10 – Dec 3: VM, file systems, protection
- 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
  - Can use blank file (editor, Google doc) for local scratch

- Obligatory: Please, do not cheat

Study Strategy

- Quickly review lectures 10/6–10/27, hw #1-2
  - Good for context
  - Will be surprised how much sense it makes now

- Review synchronization primitives and problems
- Focus on lectures 11/10–12/3, 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

- 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 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 partitioning, paging?
- What is a segment table?
- How can paging and segmentation be combined?

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

Disk

- Understand the memory hierarchy concept, locality
- Disk performance
  - What steps determine disk request performance?
  - What are seek, rotation, transfer?

- Can skip physical disk structure, characteristics

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 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 master block (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?

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?

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…