Reminder

- **Midterm Monday**
- **Covers:**
  - Mostly readings and lectures
  - May reference lab—e.g., assume you understand NFS3
- **Open Book**
  - Make sure you bring copies of all papers and handouts
  - You can print out and bring class notes, too
Socket I/O

- **By default socket I/O is synchronous**
  - Read will block until there is some data to return
  - Write will block if kernel socket buffer is full

- **Traditional servers get concurrency with processes**
  - For TCP: Parent in accept, fork, close loop
  - Okay for single-client child to block in read/write

- **Other option: Non-blocking I/O** *(make_async)*
  - Read and write return EAGAIN instead of blocking
  - But disk I/O still synchronous (unless you use NFS)
Disk scheduling

- **Sequential transfer speeds fast** (>10MB/sec)
- **Seek times slow**
  - Short seeks \(\sim 1\) ms (settle time), long seeks \(\geq 15\) ms
- **Schedule disk to improve seek time**
  - Closer logical block numbers often physically closer (truest at larger distances when head movement dominates)
  - OS should attempt multiple requests near each other (CSCAN)
  - Disk can optimally schedule requests (*command queuing*)
  - The more requests the OS has, the better it can do
Deceptive idleness

- Request locality often exists within a process
  - Competing processes can cause much longer disk seeks
  - But each process doesn’t always have a request outstanding
    (Takes short time after previous request to generate next)

- Idea: Delay requests in case closer one generated
  - Decision based on cost benefit analysis
UBM

- Optimal: Evict block needed furthest in future
- LRU works well for most workloads, except
  - Sequential (will never look at data again)
  - Looping (MRU is best to evict)
- Detection: sequential, looping, or other
- Replacement: MRU for seq. & loop, LRU for other
- Allocator: Chose pool based on marginal gain
- Cylinder groups: Put directories, inodes near files
- Write allocation: Try to write in big (64K) contiguous chunks
Shadow paging

- **Idea:** Never overwrite blocks in place
  - Keep page table mapping logical to actual block #s
  - Always write new copy of blocks (copy-on-write)
  - Update pointer to page table atomically

- **LFS**
  - Checkpoint & reset root every 30 seconds (consistent)
  - Can roll forward to lose less than 30 seconds

- **System R**
  - Transactions may be in progress at file update (inconsistent)
  - File root block also points to last checkpoint in log
  - Why use shadow paging?
Logging

- **Log-structured storage (LFS)**—Data lives in log

- **Write-ahead logging**
  - Separate log and “permanent” location for data
  - Always write log before permanent location
  - After crash, replay log—updates must be idempotent

- **Do/undo/redo**
  - Updates possibly not idempotent (e.g., external interactions)
  - Must undo “losers”, redo “winners”
XFS

• Tricks for good contiguous allocation
  - Delay allocation until write-back (more to coalesce)
  - Use (position, length) extents instead of block pointers
  - B-tree free map lets you find blocks near desired location

• Journaling for fast crash recovery
  - Also allows metadata write-behind
Soft updates

• Three rules of crash recovery
  1. Never write pointer before initializing structure
  2. Never reuse block before nullifying pointers to it
  3. Set new pointer to live resource before clearing old

• Undo any violations of rules before writing block

• Delay some updates until other blocks written
AFS

- **Whole file caching w. close-to-open consistency**
  - Client can keep large on-disk cache

- **Designed to scale to many clients**
  - Callbacks – many opens don’t go to server
  - Directory caching, w. component-by-component lookup

- **Break cell up into a number volumes**
  - Like a mini-file system that can be resized, moved
  - Copy on write mechanism helpful for backup, migration
  - Volume location server replicated at AFS servers, tells clients where to find a particular volume
SFS

- Goal, access any server from any client, securely
- Idea: Make file system security independent of key management
- Specify server keys in *self-certifying pathnames*: `/sfs/@sfs.mit.edu,bzcc5hder7cuc86kf6qswyx6yuemnw69/dm/`
- Allows multiple key management schemes to coexist
  - Local symbolic link place by system administrator
  - Use password to download path securely from server
  - Remote symbolic link offers delegation