ECE 531 – Advanced Operating Systems
Lecture 29

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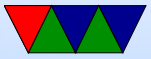
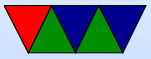
Announcements

- Homework #7 will be posted today
  - Issues getting it to work (7 year old poorly commented code)
  - when 1:1 VM kernel/user protection it means you need to have two separate pools for allocating memory, one for kernel and one for user
  - the idle task runs in kernel space so you have to make sure it's set up to do that properly
  - weird bugs when dcache turned on. Still haven't



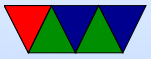
figured out why yet. Turned off for now

- Did write better kernel panic handler though (move irqs to have assembly rather than C functions)

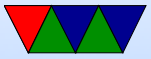


Project Status Reports

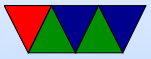
- Due Friday the 21st
- Send e-mail, one per group
  - Group members
  - Brief summary of project
  - Brief status on how it is going
  - Which day you want to present (Wednesday or Friday)
  - **Related Work** find two per group member. Can be academic paper, website, book, blog. Write a sentance or two on each, how it relates to your project, and then



do a proper citation

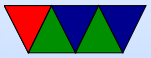


More Filesystems



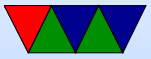
Low-level Disk Layout

- Often a MBR (master boot record) and partition table
- Disks divided into partitions. Why?
  - Split up system (/, /boot, /usr, /home)
  - Why is boot separate? Smaller so boot loader can access, maybe a different fs type.
  - Also if Dual-booting operating systems
  - Can have swap partitions



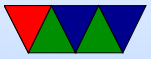
Filesystem – High Level On Disk

- A header containing master info (often called the superblock)
- Some sort of free list, saying what areas are free (bitmap or pointers)
- inodes, an array of data structures containing master info for each file (and if file is small, contents of file)
- Directory info: root directory entry, directory layout
- Actual file data



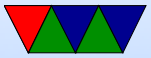
Filesystems – System Calls

- `mount()` – to take a filesystem and make it appear in the filesystem namespace (looks like a directory; on Windows traditionally have a drive letter instead, C:, D:, etc)
- `umount()` – unmounts filesystem
- `statfs()` gives info on filesystem (including disk space, `df`)



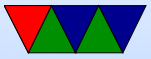
File Layout – How Are Blocks Allocated

- When a file is on disk it might span multiple disk blocks
- Some sort of data structure is used to find them
- Also to allocate new blocks to grow/shrink a file
- What follows are a few common ways of doing this



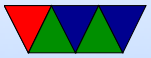
File Layout – Contiguous

- Files in consecutive blocks.
- Simple. Fast to read (just read X blocks)
- Has fragmentation problems like with memory alloc.
- What happens if append to file?
- Ever used? read-only, CD-ROMs, romfs



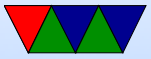
File Layout – Linked List

- Inode points to first part, each block points to next.
- No fragmentation, seeking through file involves lots of reads.
- Waste part of block size for next pointer



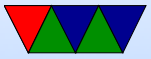
File Layout – File Allocation Table

- Like linked list, but the links are stored in a separate area on disk
- Can also instead have the pointers in one single block, each pointing to next block.
- Whole thing has to be in memory at once. Makes it faster (no need to do lots of disk reads on seek) but problem if structure is big



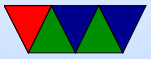
File Layout – Inode table

- Special structure named inode that holds file attributes and list of blocks.
- If need more blocks then fit, last one points to another block with more.
- Only has to be in memory if file is open



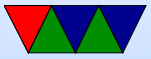
File Layout – Database

- Treat disk as if it were a database, with the files the info you want to retrieve



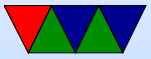
Folder / Directories

- Typically have a hierarchical way of search for files
- A “root” directory that you start path searches from
- Inside the directory are many files, but also sub-directories



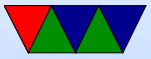
Directories – Filename Size

- How big can a filename be?
  - Fixed (small) like FAT 8.3
  - Fixed (large)
  - Dynamically sized, meaning directory entry size is variable



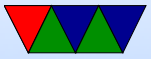
Directories – Path Size

- Also have to track path size, which is the full path to a file
- Something like `/home/bob/hw4/hw4.txt`
- Linux `PATH_MAX` is typically 4096 bytes
- Windows by default 260 (unicode?). Can be extended to 32,767



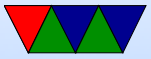
Directories Filename Lookup

- Linear search (can be slow on large directories)
- Some sort of tree
- Hashtable



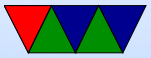
Directories – Where to store metadata?

- Where to store attributes?
  - In the directory entry (FAT)
  - In the inode



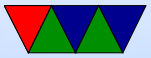
Shared Files (Linking)

- What if you want to share files? Two names for same file?
- Can be useful to link directories together too
- More common on Unix though Windows has some support



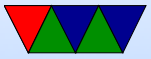
Symbolic Links

- Make with `ln -s dest src`
- Can link to files on other filesystems
- Downside, have to traverse link
- if original file removed end up with broken links
- Takes more disk space (extra inode/file)



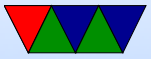
Hard Links

- different directory entries can point to same inode
- essentially, a file/directory can have more than one name
- This is why filename is in dir entry but everything else in inode on UNIX/Linux
- Trouble: what if create circular links in filesystem?
- What if backing up filesystem or doing a search, can see same file multiple times

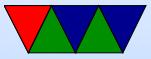


Deleting Files on Linux

- Since file can have multiple names you don't delete it but rather unlink the name
- This is why delete on Linux is called "unlink"
- You are just decrementing the link count.
- What happens when link count goes to zero?
  - If the file is not open, it gets deleted
    Note this is forever, no recycle-bin
  - If file is open it is removed from the namespace but it is kept around until the last program closes it



- This keeps programs from crashing if an open file removed
- This includes a running executable, which is considered open while the program is running
- This is why on a Linux upgrade instead of over-writing executables, what actually happens is old files are moved and deleted with new ones put in their place



Disk Quotas

- Don't hear about them much any more, but on a shared system constantly running out of disk space.
- When undergrad, shared mail server, 7MB of disk quota
- Structure on disk with quota limits, checks on file access to make sure not go over.