Review 2

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Synchronization

- Exam will be closed-book
  - ***But you may bring a 1-sided 8.5x11 sheet of notes***
    - 6 point font or larger :-)
  - ***Weakly*** non-cumulative
    - Emphasis on new material, design questions
    - You will need to use some “old” knowledge
    - We didn't really test on “P2 knowledge” (nor P3)

Synchronization

- About today's review
  - Mentioning key concepts
  - Not exhaustive coverage
  - Reading ***some*** of the textbook is advisable!
- Faculty evaluation forms
- SCS Facilities summer jobs

Read Your Code

- Re-read your P2
- Re-read your P3
- Go over feedback
- Talk about them with your partner
  - Schedule a time
- You should understand “the hard parts”

Core “Phase I” concepts

- Process model
  - You should be a memory-map ***expert***
    - Kernel space, user space, virtual memory
  - Process vs. thread
  - ***Exactly*** what goes on a stack, where it comes from...
- Mutual exclusion
  - mutex, cvar, what's inside, why
- Concurrency
- Deadlock

IPC

- Communicating process on one machine
- Naming
  - Name server?
  - File system?
- Message structure
  - Sender id, priority, type
  - Capabilities: memory region, IPC rights
- Synchronization/queueing/blocking

IPC

- Group receive
- Copy/share/transfer
- A Unix surprise
  - sendmsg()/recvmsg() pass file descriptors!

RPC Overview

- RPC = Remote Procedure Call
- Extends IPC in two ways
  - IPC = Inter-Process Communication
    - OS-level: bytes, not objects
  - IPC restricted to single machine
- ***Marshalling***
- Server location

RPC Overview

- Call semantics
  - Asynch? Batch? Net/server failure?
- Client flow, server flow
  - Stub routines, dispatch skeleton
- Java RMI

Marshalling

- Values must cross the network
- Machine formats differ
  - Integer byte order
    - www.scieng.com/ByteOrder.PDF
  - Floating point format
    - IEEE 754 or not
  - Memory packing/alignment issues

Marshalling

- Define a “network format”
  - ASN.1 - “self-describing” via in-line tags
  - XDR – not
- “Serialize” language-level object to byte stream
  - Rules typically recursive
    - Serialize a struct by serializing its fields in order
  - Implementation probably should ***not*** be

Marshalling

- Issues
  - Some types don't translate well
    - Ada has ranged integers, e.g., 44..59
    - Not everybody really likes 64-bit ints
    - Floating point formats are religious issues
  - Performance!
    - Memory speed ≅ network speed
  - The dreaded “pointer problem”
    - See lecture notes

File System Interface

- Abstraction of disk/tape storage
  - Records, not sectors
  - Type information
- Naming
  - Directory tree
  - Complexity due to linking
  - Soft vs. hard links

File System Interface

- Mounting
- Ownership, permissions
- Semantics of multiple open()s

Operations on Files

- Create – locate space, enter into directory
- Write, Read – according to position pointer
- Seek – adjust position pointer
- Delete – remove from directory, release space
- Truncate
  - Trim data from end
  - Often all of it
- Append, Rename

File System Layers

- Device drivers
  - read/write(disk, start-sector, count)
- Block I/O
  - read/write(partition, block) [cached]
- File I/O
  - read/write(file, block)
- File system
  - manage directories, free space, mounting

Disk Structures

- Boot area (first block/track/cylinder)
- File system control block
  - Key parameters: #blocks, metadata layout
  - Unix: superblock
- Directories
- “File control block” (Unix: inode)
  - ownership/permissions
  - data location

Memory Structures

- In-memory partition tables
- Cached directory information
- System-wide open-file table
    - In-memory file control blocks
- Process open-file tables
    - Open mode (read/write/append/...)
    - “Cursor” (read/write position)

VFS layer

- Goal
  - Allow one machine to use multiple file system ***types***
    - Unix FFS
    - MS-DOS FAT
    - CD-ROM ISO9660
    - Remote/distributed: NFS/AFS
  - Standard system calls should work transparently
- Solution
  - Insert a level of indirection!

VFS layer – file system operations

```
struct vfsops {
  char *name;
  int (*vfs_mount)();
  int (*vfs_statfs)();
  int (*vfs_vget)();
  int (*vfs_unmount)();
  ...
}
```

Directories

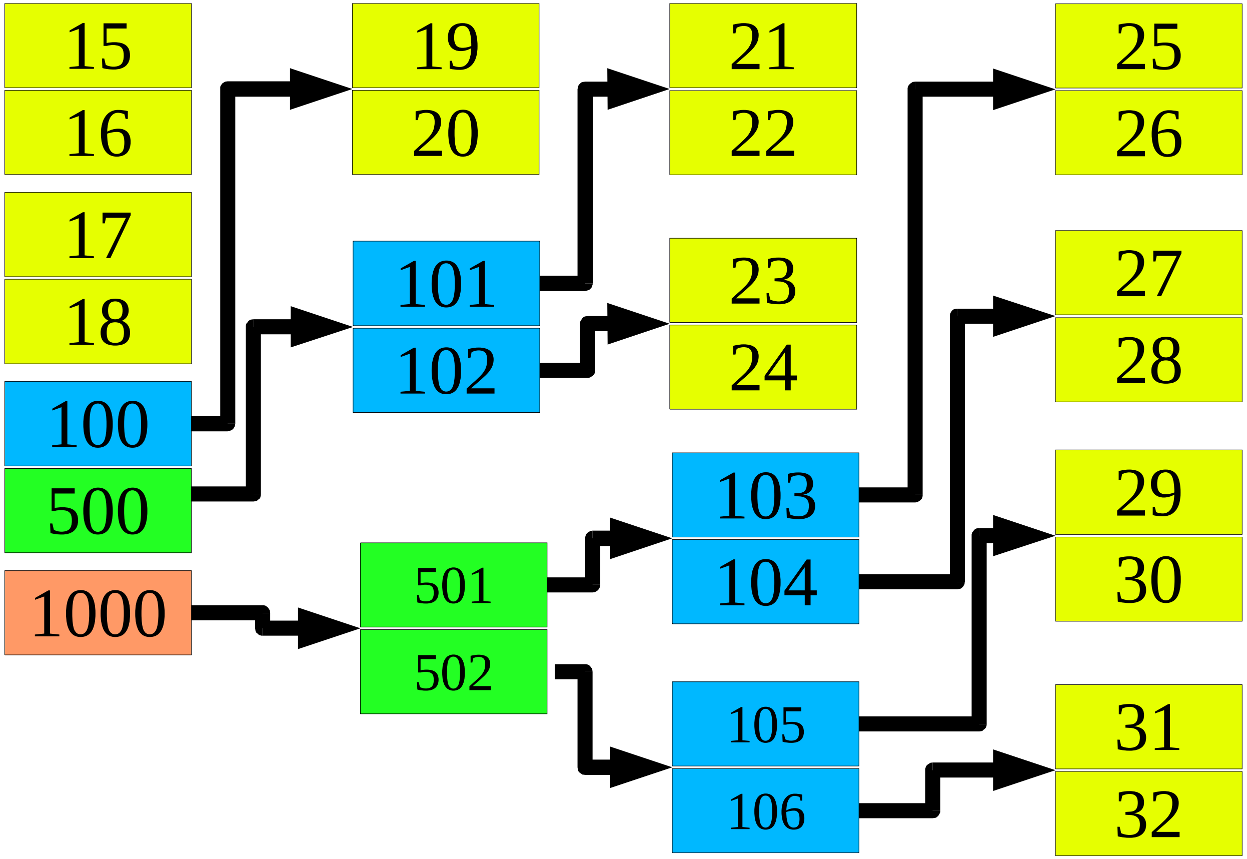
- External interface
  - vnode = lookup(vnode, name)
- Traditional Unix FFS
  - List of (name,inode #) - not sorted
  - Names are variable-length
  - Lookup is linear
    - How long does it take to delete N files?
- Common alternative: hash-table directories

Allocation - FAT

7
2
5
-1
3
-1
0
-1

hello.java	0
dir.c	1
sys.ini	4

Unix Index Blocks



Cache tricks

- Read-ahead

```
for (i = 0; i < filesize; ++i)
  putc(getc(infile), outfile);
```

  - System observes sequential reads
    - can pipeline reads to overlap “computation”, read latency
- Free-behind
  - Discard buffer from cache when next is requested
  - Good for large files
  - “Anti-LRU”

Recovery

- System crash...now what?
  - Some RAM contents were lost
  - Free-space list on disk may be wrong
  - Scan file system
    - Check invariants
      - Unreferenced files
      - Double-allocated blocks
      - Unallocated blocks
    - Fix problems
      - Expert user???

NFS & AFS

- VFS interception
- NFS & AFS
  - Architectural assumptions & goals
  - Namespace
  - Authentication, access control
  - I/O flow
  - Rough idea of rough edges

NFS Assumptions, goals

- Workgroup file system
  - Small number of clients
  - Very small number of servers
- Single administrative domain
  - All machines agree on “set of users”
    - ...which users are in which groups
  - Client machines run mostly-trusted OS
    - “User #37 says read(...)”

NFS Assumptions, goals

- “Stateless” file server
  - Files are “state”, but...
  - Server ***exports*** files without creating extra state
    - No list of “who has this file open”
    - No “pending transactions” across crash
  - Result: crash recovery “fast”, protocol “simple”
- Some “stateful” operations
  - File locking
  - Handled by separate service outside of NFS

AFS Assumptions, goals

- Global distributed file system
  - Uncountable clients, servers
  - “One AFS”, like “one Internet”
    - Why would you want more than one?
- Multiple administrative domains
  - username***@cellname***
  - davide@cs.cmu.edu de0u@andrew.cmu.edu

AFS Assumptions, goals

- Client machines are un-trusted
  - Must ***prove*** they act for a specific user
    - Secure RPC layer
  - Anonymous “system:anyuser”
- Client machines have disks
  - Can cache whole files over long periods
- Write/write and write/read sharing are rare
  - Most files updated by one user, on one machine

AFS Assumptions, goals

- Support ***many*** clients
  - 1000 machines could cache a single file
  - Some local, some (very) remote

AFS Callbacks

- Observations
  - Client disks can cache files indefinitely
    - Even across reboots
  - Many files nearly read-only
    - Contacting server on each open() is wasteful
- Server issues ***callback promise***
  - If this file changes in 15 minutes, I will tell you
    - ***callback break*** message
  - 15 minutes of free open(), read()

Disk scheduling

- Spinning platter/waving arm model
- Seek time vs. rotational latency
- FCFS, SSTF, SCAN, LOOK, C-SCAN, C-LOOK, SPTF, WSPTF
- Fairness, mean response time, variance, starvation
- Freeblock scheduling
  - Concept

Disk Array Overview

- Historical practices
  - Striping, mirroring
- The reliability problem
  - More disks ⇒ ***frequent*** array failures
  - ***Cannot*** tolerate 1/N reliability
- Parity, ECC, why parity is enough
  - Erasure channels
    - Good terminology to display at parties

Disk Array Overview

- RAID “levels” (really: flavors)
  - Understand RAID 0, 1, 4 vs. 5
  - What they're good for, why

Protection Overview

- Protection vs. Security
  - Inside vs. outside “the box”
- Objects, operations, domains
- Access control ***(least privilege)***
- 3 domain models
- Domain switch (setuid example)
- Multics ring architecture

Protection Overview

- Access Matrix
  - Concept and real-world approaches
- “Capability revocation is hard, let's go shopping”

Security Overview

- Goals & threats
  - Authentication (impersonation)
  - Secrecy (theft, eavesdropping)
  - Integrity (cracking)
  - Signature (repudiation)
- TEMPEST (and low-tech snooping)

Security Overview

- Malware
  - Trojans, trapdoors
  - Buffer overflow
  - Viruses, worms
- Password files, salt
  - What is the threat, how does the technique help
- Biometrics vs. cheating

Security Overview

- “Understand cryptography”
  - What ***secure*** hashing is good for
  - One-time pad
  - Symmetric (private-key) crypto
  - Asymmetric (public-key) crypto
    - Has private keys and public keys
  - Kerberos
    - Symmetric crypto
    - Central server avoids the n^2 problem

Preparation Suggestions

- Sleep well (***two*** nights)
- Scan lecture notes
- Read any skipped textbook sections
  - Well, the most-important ones, anyway
- Understand the code you turned in
  - Even what your partner wrote
  - What are the hard issues, why?

Preparation Suggestions

- Prepare a sheet of notes
- Read comp.risks & Effective Java
  - Ok, after the exam will suffice
- Don't panic!
  - Budget time wisely during exam
    - (don't get bogged down)

15-410 on One Slide

- What a process/thread ***really is***
  - (the novel version, not the fairy tale)
- Concurrency & synchronization
  - Issues, mechanisms, ***hazards***
- How the pieces of hardware fit together
- A sense of “what's out there” beyond the kernel
- Skills for non-small software artifacts
  - Design, debugging, partnering
  - Documenting, source control