EEL-4736/5737 Principles of Computer System Design

Final exam review slides

Announcement

- Evaluation – please make sure you enter yours (use today's time)
  - Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/

Final information

- Dec 11th 7:30-9:30am, this room
- Closed book, closed notes
  - You may bring a calculator
- Focus on material discussed in class
- Comprehensive
- Example kinds of questions – similar to midterm
  - Work-out question based on a setup that uses a design principle or system discussed in class
    - Cross-cutting issues;
  - Multiple-choice conceptual questions, similar to quizzes
  - No specific questions about the project

Preparing for the exam

- Review major topics
- Chapter 9 – one question will drill down on more details
- Remaining material – review with emphasis on understanding core concepts and connections/layering among topics
  - E.g. networking, client-server, fault-tolerance and atomicity; naming, memory/storage, virtualization, performance

Preparing for the exam

- One work-out multi-part question on chapter 9
- One work-out multi-part question on cross-cutting issues in storage abstraction, file systems, networking, client-server, performance
- One conceptual multi-part question on various topics covered throughout class
- One set of Multiple-choice questions

Major topics

- General principles to cope with complexity
  - Modularity
  - Abstraction
  - Layering
  - Hierarchy

Major topics

- Fundamental abstractions
  - Memory
    - READ/WRITE interface
    - Naming
  - Interpreter
    - Main interpreter loop
    - Its many instances
  - Communication links
    - SEND/RECEIVE
    - Contrast with the memory abstraction

Major topics

- Naming
  - Need for modularity
  - Name spaces
  - Name-mapping algorithms; resolver
  - Context and references
  - Recursive resolution
  - Naming networks
  - Multiple lookup

Major topics

- Names and layers
  - O/S layers, and their roles
  - System calls
  - Hardware layer – bus
  - Software layer – files

Major topics

- Case study – UNIX file system
  - Hierarchical organization
  - Objects
  - Naming layers: block, file, i-node, …
  - Core API
  - Resolving names
  - Links
  - Implied contexts
  - Search paths

Major topics

- Enforcing modularity with client/service
  - Procedures, stack convention
  - Soft vs. enforced modularity
  - Client/service organization
  - Trusted intermediaries
  - Marshalling
  - RPC
  - Differences w.r.t. procedures
  - Timeouts and semantics

Major topics

- Case study: NFS
  - Client/server organization
  - Relationship to system calls
  - Virtual node layer
  - File handles and object lookup

Major topics

- Virtualization abstractions
  - Role in enforcing modularity
  - Multiplexing, emulation, aggregation
  - Threads
  - Virtual memory
  - SEND/RECEIVE with bounded buffers

Major topics

- Virtual links
  - SEND/RECEIVE primitives
  - Shared buffer and sequence coordination
  - Challenges: multiple writers, multiple-step operations, coherence, ordering
  - Race conditions
  - Locking
  - Read-set-memory and lock implementation; architecture implications

Major topics

- Memory modularity and virtual memory
  - Domains and role of domain register and memory manager
  - Progressively tackling shortcomings
    - Multiple domains
    - Memory sharing
    - Permissions
  - Kernel/user modes and gates
  - Bootstrapping
  - Virtual addresses
  - Page maps, page tables
  - Supporting thread virtual address spaces
  - Translation lookaside buffer

Major topics

- Processor virtualization – threads
  - YIELD
  - Processor/thread layers
  - Stack, control flow
  - Enforcing modularity with pre-emptive scheduling and virtual address spaces

Major topics

- Designing for performance
  - Key metrics: utilization, latency, throughput
  - Identifying bottlenecks
  - Reducing latency
    - Optimize for common case; average latency
    - Concurrency: parallelism, pipelining
  - Basics of queuing
    - Queuing model based on memoryless inter-arrival and service times: $T_{queue} = \mu * [\rho/(1- \rho)]$
  - Batching, dallying, speculation

Major topics

- Scheduling
  - First-come, first-serve
  - Shortest job first
  - Round-robin with pre-emption
  - Real-time schedulers
    - Soft real-time, hard real-time
  - Earliest deadline first
  - Rate monotonic
  - Elevator scheduler

Major topics

- Network properties
  - Isochronous vs. asynchronous
  - Packet switching/forwarding
  - Guaranteed vs. best effort delivery
  - Dealing with lost messages
  - Dealing with duplicates
  - Dealing with message errors
  - Reordered delivery

Major topics

- Network design
  - Layered protocols
  - Data link layer
    - Frames
  - Network layer
    - Packets
  - End-to-end layer
    - Messages, streams; segments
  - Header, trailer; encapsulation
  - Recursive composition
  - End-to-end principle

Major topics

- Networking case studies
  - Ethernet: broadcast, switching
  - Mapping Ethernet layer to Internet IP
  - Address Resolution Protocol (ARP)
  - Network Address Translation (NAT)

Major topics

- Fault tolerance
  - Modularity: detection, containment, masking
  - Faults, errors, failures
  - Reliability R(t), unconditional failure rate f(t), conditional failure rate h(t)
  - Basic properties of exponential distribution for R(t)
  - MTTF,MTTR
  - Availability

Major topics

- Fault tolerance
  - Responding to active faults
    - Do nothing; fail fast; fail safe; fail soft; mask
  - Coding – incremental redundancy
    - Hamming distance basics
    - Simple parity and single bit correction
    - Forward vs backward correction
    - Dealing with erasures
  - Replication – massive redundancy
    - N-modular logic
    - Redundancy and NMR
    - Repair

Major topics

- Fault tolerance
  - Fault-tolerant software
    - Separating state: volatile, non-volatile
    - Durability
    - Durable storage systems and layers
      - RAW, fail-fast, careful, durable
    - RAID basics

Major topics

- Atomicity
  - All-or-nothing write for single sector
  - Journal
  - Atomicity log
  - Before-or-after – mark-point discipline
  - Locks, 2-phase locking