

CSE 120

Principles of Operating Systems

Fall 2001

Midterm Review
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Overview

- The midterm
- Architectural support for OSes
- OS modules, interfaces, and structures
- Processes
- Threads
- Synchronization
- Scheduling

Midterm

- Covers material through scheduling
- Based upon lecture material, homeworks, and project
- Open book, open notes

- Please, do not cheat
 - ◆ Do not copy from your neighbor
 - ◆ I will notice
 - ◆ No one involved will be happy, particularly me

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Arch Support for OSES

- Types of architecture support
 - ◆ Manipulating privileged machine state
 - ◆ Generating and handling events

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Privileged Instructions

- What are privileged instructions?
 - Who gets to execute them?
 - How does the CPU know whether they can be executed?
 - Difference between user and kernel mode
- Why do they need to be privileged?
- What do they manipulate?
 - Protected control registers
 - Memory management
 - I/O devices

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Events

- Events
 - Synchronous: fault (exceptions), system calls
 - Asynchronous: interrupts, software interrupt
- What are faults, and how are they handled?
- What are system calls, and how are they handled?
- What are interrupts, and how are they handled?
 - How do I/O devices use interrupts?
- What is the difference between exceptions and interrupts?

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OS Modules, Interfaces, and Structure

- Modules
 - ◊ OS services and abstractions
- Interfaces
 - ◊ Operations supported by components
- Structure
 - ◊ How modules are composed, how they interact

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Modules

- Processes
- Memory
- I/O
- Secondary storage
- Files
- Protection
- Account
- Command interpreter (shell)

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Structure

- How are the components organized?
 - Monolithic kernels
 - Layering
 - Microkernels
- What are the advantages and disadvantages of each?

Processes

- What is a process?
- What resource does it virtualize?
- What is the difference between a process and a program?
- What is contained in a process?

Process Data Structures

- Process Control Blocks (PCBs)
 - What information does it contain?
 - How is it used in a context switch?
- State queues
 - What are process states?
 - What is the process state graph?
 - When does a process change state?
 - How does the OS use queues to keep track of processes?

Process Manipulation

- What does CreateProcess on NT do?
- What does fork() on Unix do?
 - What does it mean for it to “return twice”?
- What does exec() on Unix do?
 - How is it different from fork?
- How are fork and exec used to implement shells?

Threads

- What is a thread?
 - What is the difference between a thread and a process?
 - How are they related?
- Why are threads useful?
- What is the difference between user-level and kernel-level threads?
 - What are the advantages/disadvantages of one over another?

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Thread Implementation

- How are threads managed by the run-time system?
 - Thread control blocks, thread queues
 - How is this different from process management?
- What operations do threads support?
 - Fork, yield, sleep, etc.
 - What does thread yield do?
- What is a context switch?
- What is the difference between non-preemptive scheduling and preemptive thread scheduling?
 - Voluntary and involuntary context switches

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Synchronization

- Why do we need synchronization?
 - Coordinate access to shared data structures
 - Coordinate thread/process execution
- What can happen to shared data structures if synchronization is not used?
 - Race condition
 - Corruption
 - Bank account example
- When are resources shared?
 - Global variables, static objects
 - Heap objects

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Mutual Exclusion

- What is mutual exclusion?
- What is a critical section?
 - What guarantees do critical sections provide?
 - What are the requirements of critical sections?
 - » Mutual exclusion
 - » Progress
 - » Bounded waiting (no starvation)
 - » Performance
- How does mutual exclusion relate to critical sections?
- What are the mechanisms for building critical sections?
 - Locks, semaphores, monitors, condition variables

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Locks

- What does Acquire do?
- What does Release do?
- What does it mean for Acquire/Release to be atomic?
- How can locks be implemented?
 - Spinlocks
 - Disable/enable interrupts
 - Blocking (Nachos)
- How does test-and-set work?
 - What kind of lock does it implement?
- What are the limitations of using spinlocks, interrupts?
 - Inefficient, interrupts turned off too long

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Semaphores

- What is a semaphore?
 - What does Wait/P/Decrement do?
 - What does Signal/V/Increment do?
 - How does a semaphore differ from a lock?
 - What is the difference between a binary semaphore and a counting semaphore?
- When do threads block on semaphores?
- When are they woken up again?
- Using semaphores to solve synchronization problems
 - Readers/Writers problem
 - Bounded Buffers problem

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Monitors

- What is a monitor?
 - Shared data
 - Procedures
 - Synchronization
- In what way does a monitor provide mutual exclusion?
 - To what extent is it provided?
- How does a monitor differ from a semaphore?
- How does a monitor differ from a lock?
- What kind of support do monitors require?
 - Language, run-time support

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Condition Variables

- What is a condition variable used for?
 - Coordinating the execution of threads
 - Not mutual exclusion
- Operations
 - What are the semantics of Wait?
 - What are the semantics of Signal?
 - What are the semantics of Broadcast?
- How are condition variables different from semaphores?

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Implementing Monitors

- What does the implementation of a monitor look like?
 - Shared data
 - Procedures
 - A lock for mutual exclusion to procedures (w/ a queue)
 - Queues for the condition variables
- What is the difference between Hoare and Mesa monitors?
 - Semantics of signal (whether the woken up waiter gets to run immediately or not)
 - What are their tradeoffs?

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Locks and Condition Vars

- In Nachos, we don't have monitors
- But we want to be able to use condition variables
- So we isolate condition variables and make them independent (not associated with a monitor)
- Instead, we have to associate them with a lock (mutex)
- Now, to use a condition variable...
 - Threads must first acquire the lock (mutex)
 - CV::Wait releases the lock before blocking, acquires it after waking up

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Scheduling

- What kinds of scheduling is there?
 - ♦ Long-term scheduling
 - ♦ Short-term scheduling
- Components
 - ♦ Scheduler (dispatcher)
- When does scheduling happen?
 - ♦ Job changes state (e.g., waiting to running)
 - ♦ Interrupt, exception
 - ♦ Job creation, termination

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Scheduling Goals

- Goals
 - ♦ Maximize CPU utilization
 - ♦ Maximize job throughput
 - ♦ Minimize turnaround time
 - ♦ Minimize waiting time
 - ♦ Minimize response time
- What is the goal of a batch system?
- What is the goal of an interactive system?

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Starvation

- Starvation
 - ♦ Indefinite denial of a resource (CPU, lock)
- Causes
 - ♦ Side effect of scheduling
 - ♦ Side effect of synchronization
- Operating systems try to prevent starvation

Scheduling Algorithms

- What are the properties, advantages and disadvantages of the following scheduling algorithms?
 - ♦ First Come First Serve (FCFS)/First In First Out (FIFO)
 - ♦ Shortest Job First (SJF)
 - ♦ Priority
 - ♦ Round Robin
 - ♦ Multilevel feedback queues
- What scheduling algorithm does Unix use? Why?

Deadlock

- Deadlock happens when processes are waiting on each other and cannot make progress
- What are the conditions for deadlock?
 - ◆ Mutual exclusion
 - ◆ Hold and wait
 - ◆ No preemption
 - ◆ Circular wait
- How to visualize, represent abstractly?
 - ◆ Resource allocation graph (RAG)

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Deadlock Approaches

- Dealing with deadlock
 - ◆ Ignore it
 - ◆ Prevent it (prevent one of the four conditions)
 - ◆ Avoid it (have tight control over resource allocation)
 - ◆ Detect and recover from it
- What is the Banker's algorithm?
 - ◆ Which of the four approaches above does it implement?

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