PROCESSES & THREADS

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Tanenbaum, Andrew S. (2008). *Modern Operating Systems. Third Edition.* Upper Saddle River, NJ: Prentice-Hall. ISBN: 0-13-031358-0.

CHAPTER 2: Processes and Threads

Sobell, Mark G. (2005). *A Practical Guide to Linux Commands, Editors, and Shell Programming.* Upper Saddle River, NJ: Prentice-Hall Professional Technical Reference. ISBN: 0-13-147823-0 (alk. paper).

CHAPTER 3:

CPU-Scheduling Algorithms (for Processes or Threads)

1. First-Come-First-Served
2. Shortest Job First
3. Shortest Remaining Time Next
4. Round-Robin Scheduling
5. Priority Scheduling
6. Priority Scheduling with Multiple Queues
7. Shortest Process Next
8. "Guaranteed" Scheduling
9. Lottery Scheduling
10. Fair-Share Scheduling

Part I: PROCESSES

Multiprogramming

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Initiators of Process Creation

1. **System Initialization (Boot-Up)**
2. **Explicit User-Initiation (*e.g.,* issuance of a CLI command)**
3. **Existing Process via issuance of a Process-Creation System Call**
4. **Long-Term Scheduler, in accommodating a submitted batch job**

Initiators of Process Termination

1. Completion of assigned task: normal termination (voluntary)
2. Exit upon encountering a specifically chosen error (voluntary)
3. Occurrence of a fatal error (involuntary)
4. Explicitly ordered by another (usually ancestral) process (involuntary)

Kinds of Processes

1. Foreground
2. Background
3. Daemon

Simple Model of Process States and Process Transitions

Causal events for transition:

NOTE: Fourth state (not shown): Terminated

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Individual Processes, and the Underlying OS for Interrupt-Handling & Scheduling

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Contents of a Process Descriptor

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Sequence of Activities Following the Occurrence of an Interrupt

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% CPU Utilization Depends on the Degree of Multiprogramming

$$\boxed{U_{\mathrm{CPU}} = 1 - p^{n}}$$

Degree of Multiprogramming ⟶

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Part II: THREADS

Word Processor with Multiple Threads

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1. **Waits for and then handles input from keyboard.**
2. **Reformats the document in background.**
3. **Autosaves the document at the specified time interval, copying out the current content onto the disk (foreground).**
4. **Sends the document to the print SPOOLer.**

Web Server with Multiple Threads

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Web Server: Dispatcher Thread

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Web Server: Worker Thread

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Alternative Approaches to the Design of a Web Server

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Single-Threaded and Multi-Threaded Processes

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Items Shared by All the Threads of a Single Process, and Items Unique to Each Thread

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Separate Stack for Each Thread

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Function Calls for POSIX Threads (Pthreads)

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Example of a Program that Uses *Pthreads*

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User-Level Threads *vs.* Kernel-Level Threads

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Multiplexing of Several User-Level Threads Onto a Single Kernel-Level Thread

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Creation of a New Thread in Response to the Arrival of a Message

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Inter-Thread Conflicts in the Use of a Global Variable

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Private Global Variables

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Race Conditions

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Mutual Exclusion from a Critical Region

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Use of a Spin Lock to Achieve Mutual Exclusion

Process 0:

Process 1:

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Peterson's Algorithm for Achieving Mutual Exclusion

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Use of an Atomic "Test and Set Lock" (TSL) Machine Instruction to Achieve Mutual Exclusion

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Entering and Leaving the Critical Region Using "XCHG"

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Race Condition in the "Producer-Consumer Problem"

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Use of Semaphores in the "Producer-Consumer Problem"

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Use of *mutex_lock* and *mutex_unlock* to Achieve Mutual Exclusion

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POSIX Threads: Procedure Calls for Mutual Exclusion

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POSIX Threads: Procedure Calls Pertaining to Condition Variables

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POSIX Threads: Use of Mutexes and Condition Variables to Solve the Producer-Consumer Problem

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POSIX Threads: Use of Mutexes and Condition Variables to Solve the Producer-Consumer Problem

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Use of the Monitor, a Programming-Language Construct, to Achieve Mutual Exclusion

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Use of a Monitor to Effect Mutual Exclusion in the "Producer-Consumer Problem"

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The "Producer-Consumer Problem: Solution in Java (1)

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The "Producer-Consumer Problem: Solution in Java (2)

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Figure 2-35"b".
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Message-Passing Used to Solve the "Producer-Consumer Problem:

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Use of a Barrier to Enforce the Synchronization of Multiple Processes

All processes are approaching the barrier. None has yet reached it.

Several processes have reached the barrier and are waiting until all are present.

Last process has reached the barrier. All processes may now pass through.

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CPU-Bound and I/O-Bound Processes

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Goals of the Scheduling Algorithm: Dependent upon the Computing Environment

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Long-Term (Admission) Scheduler, Medium-Term (Memory) Scheduler, and Short-Term (CPU) Scheduler

NOTE: This figure did not come from our course text.

CPU-Scheduling Algorithms

1. First-Come-First-Served (FCFS): Batch Environment, *NON*-Preemptive

CPU-Scheduling Algorithms

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2. Shortest Job First (SJF): Batch Environment, *NON*-Preemptive

Effectiveness of "Shortest-Job First" Scheduling

Jobs run in order of arrival:
First-Come-First-Served (FCFS)

Shortest Jobs run First (SJF)

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CPU-Scheduling Algorithms

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4. Round-Robin Scheduling (with Time Quantum): Interactive, ***PREEMPTIVE***

Round-Robin Scheduling

Job 'B' gets the processor:

Job 'B' uses up its quantum:

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CPU-Scheduling Algorithms

1. **First-Come-First-Served (FCFS): Batch Environment, *NON*-Preemptive**

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5. **Priority Scheduling (with Time Quantum): Interactive, *PREEMPTIVE***
6. **Priority Scheduling with Multiple Queues (with Time Quantum): Interactive,**

Priority-Based Scheduling

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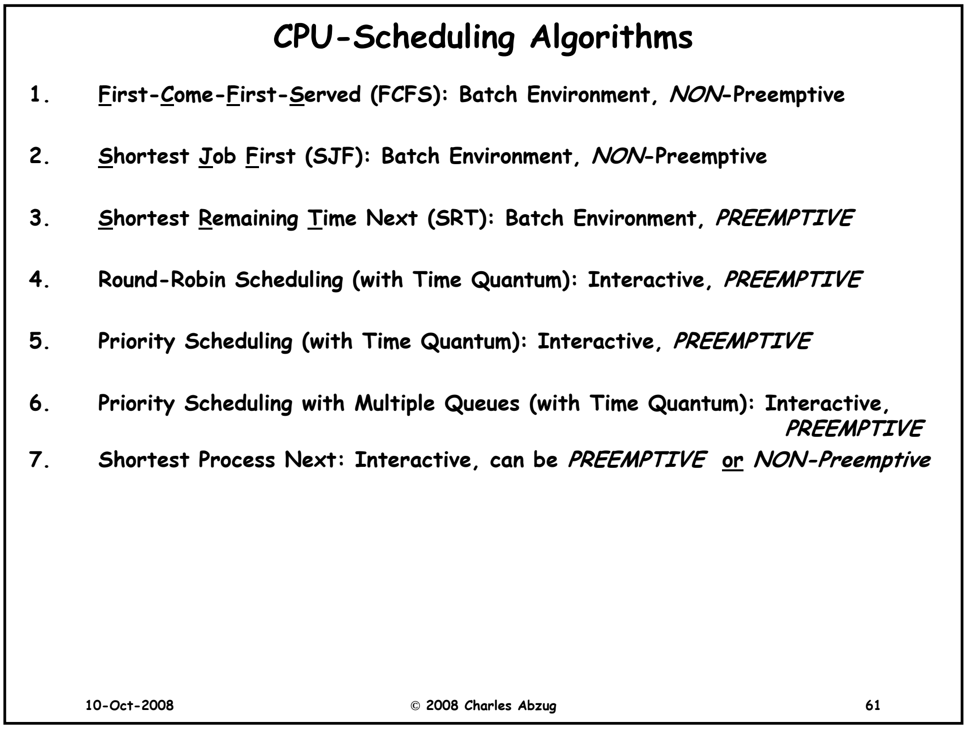

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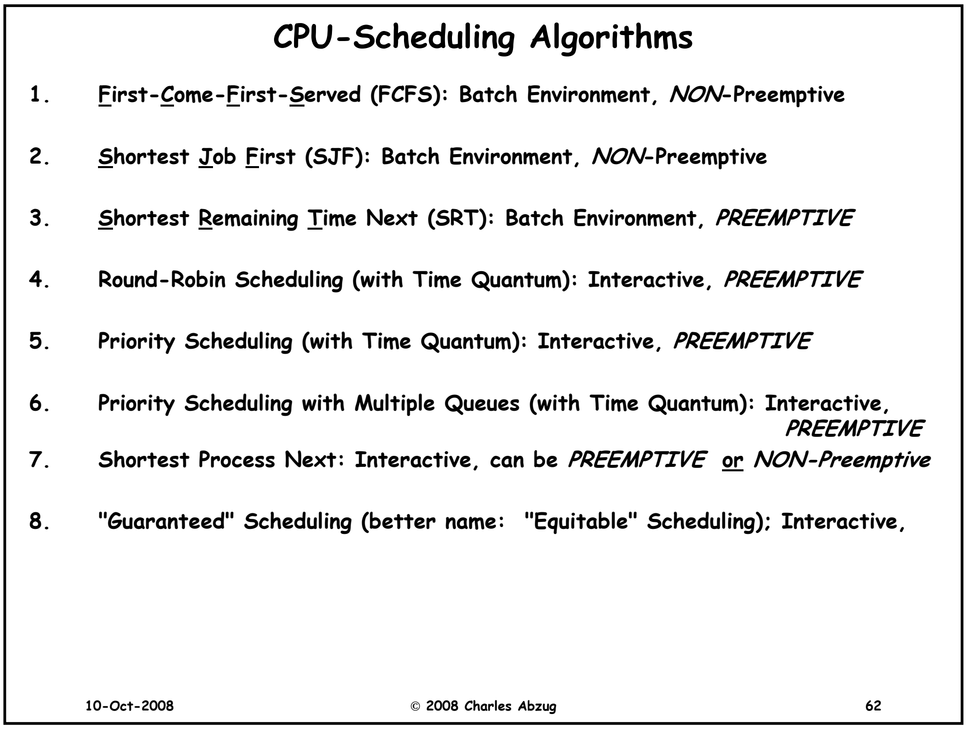
7. Shortest Process Next: Interactive, can be ***PREEMPTIVE*** or ***NON-Preemptive***



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9. Lottery Scheduling (with Time Quantum): Interactive , *PREEMPTIVE*

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10. Fair-Share Scheduling (with Time Quantum): Interactive, *PREEMPTIVE*

Scheduling of User-Level Threads

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Scheduling of Kernel-Level Threads

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The "Dining Philosophers Problem"

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Deadlock or Starvation in the "Dining Philosophers Problem"

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Use of Semaphores to Solve the "Dining Philosophers Problem" (1)

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Use of Semaphores to Solve the "Dining Philosophers Problem" (2)

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Use of Semaphores to Solve the "Readers & Writers Problem"

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