Lecture 2 - Processes

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Overview

- In this class we will discuss
  - The process model
  - Race Conditions
  - Three unsatisfactory attempts to avoid race conditions
  - Process Scheduling
    - Round Robin Scheduling
    - Priority Scheduling
    - Multiple Queues
    - Shortest Job First
    - Two-level Scheduling

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Operating System Tasks

- **Processes**
  - Run them smoothly, assign CPU time
- **Memory**
  - Organise main memory, allocation
- **Files**
  - Allocation of files stored on disk, security
- **Input / Output management**

What Is a Process?

- A process is a program in execution
- A process consists of:
  - An executable program
  - Data
  - program counter
  - stack pointer
  - some registers
  - Other information
- If a process is stopped / interrupted, to be able to proceed with the process one has to store all the information about it
  - Often stored in a Process Table
- What is the difference between a program and a process?
- Why does the operating system interrupt a running process to give CPU time to another?
- Software interrupts: Signals

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The Process Model

- Pseudo parallelism vs. true hardware parallelism
- The CPU assigns units of time to the processes running
- The processes shouldn't have built in time assumptions
- What processes have built in time assumptions?

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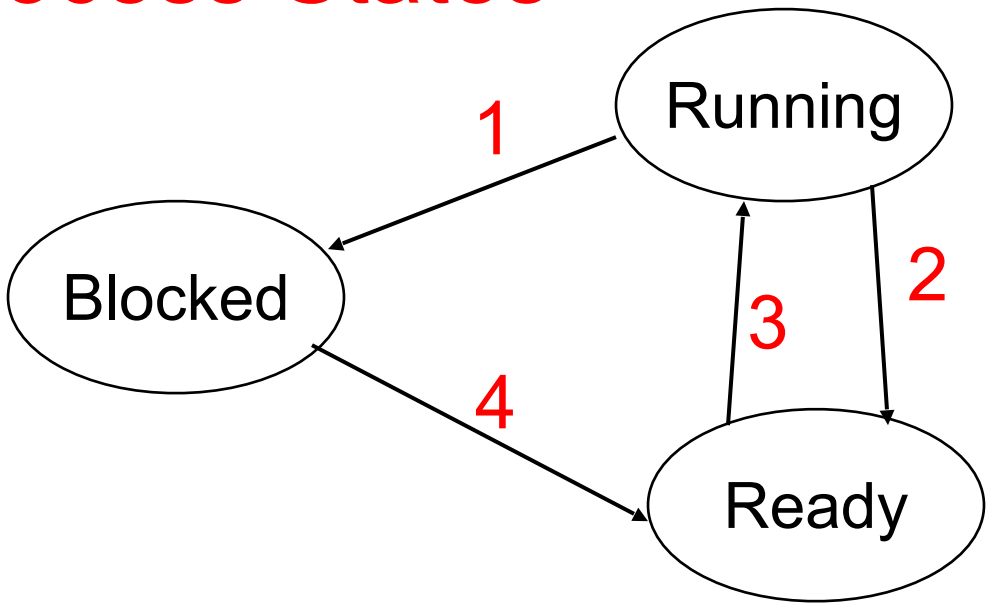
Process States



1. Process blocks for input
2. Scheduler picks another process
3. Scheduler picks this process
4. Input becomes available

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Race Conditions

- Processes often share files or resources
- Example Race condition – Printer spool slots
- How can we avoid race conditions?
- Critical sections
  - No two processes may be simultaneously inside their critical sections
  - No assumptions may be made about speeds or the number of CPUs
  - No process running outside its critical section may block other processes
  - No process should have to wait forever to enter its critical section

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Attempts to Avoid Race Conditions

- Disabling Interrupts
  - too much power for user processes
- Lock Variables
  - same problem as in example
- Strict Alternation
  - busy waiting

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Scheduling

- When more than one process is runnable the operating system must decide which one to run
- The part of the operating system concerned with this decision is called the **scheduler**
- the algorithm it uses is called the **scheduling algorithm**
- Complications
  - Every process is unique and unpredictable
  - Clock interrupts
  - pre-emptive scheduling or run to completion?

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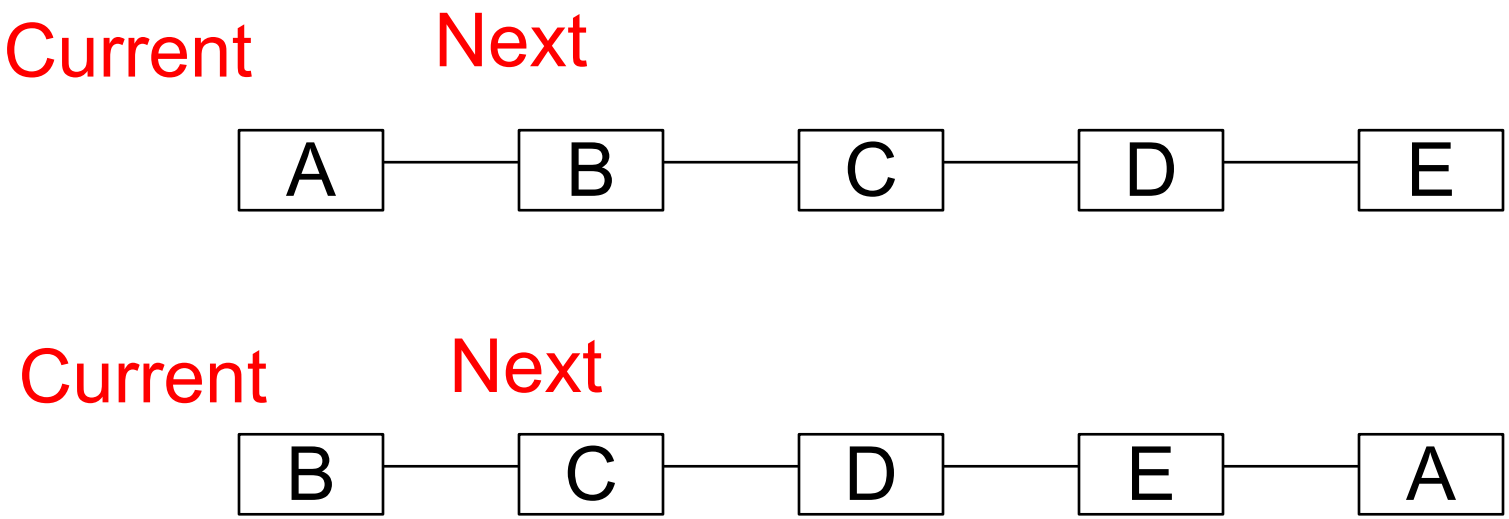
Aims of the Scheduling Algorithm

- Fairness
  - make sure each process gets its fair share of the CPU
- Efficiency
  - keep the CPU busy 100 percent of the time
- Response time
  - minimise response time for interactive users
- Turnaround
  - minimise the time batch users must wait for output
- Throughput
  - maximise the number of jobs processed per hour

Round Robin Scheduling

- Each process is assigned a time interval called its quantum which it is allowed to run
- If the process is still running at the end of the quantum the CPU is given to another process



Round Robin Quantum Size

- Interesting question: Length of the quantum?
- Switching from one process to the next one *(process switch)* requires a certain amount of time
- Suppose switch takes 5 msec
- What %-age of time is used in process switches if:
  - quantum set to 20 msec
  - quantum set to 100 msec

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Priority Scheduling

- The processes are not equally important some will get higher priority than the other
- But high priority processes should not be run forever! Therefore decrease the priority of the currently running process *after some time*
- E.g. decrease the priority at each clock tick. If the priority dropped below that of the next highest process, then do a process switch
- Priorities can be assigned to processes statically or dynamically

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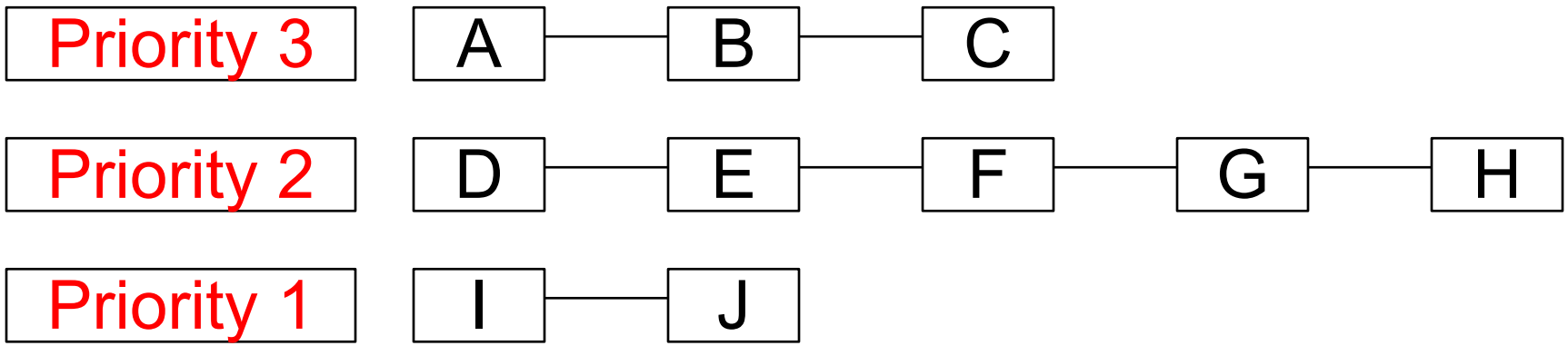
Priority Classes

- It is convenient to group processes into priority classes
- Among the classes priority scheduling but -
- within each class Round Robin Scheduling



Multiple Queues

- Depending on the time a process switch takes it could be more efficient to give processes big amounts of CPU time once in a while instead of small quanta frequently
- On the other hand, giving all processes a large quantum would mean poor response time
- Solution - Priority classes where in the highest priority class, each process gets one quantum, in the second class processes run for 2 quanta etc

Multi-queue Example

- Suppose a process needs to compute continuously for 7 quanta
- Using multiple queues this process would only need 3 swaps (1 -> 2 -> 4)
- With Round Robin Scheduling it would have needed 7 swaps
- Suppose a process needs the CPU continuously for 100 quanta
  - How many swaps do we need for it with multiple queues?
  - And with Round Robin?

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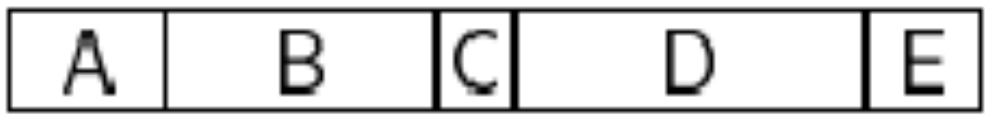
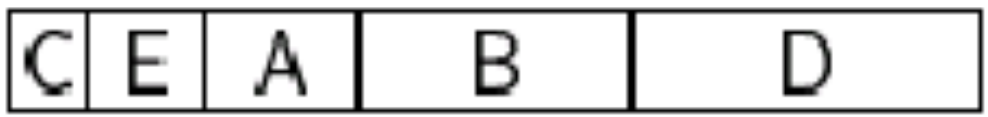
Shortest Job First

- If we have more information about processes
  - e.g. the run times of the processes
- we can apply a more specialised algorithm
- Suppose we know the run times of the incoming jobs
- several of (equally important) jobs are waiting for the CPU
- We should run the Shortest Job First

Shortest Job First example

- processes A through E are waiting to be run
- Their run times are
  - A - 4 minutes
  - B - 7minutes
  - C - 2minutes
  - D - 9 minutes
  - E - 3 minutes





Features of Shortest Job First

- Always minimum average time. It would be nice if it could be used for interactive processes as well
- Estimates could be made based on past behaviour Then run the process with the shortest estimated running time
- Suppose T_0 estimated time for a terminal
- T_1 length of next run
- $T = aT_0 + (1 - a)T_1$ new estimate for the terminal
- The parameter *a* regulates the memory of the estimation
  - Aging
- Problem with processes not arriving simultaneously

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About Scheduling

- Guaranteed scheduling
- Policy versus Mechanism

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Two Level Scheduling

- In the situation where the main memory is insufficient some of the runnable processes will be kept on the disk
- Two level scheduler
  - lower level scheduler only choosing processes which are in main memory
  - periodically the higher level scheduler removes processes that have been in memory long enough and loads processes that have been on the disk too long