CS343 Operating Systems

Lecture 3

Introduction to CPU Scheduling

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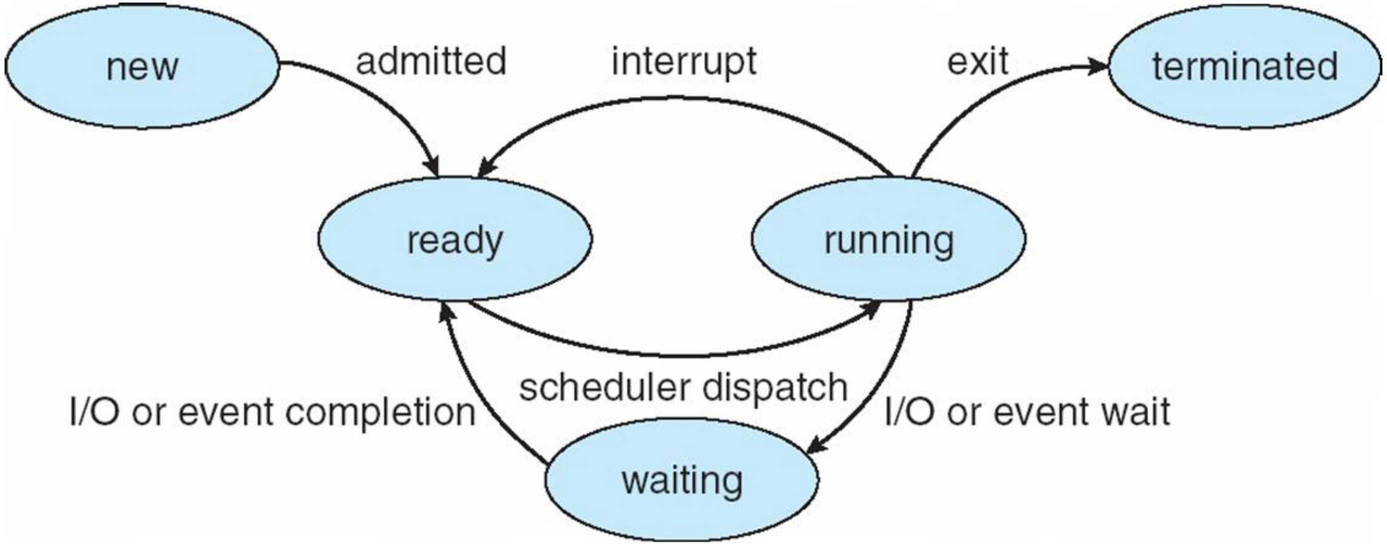
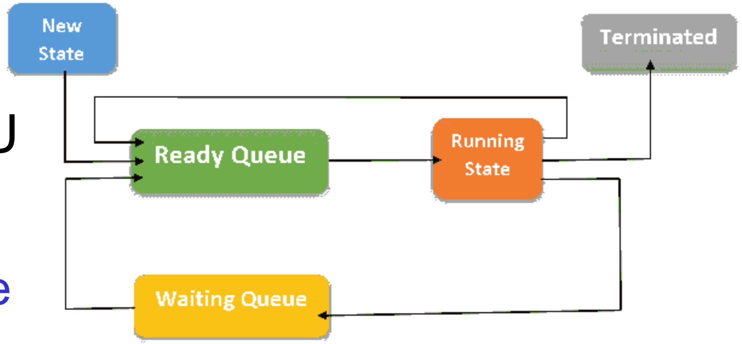
Process State Diagram



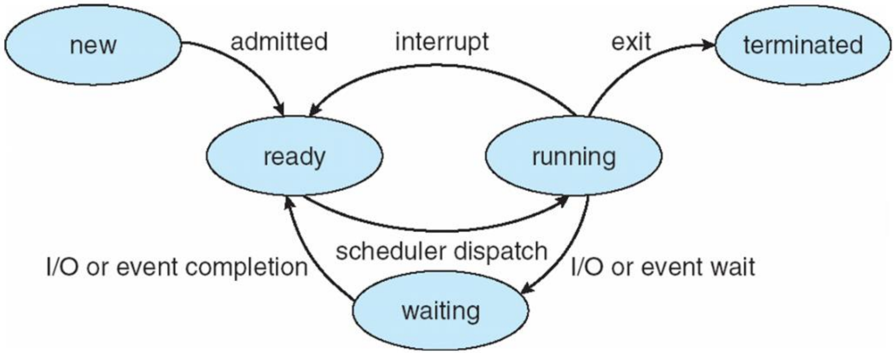
CPU Schedulers

- **Short-term scheduler (CPU scheduler)** selects from among the processes that are ready to execute and allocates the CPU to one of them.
  - Selection from Ready state to Running state
  - Short-term scheduler is invoked frequently



Preemptive vs Non-preemptive Scheduling

❖ CPU-scheduling decisions happen during the four circumstances:



1. When a process switches from the running state to the waiting state
2. When a process switches from the running state to the ready state
3. When a process switches from the waiting state to the ready state
4. When a process terminates

Preemptive vs Non-preemptive Scheduling

- CPU-scheduling decisions happen during the four circumstances:
  1. When a process switches from the running state to the waiting state
  2. When a process switches from the running state to the ready state
  3. When a process switches from the waiting state to the ready state
  4. When a process terminates
- 1 & 4, the scheduling is **non-preemptive** (cooperative)
- A running process keeps the CPU until it releases the CPU (terminating or by switching to the waiting state).
- 2 & 3, the scheduling is **pre-emptive**
- The process is removed from running state forcefully.

Scheduling Criteria

- Different CPU-scheduling algorithms have different properties.
- Certain characteristics/criteria are used for comparing various CPU scheduling algorithms.
  - CPU Utilization
  - Throughput
  - Turnaround time
  - Waiting Time
  - Response Time

Scheduling Criteria

- CPU Utilization – Percentage time CPU is busy executing process.⇧
- Throughput - Number of processes that are completed per time unit.⇧
- Turnaround time - The interval from the time of submission of a process to the time of completion.⇩
- Waiting Time - Amount of time that a process spends waiting in the ready queue. ⇩
- Response Time - Time from the submission of a request until the first response is produced.⇩

Categories of Scheduling Algorithms & Goals

- **Batch System**
  - Complete maximum number of jobs per unit time.
  - Minimize time between submission and termination
  - Keep CPU busy all time
- **Interactive System**
  - Response to requests quickly
  - Reduce waiting time
  - Meet user expectations
- **Real time System**
  - Meeting deadlines
  - Ensure quality constraints

CPU Scheduling Algorithms

Batch Systems

- First-come first-served
- Shortest job first
- Shortest remaining Time next

Interactive Systems

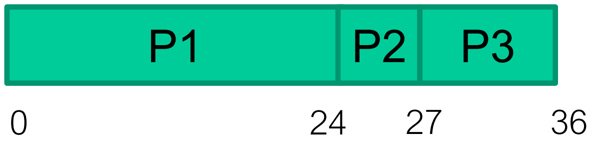
- Round-robin scheduling
- Priority scheduling
- Multiple queues
- Shortest process next
- Guaranteed scheduling
- Lottery scheduling
- Fair-share scheduling

FCFS Scheduling

- Simplest CPU-scheduling algorithm
- First-come, first-served - process that requests the CPU first is allocated the CPU first
- FCFS policy is managed with a FIFO queue
- When a process enters the ready queue, its PCB is linked onto the tail of the FIFO queue
- When the CPU is free, it is allocated to process at the head of the queue
- The running process is then removed from the queue
- It is non-preemptive, once scheduled it will complete
- Short jobs wait for long

FCFS Scheduling

- Example: Three processes arrive in order P1, P2, P3 all at time 0.
  - P1 burst time: 24
  - P2 burst time: 3
  - P3 burst time: 9



- Waiting Time
  - P1: 0, P2: 24, P3: 27
- Completion Time:
  - P1: 24, 2: 27, P3: 36
- Average Waiting Time: (0+24+27)/3 = 17
- Average Completion Time: (24+27+36)/3 = 29

SJF Scheduling

- Shortest (in terms of CPU time) job available is scheduled first
- Shorter processes makes progress
- SJF policy is managed with a priority queue with burst time as input
- When a process enters the ready queue, its PCB is linked onto the priority queue at the appropriate entry
- When the CPU is free, it is allocated to the process at the head of the priority queue
- If too many short jobs, long processes will starve
- SJF is non-preemptive; once allotted the process will complete
- Lowest turnaround time

SJF Scheduling

- Consider 3 process P2, P3, P1 all arriving at time T0.
  - P1 burst time: 24
  - P2 burst time: 3
  - P3 burst time: 9

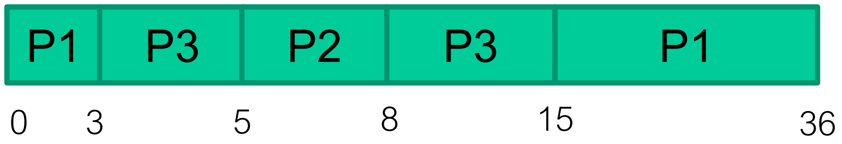
- Waiting Time
  - P1: 12,   P2: 0,   P3: 3
- Completion Time:
  - P1: 36,   P2: 3,   P3: 12
- Average Waiting Time: (12+0+3)/3 = 5 (compared to 17)
- Average Completion Time: (36+3+12)/3 = 17 (compared to 29)

SRTF Scheduling

- Shortest Remining Time First (SRTF) job is scheduled first
- Preemptive scheduling algorithm
- A priority queue with remaining time is used as input
- When a process enters/re-enters the ready queue, its PCB is linked onto the priority queue at the appropriate entry
- When the CPU is free, it is allocated to the process at the head of the priority queue
- Newly arriving short process may forcefully preempt currently running process.
- Longer process may have multiple context switch before completion

SRTF Scheduling

- Consider the following process arriving at different time slots
  - P1 burst time: 24 arrives at 0
  - P2 burst time: 3 arrives at 5
  - P3 burst time: 9 arrives at 3



- Waiting Time
  - P1: (15-3) =12,   P2: 0,   P3: (8-5) = 3
- Completion Time:
  - P1: 36,   P2: 8,   P3: 15
- Average Waiting Time: (0+3+12)/3 = 5
- Average Completion Time: (5+10+36)/3 = 17

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